Burden of hypertension in The Gambia: Evidence from a national World Health Organisation (WHO) STEP survey

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Key Messages

- One-third of the adult population (25-64 years) in The Gambia are hypertensive and a high proportion are undiagnosed.
- Unlike previous studies in sub-Saharan Africa, hypertension was more prevalent in rural than urban residents in The Gambia.
- There should be periodic screening of blood pressure, especially among rural residents.
- Overweight and obesity were strongly associated with hypertension, hence preventive efforts should be directed to diet and socio-cultural factors that facilitate the increasing burden of hypertension.

Abstract

Introduction

Non-communicable diseases are increasing in sub-Saharan Africa and estimated to account for 32% of adult deaths in The Gambia. Worldwide, prevalence of hypertension is highest in the African region (46%) and a very high proportion is undiagnosed. This study examined diagnosed and undiagnosed hypertension in The Gambian adult population.

Methods

Data was collected in 2010 from a nationally-representative random sample of 4111 adults aged 25-64 years using the WHO STEPwise cross-sectional survey methods. Analyses were restricted to non-pregnant participants with three valid blood pressure measurements (n=3573). We conducted gender-stratified univariate and multivariate regression analyses to identify the strongest sociodemographic, behavioural and biological risk factors associated with hypertension.

Results

Almost one-third of adults were hypertensive; a high proportion were undiagnosed, particularly among men (86% of men vs 71% of women with hypertension, $p<0.001$). Rural and semi-urban residents and overweight/obese persons had increased odds of hypertension. Compared with urban residents, participants from one of the most rural regions had higher odds of hypertension among both men (Adjusted Odds Ratio, AOR 3.2[95% CI: 1.6-6.4]) and women (AOR 2.5[95% CI: 1.3-4.6]). Other factors strongly associated with hypertension in multivariate analyses were age, smoking, physical inactivity and ethnicity.

Conclusions

Rural and semi-urban residence were strongly associated with hypertension, contrary to what has been found in similar studies in sub-Saharan Africa. Intervention to reduce the burden of hypertension in The Gambia could be further targeted towards rural areas.

Key words: Hypertension, Gambia, sub-Saharan Africa, WHO STEP survey, health examination survey

MeSH Terms: Hypertension, blood pressure, cardiovascular diseases, obesity, Gambia, Africa south of the Sahara, developing countries, health survey, rural health, world health organization

Word count: Abstract= 233; main document =2987

Background

Globally, there is an increasing epidemiological transition in the disease profile from infectious diseases and nutritional deficiencies to non-communicable diseases (NCDs), but the burden of NCDs is higher in sub-Saharan Africa (SSA).[1-8] NCDs account for 70% of global deaths annually; 80% occur in low- and middle-income countries.[9] Countries in SSA are also grappling with the double burden of communicable and non-communicable diseases.[10, 11] Less than 3% of global aid is directed towards NCD prevention and control.[12]

Hypertension is a global health challenge, with a higher burden in SSA. In 2008, the worldwide prevalence of hypertension among adults aged 25 years and above was 40% and was highest in Africa (46%).[13] Of even greater concern, a large proportion of hypertension in Africa is undiagnosed.[5, 14] Although hypertension is the commonest modifiable risk factor for stroke and other cardiovascular diseases (CVDs) in Africa, its prevention and control is not prioritised.[5, 15] Early detection and treatment is crucial for the effective control of hypertension and the prevention of complications.

NCDs are increasing in The Gambia, the smallest country on mainland Africa, with a population of 1.8 million. NCDs account for around 32% of adult deaths.[16] A study using verbal autopsy in rural Gambia also found 38% of deaths in 1998-2007 were associated with NCDs.[17] Studies on hypertension in The Gambia are very limited; few used population-based health examination survey data. A population-based survey on hypertension (part of a nationwide survey on blindness and low vision in 1996) reported a prevalence of 10% (blood pressure ≥160/95mmHg) among adults 15 years and above, and 24% above 140/90mmHg.[18] More than half of the participants in that study were surveyed during the holy month of Ramadan, which can influence the anthropometric and blood pressure (BP) measurements. A

related study showed that people in The Gambia with a family history of hypertension had higher BP, cholesterol and uric acid than those without that family history.[19]

Hypertension poses both public-health and economic burdens to individuals, families, governments and society.[20] Many governments and families in SSA, including The Gambia, will not cope with this increasing burden coupled with the existing burden of infectious diseases. This can pose a barrier to poverty alleviation, hindering attainment of the United Nations Sustainable Development Goals.[7, 9, 21, 22] Despite this, there is very limited up-to-date information on the burden of hypertension and associated risk factors in The Gambia. This study aimed to examine diagnosed and undiagnosed hypertension in Gambian adults.

Methods

Study setting, design and sample

This paper is based on secondary analysis of data from the WHO STEP survey conducted among adults aged 25-64 years from January to March 2010 in The Gambia.[23] The survey is the most recent nationally-representative, population-based, cross-sectional health examination survey in The Gambia, and the only one conducted based on the WHO STEPwise approach for NCDs. The WHO STEPwise approach, otherwise known as WHO STEPS, is a standard population-based health-examination survey approach to NCD surveillance. Data is collected in up to three steps.[24] Step one uses interview-based questionnaires, collecting information on sociodemographic and behavioural risk factors as well as history of diabetes and hypertension. Step two involves physical measurement of weight, height, waist circumference, blood pressure (BP) and pulse rate. (Biochemical

measurement of fasting blood glucose and cholesterol is conducted in step three, not done in The Gambia).

Survey participants were selected using a multi-stage, stratified sampling technique based on the 2003 population census. The Gambia is divided into eight local government areas (LGAs) and 4098 enumeration areas (EAs). The LGAs served as sampling strata; 264 EAs were selected across the country by simple random sampling. The number of EAs selected per stratum (LGA) was proportional to the strata population. From each selected EA, 20 households were selected by simple random sampling. One eligible participant was enrolled in each selected household, using the Kish Method. The target was 5280 but 4111 responded (77.9% response rate). The age, sex and geographical distribution of the participants were similar to that of the 2003 and 2013 census reports. The 232 pregnant women were excluded because of the impact of pregnancy on anthropometric and BP measurements. The analytical sample was limited to participants with three valid BP measurements (n=3573).

Research Instrument and Data collection

Personal Digital Assistants (PDAs) programmed with eSTEPS software, an electronic version of the WHO STEPwise paper-based questionnaire, were used for data collection. eSTEPS has an automatic skip pattern and allows errors to be checked as the interview is ongoing, so is less prone to errors compared with the paper-based version. Data was collected by health staff drawn from all regions. Sampled participants were visited at their home for both interview and physical measurements. Eligible participants not reached after several visits and those who declined to participate were not replaced. BP was measured three times in the sitting position using an automated sphygmomanometer. Ethical approval was obtained from the national ethics committee; participants gave either verbal or written consent.

Definition of variables

Outcome variables

Definitions of most of the variables were based on the WHO STEP criteria.[24] The mean of the second and third BP readings were used in analysis. The main outcome variables in this study are:

- *Total hypertension:* defined as measured raised BP (systolic BP ≥140mmHg and/or diastolic BP ≥90mmHg), and/or self-reported hypertension (as diagnosed by a doctor or health professional, which included all on treatment)
- *Undiagnosed hypertension:* the proportion of participants with total hypertension not aware of their status prior to the survey.

Covariates

These comprised sociodemographic, behavioural and biological risk factors including age, ethnicity, education, residence, fruit and vegetable intake, physical inactivity, smoking, alcohol use and generalised and abdominal obesity (categories shown in Table 1). Alcohol use was not included in multivariate analysis due to low prevalence. Body mass index (BMI) and waist circumference were used to determine generalised and abdominal obesity, using the WHO and International Diabetes Federation thresholds respectively.[25, 26] We used two variables on residence: the region/LGA of participants and rural/urban residence (determined using The Gambia Bureau of Statistics benchmarks).[23]

Data management and statistical analysis

We report the prevalence of hypertension as percentages with their corresponding 95% confidence intervals (CI). We carried out age-adjusted bivariate analysis for each covariate separately, then used multivariate regression analysis to identify factors associated with hypertension. Each model was stratified by gender because of known marked differences in hypertension.[14] The two hypertension outcomes described above were analysed separately. (Measured raised BP was also assessed: however results were similar to total hypertension, and are therefore shown in Supplementary Tables). Due to the overlap of the two variables on residence, fully-adjusted models were repeated interchanging these variables. Age-adjusted (^{a}OR) and fully-adjusted odds ratios (AOR) with corresponding 95% CI are reported. We explored variables that could modify the association between hypertension and potential socio-demographic and biological risk factors by fitting interaction terms. There was no evidence of modification (all $p>0.05$), hence multivariate regression models without interaction terms are reported. Apart from the description of the characteristics of study participants, all analyses were weighted and adjusted for complex survey design, using Stata 14.

Results

Of the 4111 participants, 3573 had three valid BP measurements. Figure 1 outlines the number of participants excluded, with the reasons for exclusion. The unweighted sociodemographic, behavioural and biological risk factors are presented in Table 1. The mean age of participants was 38±10.9 years. A high proportion (44%) were aged 25-34 years. Men were generally older, with a higher level of education than women (all $p <0.001$). There was no age difference by gender after weighting ($p= 0.953$, Table S1). Most participants (98%)

reported being lifetime abstainers from alcohol. The prevalence of generalised and abdominal obesity was higher among women (Table 1).

Figure 1: Flow diagram of study participants with no excluded and reasons

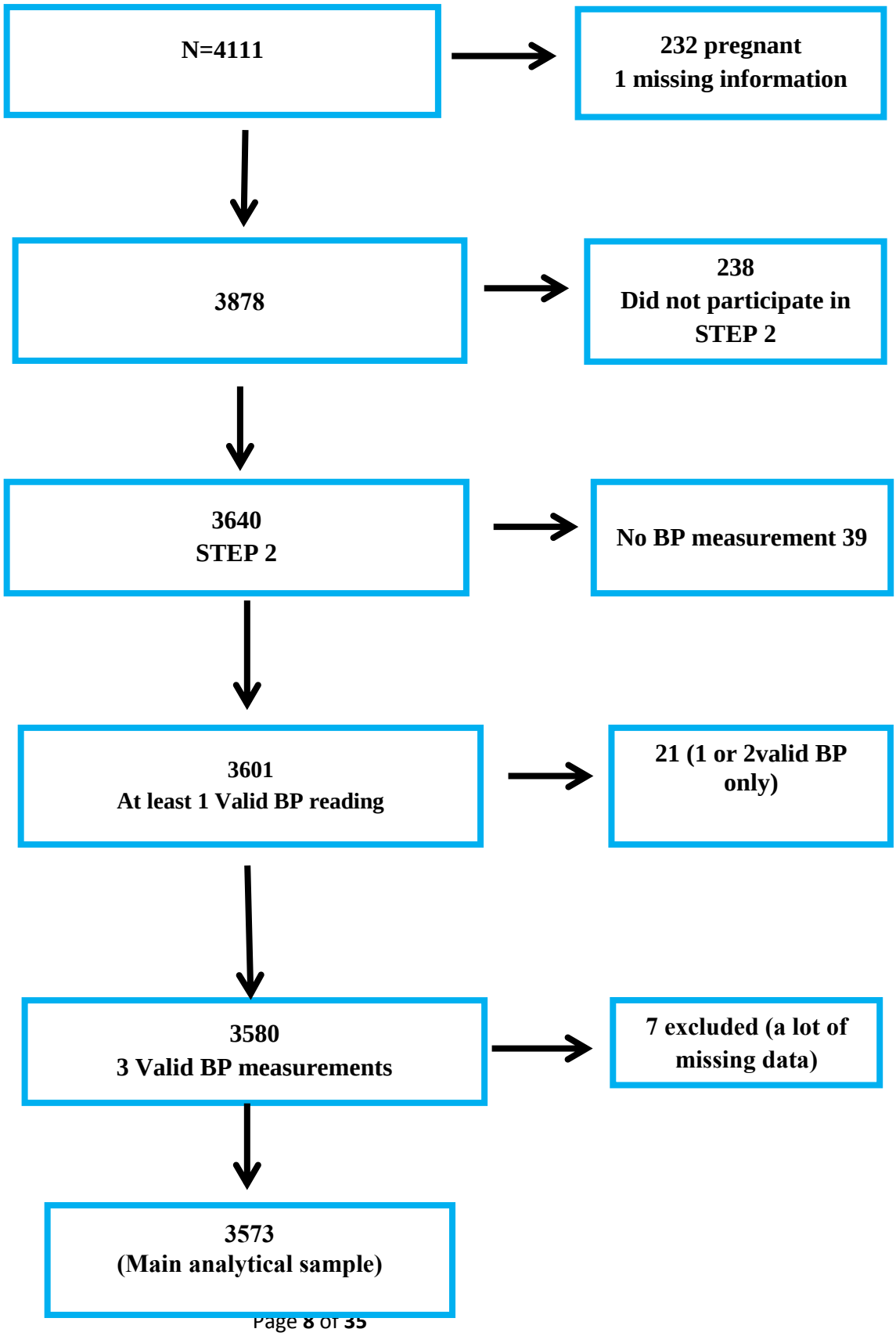

Table 1: Characteristics of study participants by selected demographic, behavioural and biological risk factors (unweighted & unadjusted for complex survey design)

Variable	Categories	Men 1633		Women 1940		Total 3573	
		N	%	N	%	N	%
Age Group	25 -34	537	32.9	1030	53.1	1567	43.9
	35-44	481	29.2	485	25.0	966	27.0
	45-54	346	21.2	278	14.33	624	17.5
	55-64	269	16.5	147	7.6	416	11.6
		P<0.001					
	Mean age	41.0±11.2		36.1±10.1		38.3±10.9	
Ethnicity	Mandinka	692	42.5	811	41.8	1503	42.1
	Wollof	251	15.4	293	15.1	544	15.2
	Fula	344	21.1	377	19.4	721	20.2
	Jola	186	11.4	257	13.3	443	12.4
	Other	157	9.6	201	10.4	358	10.0
		P=0.374					
Years spent in school	≤6 Years	938	62.3	1320	76.2	2258	69.7
	7-12 Years	376	25.0	353	20.4	729	22.5
	>12 Years	191	12.7	60	3.5	251	7.8
		P<0.001					
Residence (Local government area) [a]	Banjul	84	5.1	95	4.9	179	5.0
	KMC	367	22.5	454	23.4	821	23.0
	WCR	503	30.8	564	29.1	1067	30.0
	LRR	138	8.5	157	8.1	295	8.3
	NBR	254	15.6	356	18.4	610	17.1
	CRRN	36	2.2	49	2.5	85	2.4
	CRRS	83	5.1	108	5.6	191	5.4

Variable	Categories	Men 1633		Women 1940		Total 3573	
	URR	168	10.3	157	8.1	325	9.1
		P=0.139					
Residence (Rurality)	Urban	826	50.6	947	48.8	1773	49.6
	Semi urban	169	10.4	185	9.5	354	9.9
	Rural	638	39.1	808	41.7	1446	40.5
		P=0.271					
Physical activity	<600METS/week	188	12.0	310	16.7	498	14.6
	≥600METS/week	1377	88.0	1546	83.3	2923	85.4
		P<0.001					
Smoking	Never smokers	922	56.5	1906	98.3	2828	79.2
	Current smokers	535	32.8	22	1.1	557	15.6
	Ex-smokers	176	10.8	11	0.6	187	5.2
		P<0.001					
Ever consumed alcohol	Yes	61	3.7	22	1.1	83	2.3
	No	1572	96.3	1917	98.9	3489	97.7
		P<0.001					
Servings of fruits and vegetables	< 5/day	1120	77.9	1336	77.6	2456	77.8
	≥5 /day	318	22.1	385	22.4	703	22.2
		P= 0.863					
BMI[b]	Underweight	162	10.1	160	8.4	322	9.2
	Normal	911	56.9	937	49.3	1848	52.8
	Overweight	403	25.2	517	27.2	920	26.3
	Obese	124	7.8	286	15.1	410	11.7
		P<0. 001					
	Mean BMI	23.5±4.5		24.9±7.1		24.3±6.1	

Variable	Categories	Men 1633		Women 1940		Total 3573	
Mean height (in cm)		167.2±11.7		160.3±9.8		163.5±11.2	
Mean weight (in kg)		65.2±11.4		63.6±17.0		64.3±14.7	
High Waist circumference [c]	Normal	1402	87.8	993	53.2	2395	69.1
	High	195	12.2	874	46.8	1069	30.9
		P<0.001					
Mean waist circumference ±SD		72.9±15.4		76.2±17.7		74.7±16.8	

[a] KM=Kanifing Municipality; WCR =West Coast Region; LRR= Lower River Region; NBR =North Bank Region; CRRN = Central River Region North, CRRS=Central River Region South; URR =Upper River Region
[b]Based on WHO standards
[c]Based on the definition of the International Diabetes Federation (≥90 cm men or ≥80 cm women)
NB: The p value indicates the difference between men and women

Prevalence of hypertension

The weighted mean systolic and diastolic BP were 130.3mmHg (95% CI: 129.2-131.5) and 80.2mmHg (95% CI: 79.5-81.0) respectively (Table S1). More than one-quarter (27%, 95% CI: 24.1-29.2) of participants had raised BP. When including self-reported hypertension, prevalence of total hypertension was 29% (95% CI:26.6-31.8). Table 2 shows the prevalence of total and undiagnosed hypertension by gender. Hypertension was lower in Banjul and Kanifing, which are purely urban, and was higher in the more rural LGAs. This was also the case when rurality was used to denote residence. Prevalence was very high among the obese, those with a lower level of education, and ex-smokers. More than three-quarters (79%, 95% CI:74.5-82.2) of the participants classed as hypertensive were undiagnosed; this was higher among men (86%, 95% CI:81.7-89.4 vs 71%, 95% CI: 65.2-76.9; p<0.001). Undiagnosed hypertension was also higher among the younger age cohort and lower among the obese in both sexes (Table 2).

Half (49%) of participants with reported hypertension (n=314) were on treatment (data not shown). However, there was a major difference by LGA: the proportion was lower in rural regions. Only 24% of those on treatment had their BP controlled, with no gender difference (26% men vs 23% women, p=0.787). Overall, only 14% of all hypertensives (according to the definition of total hypertension) were on treatment and only 4% had their BP controlled.

Table 2: Prevalence of hypertension and proportion undiagnosed by selected socio-demographic and health factors [a, b]

Variable	Categories	Prevalence of Total hypertension						Proportion of total of hypertension that is undiagnosed					
		Men n=1633			Women n=1940			Men n=491			Women n=509		
		N	Hypertensive % (95% CI)	χ^2 P value	N	Hypertensive % (95% CI)	χ^2 P value	N	Undiagnosed % (95% CI)	χ^2 P value	N	Undiagnosed % (95% CI)	χ^2 P value
Total		1633	27.7(24.5-31.2)		1940	30.5(27.4-33.8)		491	86.0(81.7-89.4)		509	71.4(65.2-76.9)	
Age Group	25 -34	537	17.5(13.9-21.8)	<0.001	1030	16.9(44.9-61.7)	<0.001	101	95.3(88.4-98.2)	<0.001	150	88.2(80.4-93.2)	<0.001
	35-44	481	26.3(21.3-32.1)		485	33.6(13.4-21.1)		109	93.7(86.9-97.1)		153	73.0(62.4-81.6)	
	45-54	346	43.0(35.8-50.4)		278	45.4(29.3-38.1)		135	85.7(76.5-91.7)		115	65.9(55.7-74.9)	
	55-64	269	53.4(44.9-61.7)		147	60.4(38.6-52.4)		146	61.3(51.0-70.8)		91	54.7(42.1-66.6)	
Ethnicity	Mandinka	692	25.8(21.4-30.9)	0.182	811	34.2(30.0-38.7)	0.154	200	84.4(78.3-89.0)	0.240	233	73.1(64.6-80.2	0.464
	Wollof	251	32.7(25.7-40.6)		293	29.0(22.6-36.3)		86	82.1(67.8-90.9)		71	62.7(45.9-76.9)	
	Fula	344	26.4(21.2-32.3)		377	29.4(24.1-35.4)		101	85.3(76.7-91.1)		95	67.5(56.9-76.5)	
	Jola	186	25.1(18.1-33.6)		257	24.9(19.6-31.1)		46	95.2(87.6-98.2)		57	79.5(61.8-90.3)	
	Others	157	34.2(26.7-42.6)		201	29.3(21.4-38.6)		57	85.9(78.9-96.0)		53	74.0(54.7-87.1)	
Residence (Local government	Banjul & KM	451	21.7(15.6-29.5)	0.019	549	22.0(17.3-27.6)	<0.001	97	87.6(76.5-93.8)	0.759	106	75.0(62.1-84.6)	0.514
	WCR	503	28.5(23.7-33.9)		564	33.7(29.0-38.7)		151	88.0(82.5-92.0)		146	71.0(57.7-81.4)	

Variable	Categories	Prevalence of Total hypertension						Proportion of total of hypertension that is undiagnosed					
		Men n=1633			Women n=1940			Men n=491			Women n=509		
		N	Hypertensive % (95% CI)	χ^2 P value	N	Hypertensive % (95% CI)	χ^2 P value	N	Undiagnosed % (95% CI)	χ^2 P value	N	Undiagnosed % (95% CI)	χ^2 P value
area) [c]	LRR	138	36.6(30.0-43.8)		157	43.5(32.5-55.1)		57	80.4(71.0-87.2)		60	62.4(46.6-75.9)	
	NBR	254	34.8(28.5-41.6)		356	38.8(35.4-42.3)		99	81.0(73.7-86.7)		121	74.0(64.4-81.7)	
	CRR	119	36.3(28.7-44.7)		157	36.5(28.8-45.0)		44	85.0(58.0-95.9)		46	76.2(62.3-86.2)	
	URR	168	23.5(15.0-44.7)		157	25.3(18.7-33.4)		43	86.8(65.1-95.9)		30	57.8(35.8-77.1)	
Residence (Rurality)	Urban	826	23.9(19.6-28.8)	0.004	947	26.1(22.2-30.4)	0.002	204	88.0(81.8-92.3)	0.542	205	69.1(59.4-77.3)	0.191
	Semi urban	169	29.5(22.1-38.2)		185	42.1(29.7-55.5)		51	81.9(64.1-92.0)		59	62.2(54.2-69.6)	
	Rural	638	33.9(29.6-38.6)		808	35.4(31.7-39.3)		236	84.5(77.5-89.6)		245	76.0(66.0-83.8)	
Years spent in school	≤6 Years	938	31.3(27.7-35.0)	0.026	1320	35.5(32.2-39.0)	0.002	319	81.3(75.5-86.0)	0.024	391	70.1(63.2-76.2)	0.522
	7-12 Years	376	24.7(19.4-31.0)		353	20.9(15.1-28.2)		99	94.7(87.5-97.8)		56	62.5(45.6-76.7)	
	>12 Years	191	20.5(13.7-29.6)		60	16.7(8.6-29.9)		42	81.2(59.6-92.7)		11	68.0(36.9-88.5)	
Smoking	Never smokers	922	25.1(21.3-29.3)	0.001				264	88.3(83.1-92.0)	0.004			
	Current smokers	535	26.7(22.2-31.6)					152	89.7(82.7-94.1)				

Variable	Categories	Prevalence of Total hypertension						Proportion of total of hypertension that is undiagnosed					
		Men n=1633			Women n=1940			Men n=491			Women n=509		
		N	Hypertensive % (95% CI)	χ^2 P value	N	Hypertensive % (95% CI)	χ^2 P value	N	Undiagnosed % (95% CI)	χ^2 P value	N	Undiagnosed % (95% CI)	χ^2 P value
	Ex-smokers	176	46.5(34.7-58.6)					75	71.0(55.0-83.1)				
Servings of fruits and vegs	< 5/day	1120	26.6(22.7-30.8)	0.375	1336	31.6(27.8-35.6)	0.529	339	85.4(80.1-89.4)	0.358	358	70.6(63.4-76.8)	0.091
	≥ 5/day	318	29.8(23.8-36.6)		385	29.1(23.2-35.8)		96	89.9(80.8-95.0)		98	80.3(69.8-87.8)	
BMI[d]	Under-weight	162	25.3(18.3-33.9)	0.831	160	22.5(16.5-29.9)	<0.001	45	86.9(73.7-94)	<0.001	30	76.9(49.3-91.9)	0.023
	Normal	911	27.4(23.9-31.2)		937	26.3(22.3-30.7)		273	91.1(87.4-93.8)		213	79.3(71.9-85.1)	
	Over-weight	403	29.8(22.6-38.1)		517	32.8(27.2-38.8)		132	80.6(72.0-87.1)		157	69.1(59.9-77.0)	
	Obese	124	27.3(18.2-38.8)		286	43.5(35.1-52.3)		34	65.8(46-81.2)		99	59.1(45.3-71.5)	
High Waist circumference	Normal	1402	25.3(21.9-29.0)	<0.001	993	23.7(20.2-27.5)	<0.001	388	87.8(83.3-91.2)	0.144	200	76.0(66.3-83.6)	0.208
	High	195	43.8(36.0-52.0)		874	38.5(32.1-43.0)		91	80(67.5-88.5)		285	66.6(58.0-74.3)	

[a] Total hypertension defined as measured SBP≥140mmHg and/or DBP ≥90 mmHg and/or self-reported hypertension; Undiagnosed hypertension defined as proportion of hypertensive not aware of their condition prior to the survey

[b] Results adjusted for complex survey design and weighted for non-response

[c] KM=Kanifing Municipality; WCR =West Coast Region; LRR= Lower River Region; NBR =North Bank Region; CRR = Central River Region; URR =Upper River Region
N= unweighted sample/observations

[d]Based on WHO standards

[e]Based on the definition of the International Diabetes Federation (≥90 cm men or ≥80 cm women)

Factors associated with hypertension

Age, residence, generalised and abdominal obesity, smoking (men only), physical inactivity (women only) and ethnicity (women only) were strongly associated with total hypertension after mutually adjusting for these and other covariates (Table 3). As expected, the odds of hypertension increased with age. Compared with those from urban LGAs, participants from one of the most rural LGAs (Lower River Region) had higher odds of hypertension among both men (AOR 3.2, 95% CI: 1.6-6.4) and women (AOR 2.5, 95% CI: 1.3-4.6). Similarly, in models where rurality was used instead of LGA, participants from semi-urban and rural areas had higher odds of hypertension than urban residents (Table 3). Similar findings were found for the definition of hypertension based only on measured raised BP (Table S2).

Among all those with hypertension, men (AOR 2.6, 95% CI: 1.6-4.3) and younger participants (AOR 8.0, 95% CI: 3.6-18.0) had higher adjusted odds of undiagnosed hypertension compared with women and older adults respectively. Undiagnosed hypertension was also more common among the Jola participants, especially men, compared with other ethnic groups. However, it was less common among the obese (AOR 0.2, 95% CI: 0.1-0.4) and ex-smokers (AOR 0.4, 95% CI: 0.2-0.9) compared with those with normal weight and non-smokers respectively. Similar findings were found after stratifying the analysis by gender (Table 4). We also conducted multinomial regression analysis on hypertension with three categories (normotensive, diagnosed and undiagnosed); the findings were similar (data not shown).

Table 3: Multivariate logistic regression on factors associated with total hypertension (SBP≥140mmHg and/or DBP ≥90 mmHg and/or self-reported hypertension)

Variable	Categories	Men			Women		
		Model I[x]	Model II [y]	Model III [z]	Model I[x]	Model II [y]	Model III [z]
		[a]OR(95% CI)	AOR(95% CI)	AOR(95% CI)	[a]OR(95% CI)	AOR(95% CI)	AOR(95% CI)
Age group	25 -34	Reference	Reference	Reference	Reference	Reference	Reference
	35-44	1.68(1.22-2.33)**	1.75(1.15-2.67)**	1.54(1.02-2.34)*	2.48(1.78-3.45)***	2.23(1.53-3.28)***	2.16(1.47-3.16)***
	45-54	3.55(2.40-5.25)***	4.25(2.68-6.78)***	3.66(2.32-5.76)***	4.08(2.78-5.99)***	3.09(1.97-4.84)***	3.09(1.99-4.82)***
	55-64	5.39(3.34-8.70)***	6.75(3.78-12.03)***	6.11(3.48-10.73)***	7.49(4.26-13.20)***	8.38(4.88-14.39)***	8.13(4.62-14.33)**
Ethnicity	Mandinka	Reference	Reference	Reference	Reference	Reference	Reference
	Wollof	1.27(0.87-1.85)	1.22(0.77-1.95)	1.10(0.72-1.68)	0.71(0.50-1.02)	0.84(0.57-1.26)	0.79 (0.55-1.14)
	Fula	1.00(0.69-1.45)	1.03(0.64-1.66)	0.96(0.61-1.52)	0.94(0.68-1.30)	0.79(0.51-1.22)	0.73(0.48-1.14)
	Jola	0.90(0.56-1.44)	0.85(0.53-1.39)	0.86(0.55-1.34)	0.62(0.43-0.90)**	0.57(0.38-0.86)**	0.59(0.38-0.91)**
	Others	1.36(0.93-1.97)	1.46(0.90-2.37)	1.36(0.85-2.19)	0.73(0.47-1.13)	0.86(0.48-1.55)	0.75(0.42-1.33)
Years in school	>12 Years	Reference	Reference	Reference	Reference	Reference	Reference
	7-12 Years	1.94(1.11-3.38)*	1.72 (0.99-3.02)	1.66(0.96-2.88)	1.37(0.59-3.16)	1.32(0.53-3.27)	1.16(0.49-2.76)
	≤6 Years	1.69(0.99-2.89)	1.15 (0.66-2.00)	1.29(0.76-2.20)	1.95(0.92-4.11)	1.76(0.74-4.20)	1.57(0.67-3.67)
Residence (LGA)	Banjul and KM	Reference	Reference		Reference	Reference	
	WCR	1.77(1.09-2.87)*	2.58(1.38-4.82)**		1.79(1.19-2.70)**	2.36(1.49-3.75)***	
	LRR	2.11(1.31-3.42)**	3.17(1.56-6.44)**		2.27(1.32-3.89)**	2.46(1.33-4.55)**	
	NBR	1.88(1.14-3.10)**	2.74(1.33-5.67)**		2.00(1.38-2.90)***	2.19(1.41-3.41)***	

	CRR	2.31(1.33-4.03)**	2.74(1.46-5.13)**		2.00(1.34-2.98)***	2.61(1.66-4.11)***	
	URR	1.32(0.64-2.72)	1.45(0.55-3.85)		1.25(0.74-2.11)	1.00(0.50-2.04)	
Residence (rurality)	Urban	Reference		Reference	Reference		Reference
	Semi urban	1.37(0.86-2.18)		1.75(1.04-2.95)*	1.77(1.09-2.89)*		1.76(1.08-2.87)*
	Rural	1.54(1.11-2.15)**		1.42(0.99-2.04)	1.45(1.08-1.94)**		1.61(1.12-2.31)**
Physical activity	≥600 METS pw	Reference	Reference	Reference	Reference	Reference	Reference
	<600 METS pw	0.77(0.50-1.19)	0.73(0.37-1.45)	0.67(0.35-1.30)	0.90(0.57-1.42)	1.82(1.21-2.73)**	1.68(1.13-2.87)**
Smoking	Non smoker	Reference	Reference	Reference	Reference	Reference	Reference
	Current smoker	1.15(0.86-1.53)	1.12(0.82-1.53)	1.21(0.88-1.66)	^	-	-
	Ex-smoker	2.21(1.31-3.72)**	1.83(1.00-3.33)*	2.02(1.10-3.74)*	-		
Servings of fruit & vegs	≥5 day	Reference	Reference	Reference	Reference	Reference	Reference
	<5 /day	0.81(0.55-1.18)	0.75(0.48-1.17)	0.79(0.51-1.24)	1.10(0.73-1.66)	1.05(0.72-1.53)	1.05(0.73-1.50)
BMI	Normal	Reference	Reference	Reference	Reference	Reference	Reference
	Underweight	0.95(0.58-1.55)	0.99 (0.57-1.69)	1.08(0.63-1.86)	0.72(0.44-1.18)	0.52(0.30-0.94)*	0.56(0.31-1.01)
	Overweight	1.09(0.75-1.58)	1.60 (1.10-2.32)*	1.17(0.79-1.73)	1.23(0.89-1.72)	1.44(0.97-2.13)	1.26(0.85-1.85)
	Obese	0.88(0.50-1.53)	1.11(0.52-2.35)	0.79(0.37-1.70)	1.78(1.15-2.76)**	2.54(1.71-3.78)***	2.22(1.50-3.29)***
High Waist circumference	Normal	Reference	Reference	Reference	Reference	Reference	Reference
	High	1.89(1.27-2.81)**	1.61(1.01-2.54)*	2.00(1.27-3.09)**	1.56(1.16-2.11)**	1.19(0.83-1.70)	1.47(1.02-2.12)*

Model I[x] adjusted for age only, Model II [y] adjusted for all variables except rurality, Model III [z] adjusted for all variables except local government area
[a]OR= odds ratio adjusted for age(except for age group as the independent variable), AOR= Adjusted odds ratio(fully adjusted)
*p<0.05, **p≤ 0.01, *** p≤ 0.001 ^-removed because of small numbers LGA = local government area METS =Metabolic equivalents

Table 4: Multivariate logistic regression on factors associated with undiagnosed hypertension among participants with hypertension (Total)

Variable	Categories	Men			Women		
		Model I[x]	Model II [y]	Model III [z]	Model I[x]	Model II [y]	Model III [z]
		[a]OR(95% CI)	AOR(95% CI)	AOR(95% CI)	[a]OR(95% CI)	AOR(95% CI)	AOR(95% CI)
Age group	25 -34	12.75(4.37-37.2)***	16.01(5.56-46.07)**	15.38(4.51-52.38)***	6.23(2.59-14.99)***	4.97(1.77-13.95)**	5.50(1.83-16.52)***
	35-44	9.44(4.41-20.19)***	9.75(3.75-25.38)***	9.09(3.57-23.16)***	2.25(1.19-4.26)*	2.10(0.95-4.62)	2.22(0.96-5.12)
	45-54	3.78(1.74-8.22)***	6.71(3.00-15.00)***	6.71(3.00-15.00)***	1.61(0.89-2.89)	1.43(0.77-2.63)	1.52(0.79-2.92)
	55-64	Reference	Reference	Reference	Reference	Reference	Reference
Ethnicity	Mandinka	Reference	Reference	Reference	Reference	Reference	Reference
	Wollof	0.89(0.35-2.24)	2.09(0.74-5.89)	2.74(1.09-6.92)*	0.65(0.28-1.54)	0.64(0.27-1.54)	0.95(0.41-2.19)
	Fula	1.24(0.59-2.59)	0.97(0.34-2.75)	1.07(0.46-2.48)	0.63(0.35-1.12)	0.62(0.26-1.46)	0.77(0.36-1.64)
	Jola	4.08(1.30-12.76)*	6.85(1.49-31.47)	5.44(1.30-22.71)*	1.39(0.56-3.44)	1.15(0.45-2.94)	1.16(0.49-2.74)
	Others	2.04(0.65-6.43)	3.54(0.78-16.14)	3.63(0.77-17.23)	1.13(0.41-3.09)	1.77(0.56-5.55)	2.12(0.75-6.00)
Years in school	>12 Years	Reference	Reference	Reference	Reference	Reference	Reference
	7-12 Years	2.37(0.61-4.33)	1.45(0.32-6.62)	1.49(0.33-6.74)	0.70(0.17-2.81)	1.11(0.16-7.81)	1.17(0.20-6.80)
	≤6 Years	1.63(0.68-8.29)	1.12(0.37-3.40)	1.42(0.48-4.22)	1.43(0.50-4.11)	1.82(0.42-7.83)	1.56(0.39-6.29)
Residence (LGA)	Banjul &KM	Reference	Reference		Reference	Reference	
	WCR	0.94(0.36-2.42)	0.89(0.35-2.30)		0.81(0.36-1.86)	0.60(0.20-1.78)	
	LRR	0.93(0.32-2.68)	1.37(0.44-4.22)		0.69(0.29-1.67)	0.45(0.13-1.56)	

	NBR	0.92(0.35-2.38)	1.28(0.39-4.25)		1.13(0.53-2.41)	0.75(0.24-2.35)	
	CRR	1.13(0.21-5.99)	3.30(0.77-14.08)		1.18(0.49-2.82)	1.67(0.45-6.21)	
	URR	0.85(0.18-4.00)	0.77(0.05-11.89)		0.42(0.14-1.24)	4.45(0.58-33.89)	
Residence (rurality)	Urban	Reference		Reference	Reference		Reference
	Semi urban	0.75(0.24-2.32)		0.94(0.30-2.92)	0.89(0.49-1.60)		1.51(0.82-2.78)
	Rural	1.10(0.50-2.45)		1.01(0.47-2.19)	1.56(0.83-2.92)		1.69(0.84-3.42)
Physical activity	≥600 METS pw	Reference	Reference	Reference	Reference	Reference	Reference
	<600 METS pw	1.93(0.67-5.52)	1.50(0.35-6.48)	1.72(0.42-6.97)	0.83(0.39-1.77)	0.57(0.25-1.29)	0.77(0.35-1.69)
Smoking	Non smoker	Reference	Reference	Reference	Reference	Reference	Reference
	Current smoker	1.15(0.56-2.380	0.97(0.39-2.43)	1.05(0.44-2.55)	^	^	^
	Ex-smoker	0.38(0.18-0.88)*	0.51(0.18-1.37)	0.56(0.24-1.28)			
Servings of fruit and vegs	≥5 /day	Reference	Reference	Reference	Reference	Reference	Reference
	<5 /day	0.90(0.34-2.37)	0.95(0.32-2.85)	1.09(0.38-3.09)	0.61(0.32-1.19)	0.73(0.25-2.08)	0.71(0.28-1.75)
BMI[c]	Normal	Reference	Reference	Reference	Reference	Reference	Reference
	Underweight	0.57(0.23-1.48)	0.77(0.26-2.24)	0.75(0.25-2.20)	0.96(0.28-3.33)	1.95(0.51-7.58)	1.66(0.44-6.22)
	Overweight	0.35(0.18-0.65)***	0.41(0.14-1.20)	0.40(0.14-1.10)	0.59(0.34-1.04)	0.51(0.20-1.27)	0.53(0.23-1.22)
	Obese	0.16(0.06-0.46)***	0.11(0.02-0.53)**	0.10(0.03-0.38)***	0.40(0.20-0.80)**	0.29(0.12-0.69)**	0.35(0.14-0.87)*
High Waist	Normal	Reference	Reference	Reference	Reference	Reference	Reference

circumference [d]	High	0.55(0.24-1.28)	1.50(0.34-6.48)	1.29(0.37-4.51)	0.85(0.46-1.56)	1.26(0.62-2.61)	1.03(0.52-2.03)

Model I[x] adjusted for age only, Model II [y] adjusted for all variables except rurality, Model III [z] adjusted for all variables except local government area

[a]OR= odds ratio adjusted for age(except for age group as the independent variable), AOR= Adjusted odds ratio(fully adjusted)

*p<0.05, **p≤ 0.01, *** p≤ 0.001 ^Not included in the model because of small numbers LGA = local government area

METS =Metabolic equivalents

[b] Undiagnosed hypertension defined as proportion of hypertensive not aware of their condition prior to the survey

[c]Based on WHO standards [d]Based on the definition of the International Diabetes Federation (≥90 cm men or ≥80 cm women

Discussion

This study has confirmed that the prevalence of hypertension is very high in The Gambia, and has revealed a greater burden in rural areas. Of great concern is the high proportion (79%) of the hypertensive cases that are undiagnosed.

Rural residence was associated with hypertension after adjusting for other covariates. This association remained strong in all models regardless of whether LGA or rurality was used. This is contrary to what has been found in most other studies in SSA. Urban residence was consistently associated with hypertension in similar STEP surveys conducted in Benin,[27] Ethiopia,[28] Ghana,[29]Mozambique,[30] and Uganda.[31] However, there was no difference between urban and rural residence in a similar study in Uganda.[32] Undiagnosed hypertension did not vary by residence in The Gambia; the association with rural Gambia was for all hypertension, not an artefact of differential access to healthcare, diagnosis or treatment.

This unique finding of higher odds of hypertension in rural areas in The Gambia could be associated with various factors. The more rural LGAs are the poorest: poverty levels range from 63%-94%, compared with 8% in Banjul (the capital).[33] Rural residents also have lower education levels.[23] Even though people from higher wealth quintiles had higher risks of hypertension in previous studies, [34, 35] there is evidence on associations between low socio-economic status and CVDs including hypertension.[36, 37]

The lower risk of hypertension among rural dwellers observed in other countries in SSA may be related to occupational structure. Generally in SSA, rural dwellers are subsistence farmers, involved in laborious farming activities, while most jobs in urban areas are sedentary, leading to less opportunity for work-related physical activity.[38] However, in The Gambia, even though agriculture is the main economic activity in rural areas, it is becoming more mechanised. The farming season is also very short (May–October). Therefore, although

farmers may be active on their farmlands during the farming season, they may be sedentary for the greater part of the year. The data was collected from January to March, a time when farmers are more likely to be sedentary. On the other hand, many adults in urban areas work in the construction, fishing and manufacturing industries, which are labour intensive[39] but not seasonal. This is evident in the data, as 85% of participants met the WHO minimum recommendation on physical activity (≥600 METS/week), most of which is work- and transport-related. Another possible explanation could be diet, especially higher salt consumption. Peanuts are produced in The Gambia for export and local consumption. They can also be salted, roasted and used as snacks, which is very common in rural Gambia. High salt intake is a major risk factor for hypertension, especially among people of African descent.[8, 40-43]

Other important associations with hypertension found in this study are overweight and obesity, being an ex-smoker, physical inactivity, and ethnicity. The higher odds of hypertension among the overweight and obese are consistent with similar studies in SSA.[29, 32, 34, 44, 45] There is growing evidence on the increasing burden of obesity in SSA; The Gambia is no exception. This could be related to the perception of many SSA communities that being overweight is associated with good life and high status, especially among women.[46] Ex-smokers had higher odds of hypertension after adjusting for other covariates compared with never- and current-smokers. Smoking is a CVD risk factor and it is likely that many ex-smokers had been advised to quit because they were hypertensive. Unlike other tribes, the Jolas have retained most of their traditional beliefs and practices,[47] which could explain the lower odds of hypertension among the Jola women.

Undiagnosed hypertension, treatment and control

Almost four-fifths of hypertension in The Gambia is undiagnosed. This is consistent with findings from a national survey in Eritrea (80%),[48] lower than in Mozambique (85%)[30] and Malawi (95%),[49] and higher than in The Republic of Seychelles (36%).[50] Half (49%) of those in The Gambia with reported hypertension were on treatment, consistent with treatment levels in Mozambique[30] but much lower than in The Republic of Seychelles (93%).[50] Treatment, and the control of BP among those on treatment, were very low among rural residents in The Gambia.

The major associations with undiagnosed hypertension among those with hypertension were age, gender, obesity, being an ex-smoker and ethnicity. The odds of being undiagnosed were highest among younger hypertensives. Younger adults are less likely to visit a clinic and have their BP monitored. Men also had higher odds of undiagnosed hypertension. Women have more contact with health services because of reproductive and child healthcare services and hence are more likely to be diagnosed.[51] The odds of undiagnosed hypertension were extremely high among the Jolas, especially among men. Jolas are the most traditional ethnic group[47] and hence less likely to visit orthodox medical clinics. Undiagnosed hypertension was lower among the obese and ex-smokers. There is evidence suggesting that being overweight/obese acts as a visual trigger for healthcare workers to check BP and hence overweight/obese persons are more likely to be diagnosed.[52, 53]

Strengths and limitations of this study

This study provides the most recent nationally-representative data on hypertension and its associated risk factors in The Gambia. A complex sampling strategy and the use of the Kish method to select only the eligible participant per household reduces biases introduced by sampling strategies that favour the selection of any available participant per household. The data was collected by health workers at the residence of the participants in a very relaxed environment hence minimising the effect of "*white coat*" bias. There is evidence suggesting the burden of undiagnosed hypertension is high in SSA but data on the correlates of undiagnosed hypertension is very limited. The study outlines the major associations with undiagnosed hypertension, which can be applied in policy-making in The Gambia and other countries in SSA.

The main limitation of this study is that BP was measured on only one occasion and therefore the prevalence of hypertension may be overestimated. However, this potential bias was minimised by using the mean of the second and third measurements. Salt intake, which is one of the indicators of the Global Action Plan for the prevention and control of NCDs,[54] is a known risk factor for hypertension but was not part of the STEP instrument at the time of data collection. Some of the participants had missing BP measurements and hence were excluded (Table S3). The number excluded was very small but could have biased the estimates.

Conclusions

Contrary to what has been found in similar studies in SSA, where hypertension is highest in urban areas, we found rural residence was strongly associated with hypertension in this study. Interventions to reduce the burden of hypertension could be further targeted towards rural areas. Overweight/obesity is one of the factors strongly associated with hypertension. There

are socio-cultural norms that promote overweight in SSA. Sensitisation campaigns should promote awareness of the risk factors, especially on the importance of maintaining a healthy weight. Preventive efforts should not only focus on physical activity and diet but also on socio-cultural factors that facilitate the increasing prevalence of overweight and consequent hypertension. Governments and donor agencies should increase their attention on NCDs, including capacity-building of healthcare providers and all relevant stakeholders. Doctors and nurses should be encouraged to check the BP of patients as a routine. With new technology of portable, battery-operated BP machines, there should be periodic and systematic screening for the early detection of hypertension. This unexpected finding in rural areas generates new hypotheses on diet and socio-cultural practices that should be explored.

Funding

The survey was funded by the WHO and Bai Cham's PhD is funded by the Islamic Development Bank.

Acknowledgements.

We thank the WHO for their technical and financial support to conduct this survey and the Ministry of Health and Social Welfare of The Gambia for the authorisation to use the data. We also thank Mr Momodou Gassama (WHO Country Office, The Gambia) and Mrs Musu Kuta Komma (staff of the Gambia Bureau of Statistics at the time of survey, and currently Country Director, ChildFund International, The Gambia Office), for their role in planning and execution of the survey. The first author thanks the Islamic Development Bank (IDB) for funding his PhD research at UCL (University College London).

Conflict of interest

The authors have no conflict of interest to declare.

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Table S1: Descriptive sociodemographic, behavioural and biological risk factors of a nationally-representative sample (weighted & adjusted for complex survey design)

Variable	Categories	N	Men %(95% CI) 1633	Women %(95% CI) 1940	Total %(95% CI) 3573
Gender	Men	1633			50.5(47.9-53.1)
	Women	1940			49.5(46.9-52.1)
Age Group	25 -34	1567	46.8(42.9-50.7)	46.0(43.0-49.1)	46.4(44.0-48.9)
	35-44	966	26.3(23.9-28.8)	27.1(24.5-29.9)	26.7(24.9-28.6)
	45-54	624	17.1(15.0-19.5)	17.4(15.5-19.4)	17.2(15.8-18.9)
	55-64	416	9.8(8.2-11.8)	9.5(7.5-12.1)	09.7(08.2-11.4)
			P=0.953		
	Mean age		38.0(37.1-38.8)	37.4(36.8-38.1)	37.6(37.1-38.2)
Ethnicity	Mandinka	1503	42.8(37.3-48.3)	39.2(33.3-45.5)	41.0(35.9-46.3)
	Wollof	544	16.0(11.9-21.2)	16.4(12.7-20.9)	16.1(12.5-20.7)
	Fula	721	20.4(16.7-24.6)	18.1(14.8-22.0)	19.3(16.0-23.0)
	Jola	443	12.0(8.1-17.5)	15.0(11.0-20.0)	13.49.7-18.3)
	Others	358	8.7(6.5-11.5)	11.2(8.5-14.6)	10.1(7.8-12.6)
			P=0.082		
Years spent in school	≤6 Years	2258	54.6(50.2-59.0)	73.9(69.0-78.3)	63.9(59.7-67.8)
	7-12 Years	729	31.9(28.5-35.4)	22.7(18.9-26.9)	27.5(24.5-30.6)
	>12 Years	251	13.5(11.3-16.1)	3.4(2.3-5.0)	8.7(7.3-10.3)
			P<0.001		
Residence (Local government area) [a]	Banjul	179	7.6(2.4-21.5)	6.8(2.1-20.1)	7.2(02.4-20.2)
	KMC	821	24.0(15.7-34.8)	28.9(19.5-40.6)	26.4(17.7-37.4)
	WCR	1067	35.3(24.1-48.5)	30.6(20.3-43.3)	33.0(22.4-45.7)
	LRR	295	7.5(3.2-16.6)	7.8(3.3-17.3)	7.7(33.3-16.6)
	NBR	610	8.1(4.4-14.4)	10.2(5.6-18.0)	9.1(5.0-16.1)
	CRRN	85	2.5(6.7-8.8)	2.8(0.7-9.8)	2.6(0.7-09.3)

Variable	Categories	N	Men %(95% CI) 1633	Women %(95% CI) 1940	Total %(95% CI) 3573
	CRRS	191	6.1(2.5-14.3)	6.4(2.6-14.6)	6.3(2.6-14.2)
	URR	325	8.9(4.1-18.0)	6.4(2.8-14.2)	7.7(3.5-15.9)
			P=0.115		
Residence (Rurality)	Urban	1773	58.0(48.6-66.8)	57.0(48.2-65.4)	57.5(48.7-65.9)
	Semi urban	354	8.6(4.2-16.8)	6.7(3.0-14.1)	7.7(3.7-15.3)
	Rural	1446	33.4(27.2-40.2)	36.3(29.8-43.3)	34.8(28.8-41.4)
			P= 0.158		
Physical activity	<600METS/week	498	11.8(8.0-17.0)	20.8(14.3-29.2)	16.3(11.3-22.9)
	≥600METS/week	2923	88.2(83.0-92.0)	79.2(70.8-85.7)	83.8(77.1-88.8)
			P<0.001		
Ever consumed alcohol	Yes	83	4.1(2.8-5.9)	1.3(0.7-2.0)	2.7(2.0-3.7)
	No	3489	95.9(94.1-97.2)	98.7(98.0-99.2)	97.3(96.3-98.1)
			P<0.001		
Smoking	Never smokers	2828	57.5(52.4-62.4)	98.1(96.9-98.8)	77.6(74.1-80.7)
	Current smokers	557	32.6(28.6-36.9)	1.2(0.7-1.8)	17.0(14.6-19.8)
	Ex-smokers	187	9.9(7.12.6)	0.7(0.3-1.7)	5.4(4.1-7.0)
			P<0.001		
Servings of fruits and vegs/week	< 5/day	2456	76.1(69.2-81.5)	76.4(69.5-82.2)	76.2(69.7-81.8)
	≥5/day	703	23.9(18.2-30.8)	23.6(17.9-30.6)	23.8(18.2-30.4)
			P=0.879		
Mean height		3530	166.9(165.1-168.7)	160.6(159.6-161.6)	163.8(162.5-165.1)
Mean weight		3535	65.2(64.1-66.3)	64.8(63.6-66.1)	65.0(64.0-66.0)
Mean waist circumference ±SD		3427	72.1(69.2-75.0)	76.0(72.9-79.2)	74.0(71.2-76.9)

Variable	Categories	N	Men %(95% CI) 1633	Women %(95% CI) 1940	Total %(95% CI) 3573
BMI[b]	Underweight	322	9.8(7.6-12.4)	7.7(6.2-9.6)	8.7(7.2-10.5)
	Normal	1848	56.0(50.7-61.3)	46.6(42.8-50.5)	51.4(47.5-55.2)
	Overweight	920	26.1(21.1-31.7)	28.9(25.9-32.1)	27.5(24.0-31.2)
	Obese	410	8.1(6.0-10.0)	16.8(14.5-19.4)	12.4(10.4-14.8)
			P<0.001		
High Waist circumference[c]	Normal	2395	88.9(85.7-91.5)	52.8(46.0-59.4)	71.2(66.6-75.3)
	High	1069	11.1(8.6-14.3)	47.2(40.6-54.0)	28.9(24.7-33.4)
			P<0.001		
Mean SBP		3573	130.5(129.2-131.7)	130.1(128.5-131.8)	130.3(129.2-131.5)
Mean DBP		3573	79.9(79.0-80.8)	80.6(79.6-81.5)	80.2(79.5-81.0)

[a]KM=Kanifing Municipality; WCR =West Coast Region; LRR= Lower River Region; NBR =North Bank Region; CRRN = Central River Region North, CRRS=Central River Region South; URR =Upper River Region
N= unweighted sample/observations but the proportions and their corresponding 95% CI are weighted
[b]Based on WHO standards
[c]Based on the definition of the International Diabetes Federation (≥90 cm men or ≥80 cm women)
NB: The p value indicates the difference between men and women

Table S2: Multivariate logistic regression on factors associated with measured raised blood pressure (SBP≥140mmHg and/or DBP ≥90 mmHg)

Variable	Categories	Men			Women		
		Model I[x]	Model II [y]	Model III [z]	Model I[x]	Model II [y]	Model III [z]
		[a]OR(95% CI)	AOR (95% CI)	AOR (95% CI)	[a]OR(95% CI)	AOR(95% CI)	AOR (95% CI)
Age group	25 -34	Reference	Reference	Reference	Reference	Reference	Reference
	35-44	1.54(1.09-2.17) *	1.64(1.07-2.52) *	1.44(0.95-2.20)	2.49(1.75-3.56) ***	2.40(1. 59-3.62)***	2.31(1. 51-3.53)***
	45-54	3.41(2.26-5.13) ***	4.04(2.49-6.54) ***	3.47(2.15-5.58) ***	3.74(2.54-5.52) ***	2.73(1.74-4.28)***	2.74(1.75-4.29)***
	55-64	4.85(2.93-8.04) ***	6.18(3.44-11.11) ***	5.56(3.17-9.78) ***	7.55(4.25-13.41) ***	7.81(4.50-13.56)***	7.73(4.34-13.75)***
Ethnicity	Mandinka	Reference	Reference	Reference	Reference	Reference	Reference
	Wollof	1.33(0.88-2.02)	1.22(0.76-1.94)	1.10(0.72-1.69)	0.76(0.51-1.11)	0.88(0.59-1.33)	0.84(0.57-1.24)
	Fula	1.01(0.68-1.50)	1.04(0.65-1.66)	0.98(0.62-1.53)	1.11(0.78-1.57)	0.92(0.59-1.42)	0.84(0.54-1.28)
	Jola	0.92(0.57-1.48)	0.85(0.53-1.39)	0.84(0.54-1.30)	0.74(0.49-1.10)	0.77(0.50-1.20)	0.73(0.46-1.17)
	Others	1.34(0.89-2.00)	1.41(0.86-2.31)	1.32(0.80-2.15)	0.83(0.52-1.31)	1.10(0.61-1.20)	0.95(0.53-1.72)
Years in school	>12 Years	Reference	Reference	Reference	Reference	Reference	Reference
	7-12 Years	1.77(1.03-3.05)*	1.54(0.91-2.63)	1.49(0.89-2.51)	1.09(0.46-2.54)	1.04(0.42-2.60)	0.94(0.39-2.28)
	≤6 Years	1.52(0.89-2.58)	1.04(0.60-1.83)	1.16(0.68-2.00)	1.59(0.76-3.29)	1.43(0.61-3.35)	1.29(0.56-3.01)
Residence (LGA)	Banjul &KM	Reference	Reference		Reference	Reference	
	WCR	1.67(1.03-2.73)*	2.60(1.38-4.95)**		1.44(0.91-2.27)	1.97(1.21-3.21)**	
	LRR	2.12(1.33-3.36)**	3.49(1.70-7.19)***		2.33(1.29 -4.18)**	2.76(1.48-5.16)**	
	NBR	1.82(1.12-2.98)**	2.79(1.32-5.93)**		2.01(1.35-2.99)***	2.41(1.55-3.74)***	
	CRR	2.08(1.27-3.42)**	2.99(1.59-5.63)***		1.95(1.29-2.97)**	2.57(1.61-4.12)***	
	URR	1.22(0.61-2.45)	1.48(0.54-4.11)		1.04(0.54-2.04)	0.62(0.38-1.00)	
Residence	Urban	Reference		Reference	Reference		Reference

(rurality)	Semi urban	1.36(0.83-2.24)		1.78(1.04-3.07)*	1.91(1.14-3.20)**		2.00(1.22-3.27)**
	Rural	1.54(1.12-2.13)**		1.58(1.09-2.29)*	1.54(1.12-2.14)**		1.76(1.16-2.66)**
physical activity	≥600 METS/week	Reference	Reference	Reference	Reference	Reference	Reference
	<600 METS/week	0.82(0.54-1.26)	0.80(0.40-1.58)	0.73(0.37-1.42)	0.94(0.60-1.47)	1.73(1.14-2.63)**	1.62(1.06-2.46)*
Smoking	Non smoker	Reference	Reference	Reference	Reference	Reference	Reference
	Current smoker	1.06(0.76-1.46)	1.01(0.71-1.44)	1.09(0.76-1.54)	^		^
	Ex-smoker	1.88(1.10-3.21)*	1.73(0.96-3.15)	1.93(1.06-3.55)*		-	-
Servings of fruits and vegs	≥5 servings/day	Reference	Reference	Reference	Reference	Reference	Reference
	<5 Servings/day	0.85(0.59-1.24)	0.75(0.49-1.16)	0.80(0.52-1.25)	1.18(0.78-1.79)	1.18(0.79-1.75)	1.25(0.85-1.85)
BMI	Normal	Reference	Reference	Reference	Reference	Reference	Reference
	Underweight	0.99(0.60-1.62)	1.02(0.60-1.74)	1.12(0.65-1.92)	0.71(0.44-1.14)	0.55(0.30-0.99)*	0.57(0.32-1.03)
	Overweight	1.14(0.77-1.67)	1.65(1.09-2.48)*	1.22(0.80-1.86)	1.26(0.89-1.78)	1.43(0.93-2.20)	1.29(0.85-1.95)
	Obese	0.95(0.54-1.66)	1.16(0.52-2.63)	0.84(0.37-1.89)	1.58(1.07-2.35)*	2.10(1.44-3.06)***	1.93(1.32-2.84)***
High Waist circumference	Normal	Reference	Reference	Reference	Reference	Reference	Reference
	High	1.87(1.22-2.89)**	1.45(0.88-2.39)	1.79(1.11-2.89)*	1.43(1.07 -1.93)*	1.10(0.77-1.58)	1.34(0.95-1.90)

Model I[x] adjusted for age only, Model II [y] adjusted for all variables except rurality, Model III [z] adjusted for all variables except local government area

[a]OR= odds ratio adjusted for age (except for age group as the independent variable), AOR= Adjusted odds ratio(fully adjusted)

*p<0.05, **p≤0.01, *** p≤0.001 ^-removed because of small numbers LGA = local government area METS =Metabolic equivalents

Table S3 Missing data by gender, age, residence and education (unweighted)

Variable	Categories	Sample surveyed (n=3878)*	Sample excluded (n=305)**	Analytical sample (n=3573)	X^2 p value [a]
Gender	Men	1,771(45.7)	138(45.3)	1,633(45.7)	0.8780
	Women	2,107(54.3)	167(54.8)	1,940(54.3)	
Age Group	25 -34	1681(43.3)	114(37.4)	1,567(43.9)	**0.0300**
	35-44	1072(27.6)	106(34.8)	966(27.0)	
	45-54	675(17.4)	51(16.7)	624(17.5)	
	55-64	443(11.4)	27(8.9)	416(11.6)	
	Missing	7(0.2)	7(2.3)	-	
	Mean age ±SD	38.4±10.9	38.4±10.0	38.3±10.9	
Local government area [b]	Banjul	181(4.7)	2(0.7)	179(5.0)	<**0.0001**
	KM	984(25.4)	163(53.4)	821(23.0)	
	WCR	1109(28.6)	42(13.8)	1,067(29.9)	
	LRR	297(7.7)	2(0.7)	295(8.3)	
	NBR	615(15.9)	5(1.6)	610(17.1)	
	CRRN	92(2.4)	7(2.3)	85(2.4)	
	CRRS	203(5.2)	12(3.9)	191(5.4)	
	URR	397(10.2)	72(23.6)	325(9.1)	
Education (years excluding preschool)	≤6 Years	2399(61.9)	141(46.2)	2,258(63.2)	<**0.0001**
	7-12 Years	778(20.1)	49(16.1)	729(20.4)	
	>12 Years	260(6.7)	9(3.0)	251(7.02)	
	Don't know/Refused	441(11.4)	106(34.8)	335(9.4)	

*This does not include pregnant women

**Sample excluded because of missing blood pressure readings

[a] difference between excluded and analytical samples

[b]KM=Kanifing Municipality; WCR =West Coast Region; LRR= Lower River Region; NBR =North Bank Region; CRRN = Central River Region North, CRRS=Central River Region South; URR =Upper River Region