PLOS ONE

RESEARCH ARTICLE

Increasing prevalence of hypertension among HIV-positive and negative adults in Senegal, West Africa, 1994-2015

Noelle A. Benzekri[1]*, Moussa Seydi[2], Ibrahima N. Doye[3], Macoumba Toure[2], Marie Pierre Sy[2], Nancy B. Kiviat[4], Papa Salif Sow[2], Geoffrey S. Gottlieb[1,5], Stephen E. Hawes[5,6]

1 Department of Medicine, University of Washington, Seattle, WA, United States of America, **2** Services des Maladies Infectieuses et Tropicales, Centre Hospitalier Universitaire de Fann, Dakar, Senegal, **3** Conseil National de Lutte contre le Sida, Dakar, Senegal, **4** Department of Pathology, University of Washington, Seattle, WA, United States of America, **5** Department of Global Health, University of Washington, Seattle, WA, United States of America, **6** Department of Epidemiology, University of Washington, Seattle, WA, United States of America

* benzekri@uw.edu

OPEN ACCESS

Citation: Benzekri NA, Seydi M, N. Doye I, Toure M, Sy MP, Kiviat NB, et al. (2018) Increasing prevalence of hypertension among HIV-positive and negative adults in Senegal, West Africa, 1994-2015. PLoS ONE 13(12): e0208635. https://doi.org/10.1371/journal.pone.0208635

Editor: Olalekan Uthman, The University of Warwick, UNITED KINGDOM

Received: August 2, 2018

Accepted: November 20, 2018

Published: December 31, 2018

Data Availability Statement: All relevant data are within the manuscript and its Supporting Information files.

Funding: The parent studies were supported by the following grants from the National Institutes of Health: NIH/NCI R01 CA62801 (to NBK), NIH/NIDCR R01 DE12925 (to SEH), NIH/NIAID R01 AI48470 (to NBK), NIH/NCI R01 CA111187 (to NBK), NIH/NIAID R01 AI 60466 (to GSG). The funders had no role in study design, data collection

Abstract

Background

Non-communicable diseases, including hypertension (HTN), are increasingly recognized as important causes of morbidity and mortality among people living with HIV (PLHIV) in resource-limited settings. The goals of this study were to determine the prevalence of HTN among PLHIV in Senegal over time and to identify predictors of HTN among HIV-positive versus HIV-negative adults.

Methods

We conducted a retrospective study using data from individuals enrolled in previous studies in Senegal from 1994–2015. Blood pressure (BP) measurements taken during study visits were used for analysis. HTN was defined as systolic BP$\geq$140 or diastolic BP$\geq$90. We used logistic regression to identify predictors of HTN.

Results

We analyzed data from 2848 adults (1687 HIV-positive, 1161 HIV-negative). Among PLHIV, the prevalence of HTN increased from 11% during 1994–1999 to 22% during 2010–2015. Among HIV-negative individuals, the prevalence of HTN increased from 16% to 32%. Among both groups, the odds of HTN more than doubled from 1994–1999 to 2010–2015 (HIV-positive OR 2·4, 95% CI 1·1–5·0; HIV-negative OR 2·6, 95% CI 1·5–4·6). One quarter of all individuals with HTN had stage 2 HTN. The strongest risk factor for HTN was obesity (HIV-positive OR 3·2, 95% CI 1·7–5·8; p<0·01; HIV-negative OR 7·8, 95% CI 4·5–13·6; p<0·01). Male sex and age $\geq$50 were also predictive of HTN among both groups. Among HIV-positive subjects, WHO stage 1 or 2 disease was predictive of HTN and among HIV-negative subjects, having no formal education was predictive.

and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

Conclusion

Over the past 20 years, the prevalence of HTN has doubled among both HIV-positive and HIV-negative adults in Senegal. Our study indicates that there is an increasing need for the integration of chronic disease management into HIV programs in Senegal. Furthermore, our findings highlight the need for enhanced prevention, recognition, and management of non-communicable diseases, including hypertension and obesity, among both HIV-positive and HIV-negative individuals in Senegal.

Introduction

Global antiretroviral therapy (ART) coverage has reached 46%, resulting in a 26% decline in AIDS-related deaths globally since 2010 [1]. With the increasing availability of ART, people living with HIV (PLHIV) are living longer and are increasingly confronted by the burden of non-communicable diseases (NCD), including hypertension (HTN) [1–5]. Hypertension is a leading risk factor for mortality and disability worldwide [6–11]. Although data regarding the changes in the epidemiology of HTN in sub-Saharan Africa are limited relative to other regions of the world, recent studies have demonstrated that both mean blood pressure and the prevalence of hypertension are increasing in the region [12–16]. Recent estimates suggest that many countries in West Africa, including Senegal, are now among the highest ranked globally in terms of prevalence of HTN in the general population [12].

Although nearly 70% of the world's HIV-positive population lives in sub-Saharan Africa [1] and more than 80% of global premature deaths due to NCD occur in low and middle-income countries [6], the majority of studies evaluating the epidemiology of HTN among PLHIV have been conducted in high-income countries [17–21]. Data regarding the epidemiology of HTN among PLHIV in sub-Saharan Africa are limited, and there have been no studies evaluating changes in the prevalence of HTN among PLHIV in sub-Saharan Africa over time. Such studies are needed to guide national programs, develop effective interventions, and set priorities for resource allocation.

We used over 20 years of data to evaluate changes in the prevalence of HTN in Senegal, West Africa and to identify risk factors for HTN among HIV-positive versus HIV-negative individuals.

Methods

We conducted a retrospective study using data from individuals enrolled in observational studies in outpatient clinics in Senegal from 1994–2015 (see **S1 Supporting Information** for a description of parent studies) [22–26]. Participants in all parent studies provided written informed consent. Study procedures for all parent studies were approved by the University of Washington Institutional Review Board and the Senegal Comité National d'Ethique pour la Recherche en Santé. Data from each individual's initial encounter were included. Pre-hypertension was defined as systolic blood pressure (SBP) 120–139 or diastolic blood pressure (DBP) 80–89. Hypertension was defined as SBP $\geq$140 or DBP $\geq$90. Stage 2 hypertension was defined as SBP $\geq$160 or DBP $\geq$100. Nutritional status was determined by BMI (kg/m^2), whereby a BMI $<$18.5 was classified as underweight, a BMI of 18.5–24.9 was considered normal weight, overweight was defined as a BMI of 25.0–29.9, and a BMI $\geq$30.0 was classified as obese.

Data were analyzed using SPSS Statistics 23 (IBM, Armonk, N.Y.). Descriptive analysis was performed for all variables. Chi-square tests were used to identify differences in categorical variables between groups. The Mann-Whitney U test was used to identify differences in medians between groups. Logistic regression was used to identify predictors of hypertension among HIV-negative and HIV-positive individuals. Variables identified in the literature as predictive of hypertension were evaluated and included in the multiple regression model, in addition to variables that were identified as predictive using simple regression. For the categorical variable "year", the reference category was 1994–1999. For the categorical variable "age", the reference category was age 18–34. For the variable "BMI category", the reference was normal BMI. Missing data were excluded from analysis. P-values <0.05 were considered significant.

Results

A total of 2848 individuals were included in this analysis, of which 1687 were HIV-positive and 1161 were HIV-negative (**Table 1**). The majority of subjects (75.4%) were female. Age ranged from 18–84 years, with a median of 37 years among HIV-positive subjects and a median of 33 among HIV-negative subjects.

Among HIV-positive subjects, 15.8% were single, 30.6% were monogamous, 14.2% were polygamous, 27.5% were divorced, and 12.0% were widowed. Among HIV-negative subjects, 22.5% were single, 31.8% were monogamous, 22.6% were polygamous, 19.5% were divorced, and 3.7% were widowed. Nearly a quarter of female subjects had 6 or more children and the majority (61.0%) did not use contraception. Almost half of all subjects had no formal education. A quarter of HIV-positive subjects were smokers versus 18.8% of HIV-negative subjects, and approximately 14.6% of HIV-positive subjects used alcohol versus 8.5% of HIV-negative subjects. Approximately a quarter of female subjects were commercial sex workers. When excluding commercial sex workers, 23.6% of all subjects, 13.3% of HIV-positive subjects and 33.5% of HIV-negative subjects used contraception; 14.3% of HIV-positive subjects and 9.8% of HIV-negative subjects were smokers, and 6.3% of HIV-positive subjects and 2.9% of HIV-negative subjects used alcohol.

The median BMI among HIV-positive subjects was 19.5 versus 22.0 among HIV-negative subjects. Approximately 16.5% of HIV-positive subjects were overweight or obese versus 30% of HIV-negative subjects. Among HIV-positive subjects nearly 40% were underweight versus 17.4% of HIV-negative subjects.

Approximately 60% of all subjects had pre-hypertension. Among HIV-positive individuals, 11.9% had hypertension, of which 8.5% had systolic HTN and 9.0% had diastolic hypertension. Among HIV-negative individuals, 17.6% had hypertension, of which 13.3% had systolic HTN and 11.2% had diastolic hypertension. One quarter of both HIV-positive and HIV-negative individuals with HTN had stage 2 HTN. Among HIV-positive individuals, systolic blood pressure (SBP) ranged from 80–200 and diastolic blood pressure (DBP) ranged from 40–130, versus a SBP range of 90–220 and a DBP range of 40–120 among HIV-negative individuals.

Among HIV-positive subjects, 43.5% had WHO stage 3 or 4 disease, 40.0% had a CD4 count $<200/mm^3$, and 11.0% were on antiretroviral therapy (ART). The odds of receiving ART increased with time (OR 1.89 per year, 95% CI 1.71–2.10; $p<0.01$).

Among HIV-positive individuals, the overall prevalence of hypertension increased from 10.7% in 1994–1999, to 22.2% in 2010–2015 ($p<0.01$) (**Fig 1A**). Among HIV-negative individuals, the overall prevalence of hypertension increased from 15.6% in 1994–1999, to 32.2% in 2010–2015 ($p<0.01$). Among both HIV-positive and HIV-negative subjects the prevalence of hypertension increased with age (**Fig 1B**). Among HIV-positive individuals the prevalence of HTN was 8.9% for those age 18–34, 12.3% for those 35–49, and 20.3% for those $\geq$50 ($p<0.01$).

Table 1. Participant characteristics and comparison according to HIV status.

	Combined n (%)	HIV positive n (%)	HIV negative n (%)	p-value
N, number of individuals	2848	1687 (59.2)	1161 (40.8)	
Female	2141 (75.4)	**1172 (69.6)**	**969 (83.8)**	**<0.01**
Age, median years (range)	35 (18–84)	**37 (18–72)**	**33 (18–84)**	**<0.01**
Age categories				**<0.01**
18–34	1302 (46.2)	**677 (40.5)**	**625 (54.4)**	-
35–49	1201 (42.6)	**798 (47.7)**	**403 (35.1)**	-
50+	318 (11.3)	**197 (11.8)**	**121 (10.5)**	-
Marital status				**<0.01**
Single	518 (18.5)	**261 (15.8)**	**257 (22.5)**	-
Monogamous	869 (31.1)	**506 (30.6)**	**363 (31.8)**	-
Polygamous	492 (17.6)	**234 (14.2)**	**258 (22.6)**	-
Divorced	677 (24.2)	**454 (27.5)**	**223 (19.5)**	-
Widowed	240 (8.6)	**198 (12.0)**	**42 (3.7)**	-
Children*				**<0.01**
0–2	872 (41.3)	**491 (42.7)**	**381 (39.6)**	-
3–5	738 (34.9)	**428 (37.2)**	**310 (32.2)**	-
6+	503 (23.8)	**232 (20.2)**	**271 (28.2)**	-
Use contraception[*,$]	765 (39.0)	**313 (31.2)**	**452 (47.2)**	**<0.01**
Use OCP	185 (9.4)	**67 (6.7)**	**118 (12.3)**	**<0.01**
No education	1320 (47.5)	**873 (53.2)**	**447 (39.3)**	**<0.01**
Smoking[$]	626 (22.5)	**411 (25.0)**	**215 (18.8)**	**<0.01**
Alcohol use[$]	337 (12.1)	**240 (14.6)**	**97 (8.5)**	**<0.01**
Commercial sex worker	728 (25.6)	**460 (27.3)**	**268 (23.1)**	**0.01**
BMI, median (range)	20.5 (10.2–44.5)	**19.5 (10.2–42.9)**	**22.0 (11.4–44.5)**	**<0.01**
BMI category				**<0.01**
Underweight	739 (30.8)	**572 (39.7)**	**167 (17.4)**	-
Overweight	345 (14.4)	**161 (11.2)**	**184 (19.2)**	-
Obese	177 (7.4)	**77 (5.3)**	**100 (10.4)**	-
Pre-hypertension[a]	1681 (59.1)	**968 (57.4)**	**713 (61.7)**	**0.02**
Hypertension[b]	405 (14.2)	**201 (11.9)**	**204 (17.6)**	**<0.01**
Stage 2 hypertension[c]	100 (25.0)[d]	50 (24.9)[d]	50 (25.1)[d]	0.95
SBP, median (range)	120 (80–220)	**120 (80–200)**	**120 (90–220)**	**<0.01**
DBP, median (range)	80 (40–130)	80 (40–130)	80 (40–120)	0.06
HIV-associated factors				
WHO stage 3 or 4		684 (43.5)		
CD4, median (range)		281 (1–2000)		
CD4<200/mm^3		534 (40.0)		
On ART		161 (11.0)		

[a]Pre-hypertension: Systolic blood pressure (SBP) 120–139 or diastolic blood pressure (DBP) 80–89

[b]Hypertension: SBP ≥140 or DBP ≥90

[c]Stage 2 hypertension: SBP ≥160 or DBP ≥100. [d]Percent of hypertensive subjects with stage 2 hypertension.

*Data available for female subjects only.

[$]When excluding CSW: 320 (23.6%) of all subjects, 88 (13.3%) of HIV-positive subjects and 232 (33.5%) of HIV-negative subjects used contraception (p<0.01); 170 (14.3%) of HIV-positive subjects and 87 (9.8%) of HIV-negative subjects were smokers (p<0.01); 75 (6.3%) of HIV-positive subjects and 26 (2.9%) of HIV-negative subjects used alcohol (p<0.01).

https://doi.org/10.1371/journal.pone.0208635.t001

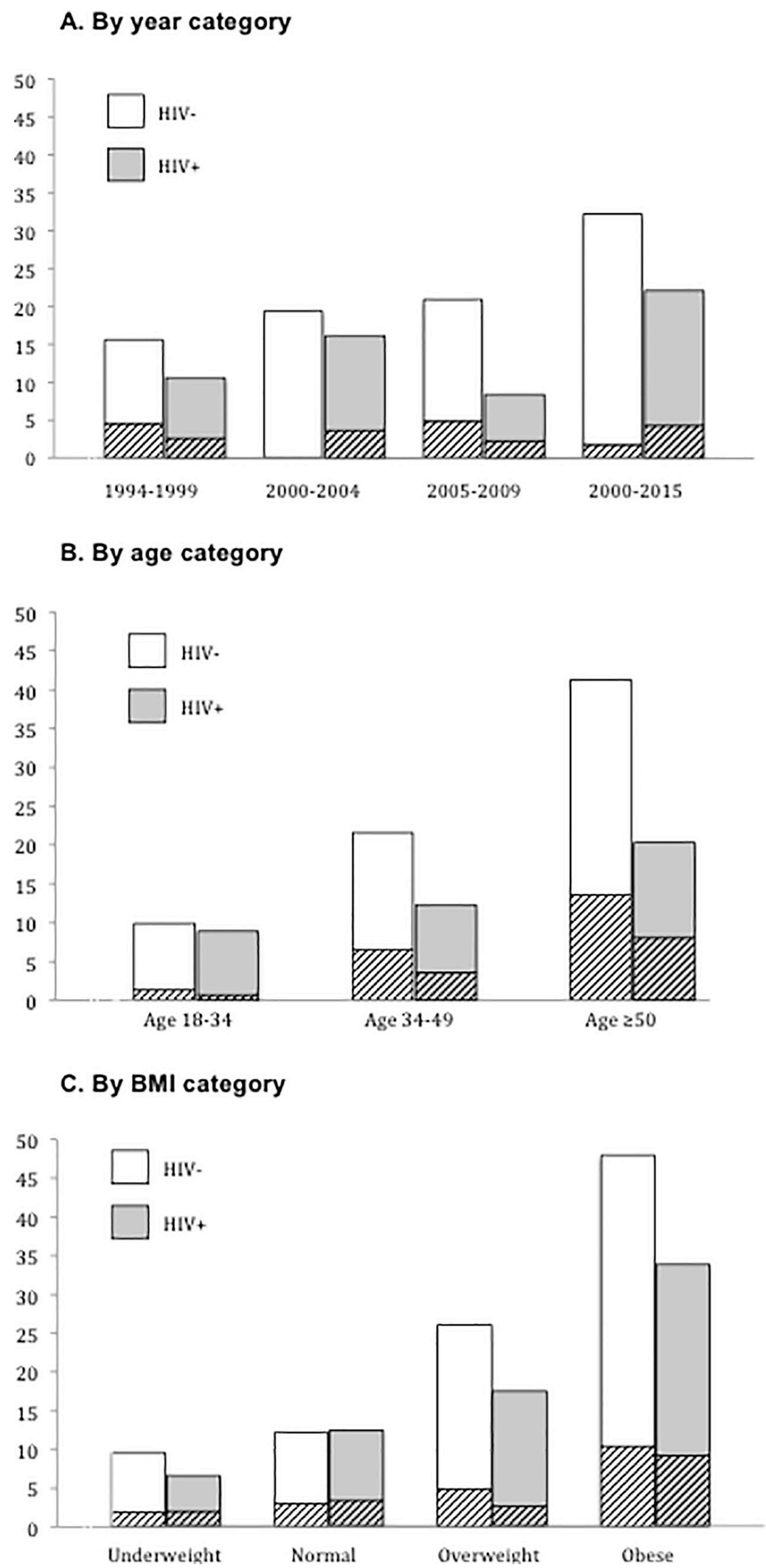
A. By year category
50
45
40
35
30
25
20
15
10
5
0
HIV-
HIV+
1994-1999
2000-2004
2005-2009
2000-2015
B. By age category
50
45
40
35
30
25
20
15
10
5
0
HIV-
HIV+
Age 18-34
Age 34-49
Age ≥50
C. By BMI category
50
45
40
35
30
25
20
15
10
5
0
HIV-
HIV+
Underweight
Normal
Overweight
Obese

Fig 1. Prevalence (%) of hypertension among HIV-positive and HIV-negative subjects. Fig 1A. X-axis: year category; **Fig 1B.** X-axis: age category; **Fig 1C.** X-axis: BMI category. For all figures, Y-axis = prevalence of HTN (SBP ≥140 or DBP ≥90) and striped portions indicate subset with stage 2 HTN (SBP ≥160 or DBP ≥100).

https://doi.org/10.1371/journal.pone.0208635.g001

For HIV-negative individuals, the prevalence of HTN was 9.9% among those age 18–34, 21.6% for those 35–49, and 41.3% for those ≥50 ($p<0.01$). The prevalence of hypertension increased with BMI for both HIV-positive and HIV-negative subjects (**Fig 1C**). Among HIV-positive individuals, the prevalence of HTN was 6.5% for underweight subjects, 12.4% for normal weight subjects, 17.4% for overweight subjects, and 33.8% among obese subjects ($p<0.01$). Among HIV-negative individuals, the prevalence of hypertension was 9.6% for underweight subjects, 12.2% for normal weight subjects, 26.1% among overweight subjects, and 48.0% among obese subjects ($p<0.01$).

HIV-negative individuals had greater odds of hypertension compared to HIV-positive individuals (OR 1.6, 95% CI 1.3–2.0; $p<0.01$) (**Table 2**). Among HIV-positive individuals, WHO stage 1 or 2 disease and CD4 cell count ≥200 were predictive of hypertension. ART status was not predictive of hypertension.

Among HIV-positive subjects, year, age, and BMI, were predictive of hypertension in simple regression analysis and the odds of HTN more than doubled from the time period of 1994–1999 to the time period of 2010–2015 (**Table 3**). Data on number of children was only available for female subjects. Women with 6 or more children had greater odds of hypertension. This relationship persisted when controlling for age.

In multiple regression analysis, among HIV-positive individuals, male sex (OR 2.19, 95% CI 1.37–3.51; $p<0.01$), age ≥50 (OR 2.26, 95% CI 1.30–3.93; $p<0.01$), obesity (OR 3.17, 95% CI 1.74–5.76; $p<0.01$), and WHO stage 1 or 2 (OR 1.99, 95% CI 1.24–3.18; $p<0.01$) were predictive of hypertension (**Table 4**). Among HIV-negative subjects, male sex (OR 2.21, 95% CI 1.30–3.76; $p<0.01$), age 35–49 (OR 1.88, 95% CI 1.22–2.90; $p<0.01$), age ≥50 (OR 4.89, 95% CI 2.61–9.16; $p<0.01$), overweight (OR 3.07, 95% CI 1.89–4.96; $p<0.01$), obesity (OR 7.81, 95% CI 4.49–13.56; $p<0.01$), and having no formal education (OR 1.61, 95% CI 1.10–2.34; $p = 0.01$), were predictive of hypertension.

Discussion

We found that over the past twenty years, the prevalence of hypertension has doubled among both HIV-positive and HIV-negative individuals in Senegal. Importantly, among those who were hypertensive, a quarter had stage 2 hypertension, suggesting inadequate disease recognition and management. Furthermore, the majority of both HIV-positive and HIV-negative participants had pre-hypertension. Our findings contribute to the growing body of literature

Table 2. Simple logistic regressions evaluating HIV-status, WHO stage, CD4 count, and ART as predictors of hypertension.

	Simple regressions			
	OR	95% CI		p-value
HIV status negative	**1.58**	1.28	1.95	**<0.01**
WHO stage 1 or 2*	**2.09**	1.50	2.91	**<0.01**
CD4 count ≥200*	**1.95**	1.36	2.78	**<0.01**
On ART*	0.72	0.41	1.28	0.265

*Among HIV-positive subjects only

https://doi.org/10.1371/journal.pone.0208635.t002

Table 3. Simple regressions evaluating predictors of hypertension among A. HIV-positive and B. HIV-negative participants.

	Simple regressions							
	A. HIV-positive				B. HIV-negative			
	OR	95% CI		p-value	OR	95% CI		p-value
Year category[a]								
2000–2004	**1.62**	1.15	2.27	<**0.01**	1.30	0.52	3.24	0.57
2005–2009	0.77	0.50	1.17	0.22	1.43	0.99	2.06	0.06
2010–2015	**2.38**	1.14	4.96	**0.02**	**2.58**	1.45	4.60	<**0.01**
Male	0.95	0.69	1.32	0.77	1.11	0.74	1.66	0.62
Age category[b]								
35–49	**1.44**	1.03	2.02	**0.04**	**2.50**	1.76	3.56	<**0.01**
50+	**2.62**	1.69	4.06	<**0.01**	**6.40**	4.09	10.00	<**0.01**
BMI category[c]								
Underweight	0.49	0.33	0.74	<0.01	0.76	0.43	1.36	0.36
Overweight	1.49	0.93	2.39	0.10	**2.53**	1.66	3.87	<**0.01**
Obese	**3.61**	2.13	6.13	<**0.01**	**6.63**	4.13	10.64	<**0.01**
Number of children[d,e]								
3–5	1.28	0.83	1.98	0.26	**2.18**	1.37	3.46	<**0.01**
6+	**2.65**	1.70	4.13	**2.65**	**4.42**	2.84	6.87	<**0.01**
No education	0.94	0.70	1.27	0.94	**1.77**	1.29	2.41	<**0.01**
Smoking	0.73	0.51	1.06	0.73	0.48	0.30	0.77	<0.01
Alcohol use	1.31	0.886	1.949	1.31	1.16	0.686	1.966	0.58

[a]Reference: 1994–1999.

[b]Reference: age 18–34.

[c]Reference: normal BMI.

[d]Reference: 0–2 children; data on number of children available only for female subjects.

[e]Women with 6 or more children had greater odds of hypertension when controlling for age: HIV-negative subjects: OR 1.77, 95% CI 1.03–3.06; p = 0.04; HIV-positive subjects: OR 2.18, 95% CI 1.33–3.55; p<0.01.

https://doi.org/10.1371/journal.pone.0208635.t003

Table 4. Multiple regressions evaluating predictors of hypertension among A. HIV- positive and B. HIV-negative participants.

	Multiple regressions*							
	A. HIV-positive (N = 1364)				B. HIV-negative (N = 935)			
	OR	95% CI		p-value	OR	95% CI		p-value
Male	**2.19**	1.37	3.51	<**0.01**	**2.21**	1.30	3.76	<**0.01**
Age category								
35–49	1.33	0.88	2.00	0.18	**1.88**	1.22	2.90	<**0.01**
50+	**2.26**	1.30	3.93	<**0.01**	**4.89**	2.61	9.16	<**0.01**
BMI category								
Underweight	0.57	0.36	0.90	**0.02**	0.58	0.31	1.11	0.10
Overweight	1.47	0.89	2.42	0.13	**3.07**	1.89	4.96	<**0.01**
Obese	**3.17**	1.74	5.76	<**0.01**	**7.81**	4.49	13.56	<**0.01**
No education	-	-	-	-	**1.61**	1.10	2.34	**0.01**
WHO stage 1 or 2 (reference WHO stage 3 or 4)	**1.99**	1.24	3.18	<**0.01**	-	-	-	-

*Controlling for year

https://doi.org/10.1371/journal.pone.0208635.t004

indicating that NCD represent an emerging public health challenge in sub-Saharan Africa [12–16].

Previous studies have demonstrated that the prevalence of hypertension in the general population is increasing in sub-Saharan Africa [12–15] and the region of West Africa is at especially high risk [11–14]. For more than half the countries in the West Africa, the prevalence of HTN is >30% [12]. This is consistent with our finding that by 2010–2015, the overall prevalence of HTN among HIV-negative subjects was 32%.

The prevalence of HTN among HIV-positive subjects in our study increased from approximately 11% in 1994–1999, to more than 22% in 2010–2015. Although data regarding the epidemiology of hypertension over time among PLHIV in sub-Saharan Africa are limited and represent heterogeneous populations [27–50], the majority of previous studies report a prevalence of HTN among PLHIV ranging from 20–35%. Similar to previous studies conducted in sub-Saharan Africa [27–52], we found that male sex, age, and BMI were risk factors for HTN among both HIV-negative and HIV-positive subjects. Obese individuals and those ≥50 years of age were at especially high risk. By 2010–2015, more than half of HIV-negative subjects ≥50 years of age and nearly half of HIV-positive subjects ≥50 years of age, had elevated blood pressure.

Obesity was the strongest risk factor for hypertension and was associated with a threefold to eightfold increase in the odds of hypertension compared to normal weight. With the rapidly increasing burden of overweight and obesity in sub-Saharan Africa [53, 54], including Senegal [55], urgent preventive measures, including enhanced dietary education and the promotion of physical activity, should be emphasized as critical components of patient care.

Approximately a quarter of all women in this study had six or more children and among both HIV-positive and HIV-negative women, having six or more children was predictive of hypertension. Importantly, less than half of the women in this study used any form of contraception and among HIV-positive women, less than a third used contraception. Ensuring universal access to family planning services is recognized as a global health priority and human right by the international community [56–59]. Our findings are consistent with previous studies which report an unmet need for modern family planning in Senegal and West Africa [60, 61]. Addressing this gap should be a top priority for health programs in the region.

An important and modifiable risk factor for poor health outcomes was the lack of any formal education for nearly half of all participants. HIV-negative subjects who had not received any education were nearly twice as likely to be hypertensive than those who had received any form of formal education, including solely primary school. This finding is consistent with previous studies which have shown that lack of education is a risk factor for hypertension [34, 35, 52, 62–64]. The links between education and improvements in health are well-established [7, 65] and the promotion of the universal availability of education must be a priority for all national health programs.

Numerous studies have evaluated the association between ART and hypertension, though the results have been inconsistent [18, 20, 66]. In our study, we did not find an association between ART and hypertension. This finding is limited by the fact that only 11% of HIV-positive subjects were receiving ART. The low level of coverage among subjects in our study is not representative of current ART coverage in Senegal, with recent country estimates ranging from 31–56% [67, 68]. Relative to other regions of the world, gains in ART coverage have been slower in countries of Western and Central Africa, where regional coverage has reached only 28% [1].

As countries in West Africa, including Senegal, continue to make progress towards universal ART coverage and resultant gains in life expectancy are achieved, HIV programs must be prepared to address the growing burden of NCD among PLHIV. Furthermore, individual governments and international partners must continue to strive towards universal access to education and modern family planning.

Our study had several limitations. This was a retrospective study and the data were pooled from multiple prior research studies at urban clinics near Dakar, which in some instances oversampled specific sub-groups such as women, commercial sex workers and ART-naive HIV-infected individuals. Thus, our results may not represent associations which would be observed in individuals from the general population of Senegal. Given that we used data from a single study encounter, we were unable to evaluate variation in blood pressure over time, which may have resulted in under- or over-estimation of hypertension. This study would have been strengthened by the availability of data regarding treatment for hypertension and the presence of other comorbidities including other cardiovascular diseases, hyperlipidemia, and diabetes. This is an important limitation and calls for prospectively designed studies to better identify and quantify risk factors for non-communicable diseases among PLHIV in Sub-Saharan Africa.

Conclusion

We utilized over 20 years of data to compare the epidemiology of hypertension among HIV-positive versus HIV-negative individuals in Senegal and provide the first evaluation of trends in hypertension over time among PLHIV in sub-Saharan Africa. We found that the burden of hypertension is increasing rapidly among both HIV-positive and HIV-negative individuals in Senegal. Obesity is a strong predictor of hypertension and is an important target for interventional strategies. Our findings demonstrate that NCD, including HTN, are increasingly important co-morbidities among PLHIV in sub-Saharan Africa and that the prevention, diagnosis, and management of NCD must be incorporated into HIV-programs.

Supporting information

S1 Supporting Information. Table A: Description of parent studies. Table B: Parent study aims and subjects.
(DOCX)

Acknowledgments

The authors would like to thank the study participants, without whom this study would not have been possible. Members of the University of Washington-Senegal Research Collaboration can be found at: http://www.uwsenegalresearch.com.

Author Contributions

Conceptualization: Noelle A. Benzekri, Geoffrey S. Gottlieb, Stephen E. Hawes.

Data curation: Noelle A. Benzekri, Stephen E. Hawes.

Formal analysis: Noelle A. Benzekri, Stephen E. Hawes.

Funding acquisition: Nancy B. Kiviat, Geoffrey S. Gottlieb, Stephen E. Hawes.

Investigation: Noelle A. Benzekri, Marie Pierre Sy, Nancy B. Kiviat.

Methodology: Noelle A. Benzekri, Nancy B. Kiviat, Papa Salif Sow, Geoffrey S. Gottlieb, Stephen E. Hawes.

Project administration: Noelle A. Benzekri, Moussa Seydi, Ibrahima N. Doye, Macoumba Toure, Nancy B. Kiviat, Papa Salif Sow, Geoffrey S. Gottlieb, Stephen E. Hawes.

Resources: Moussa Seydi, Ibrahima N. Doye, Papa Salif Sow, Geoffrey S. Gottlieb, Stephen E. Hawes.

Supervision: Moussa Seydi, Ibrahima N. Doye, Nancy B. Kiviat, Papa Salif Sow, Geoffrey S. Gottlieb, Stephen E. Hawes.

Writing – original draft: Noelle A. Benzekri, Geoffrey S. Gottlieb, Stephen E. Hawes.

Writing – review & editing: Noelle A. Benzekri, Geoffrey S. Gottlieb, Stephen E. Hawes.

References

1. UNAIDS. Global AIDS Update. 2016. Available at: www.unaids.org/sites/default/files/media_asset/global-AIDS-update-2016_en.pdf
2. United Nations Programme on HIV/AIDS (UNAIDS). October, 2014. "90-90-90 An ambitious treatment target to help end the AIDS epidemic". Available at: www.unaids.org/sites/default/files/media_asset/90-90-90_en_0.pdf.
3. UNAIDS. Chronic care for HIV and noncommunicable diseases. 2011. Available at: www.unaids.org/sites/default/files/. . ./20110526_JC2145_Chronic_care_of_HIV_0.pdf
4. The Antiretroviral Therapy Cohort Collaboration. Survival of HIV-positive patients starting antiretroviral therapy between 1996 and 2013: a collaborative analysis of cohort studies. Lancet HIV. 2017 May 10. https://doi.org/10.1016/S2352-3018(17)30066-8 PMID: 28501495.
5. Smith CJ, Ryom L, Weber R, Morlat P, Pradier C, Reiss P, et al. Trends in underlying causes of death in people with HIV from 1999 to 2011 (D:A:D): a multicohort collaboration. Lancet. 2014 Jul 19; 384 (9939):241–8. https://doi.org/10.1016/S0140-6736(14)60604-8 PMID: 25042234.
6. World Health Organization. Global Status Report on Noncommunicable Diseases. 2014. Available at: www.who.int/nmh/publications/ncd-status-report-2014/en/
7. The Global Burden of Disease Study. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016 Oct 8; 388(10053):1603–58. https://doi.org/10.1016/S0140-6736(16)31460-X PMID: 27733283.
8. The Global Burden of Disease Study. Mortality and Causes of Death Collaborators. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016 Oct 08; 388(10053):1459–544. https://doi.org/10.1016/S0140-6736(16)31012-1 PMID: 27733281. PMCID: PMC5388903.
9. The Global Burden of Disease Study. Risk Factors Collaboration. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016 Oct 08; 388(10053):1659–724. https://doi.org/10.1016/S0140-6736(16)31679-8 PMID: 27733284. PMCID: PMC5388856.
10. World Health Organization. Global Health Risks. Mortality and burden of disease attributable to selected major risks. 2009. Available at: www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf
11. Forouzanfar MH, Liu P, Roth GA, Ng M, Biryukov S, Marczak L, et al. Global Burden of Hypertension and Systolic Blood Pressure of at Least 110 to 115 mm Hg, 1990–2015. JAMA: the journal of the American Medical Association. 2017 Jan 10; 317(2):165–82. https://doi.org/10.1001/jama.2016.19043 PMID: 28097354.
12. Non-Communicable Disease Risk Factor Collaboration. Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19.1 million participants. Lancet. 2017 Jan 07; 389(10064):37–55. https://doi.org/10.1016/S0140-6736(16)31919-5 PMID: 27863813. PMCID: PMC5220163.
13. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, et al. Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-Based Studies From 90 Countries. Circulation. 2016 Aug 09; 134(6):441–50. https://doi.org/10.1161/CIRCULATIONAHA.115.018912 PMID: 27502908. PMCID: PMC4979614.
14. Danaei G, Finucane MM, Lin JK, Singh GM, Paciorek CJ, Cowan MJ, et al. National, regional, and global trends in systolic blood pressure since 1980: systematic analysis of health examination surveys

and epidemiological studies with 786 country-years and 5.4 million participants. Lancet. 2011 Feb 12; 377(9765):568–77. https://doi.org/10.1016/S0140-6736(10)62036-3 PMID: 21295844.

15. Twagirumukiza M, De Bacquer D, Kips JG, de Backer G, Stichele RV, Van Bortel LM. Current and projected prevalence of arterial hypertension in sub-Saharan Africa by sex, age and habitat: an estimate from population studies. J Hypertens. 2011 Jul; 29(7):1243–52. https://doi.org/10.1097/HJH.0b013e328346995d PMID: 21540748.
16. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet. 2005 Jan 15–21; 365(9455):217–23. https://doi.org/10.1016/S0140-6736(05)17741-1 PMID: 15652604.
17. Nguyen KA, Peer N, Mills EJ, Kengne AP. Burden, Determinants, and Pharmacological Management of Hypertension in HIV-Positive Patients and Populations: A Systematic Narrative Review. AIDS Rev. 2015 Apr-Jun; 17(2):83–95. PMID: 26035166.
18. Dillon DG, Gurdasani D, Riha J, Ekoru K, Asiki G, Mayanja BN, et al. Association of HIV and ART with cardiometabolic traits in sub-Saharan Africa: a systematic review and meta-analysis. Int J Epidemiol. 2013 Dec; 42(6):1754–71. https://doi.org/10.1093/ije/dyt198 PMID: 24415610. PMCID: PMC3887568.
19. Bloomfield GS, Khazanie P, Morris A, Rabadan-Diehl C, Benjamin LA, Murdoch D, et al. HIV and non-communicable cardiovascular and pulmonary diseases in low- and middle-income countries in the ART era: what we know and best directions for future research. Journal of acquired immune deficiency syndromes. 2014 Sep 01; 67 Suppl 1:S40–53. https://doi.org/10.1097/QAI.0000000000000257 PMID: 25117960. PMCID: PMC4133739.
20. Nduka CU, Stranges S, Sarki AM, Kimani PK, Uthman OA. Evidence of increased blood pressure and hypertension risk among people living with HIV on antiretroviral therapy: a systematic review with meta-analysis. J Hum Hypertens. 2016 Jun; 30(6):355–62. https://doi.org/10.1038/jhh.2015.97 PMID: 26446389.
21. Boccara F. Cardiovascular health in an aging HIV population. Aids. 2017 Jun 01; 31 Suppl 2:S157–S63. https://doi.org/10.1097/QAD.0000000000001384 PMID: 28471946.
22. Hawes SE, Critchlow CW, Faye Niang MA, Diouf MB, Diop A, Toure P, et al. Increased risk of high-grade cervical squamous intraepithelial lesions and invasive cervical cancer among African women with human immunodeficiency virus type 1 and 2 infections. The Journal of infectious diseases. 2003 Aug 15; 188(4):555–63. https://doi.org/10.1086/376996 PMID: 12898443.
23. Wang C, Hawes SE, Gaye A, Sow PS, Ndoye I, Manhart LE, et al. HIV prevalence, previous HIV testing, and condom use with clients and regular partners among Senegalese commercial sex workers. Sexually transmitted infections. 2007 Dec; 83(7):534–40. https://doi.org/10.1136/sti.2007.027151 PMID: 17942575. PMCID: PMC2598648.
24. Zheng NN, Kiviat NB, Sow PS, Hawes SE, Wilson A, Diallo-Agne H, et al. Comparison of human immunodeficiency virus (HIV)-specific T-cell responses in HIV-1- and HIV-2-infected individuals in Senegal. J Virol. 2004 Dec; 78(24):13934–42. https://doi.org/10.1128/JVI.78.24.13934-13942.2004 PMID: 15564501. PMCID: PMC533895.
25. Deftereos G, Corrie SR, Feng Q, Morihara J, Stern J, Hawes SE, et al. Expression of mir-21 and mir-143 in cervical specimens ranging from histologically normal through to invasive cervical cancer. PloS one. 2011; 6(12):e28423. https://doi.org/10.1371/journal.pone.0028423 PMID: 22194833. PMCID: PMC3237431.
26. Gottlieb GS, Badiane NM, Hawes SE, Fortes L, Toure M, Ndour CT, et al. Emergence of multiclass drug-resistance in HIV-2 in antiretroviral-treated individuals in Senegal: implications for HIV-2 treatment in resouce-limited West Africa. Clinical infectious diseases: an official publication of the Infectious Diseases Society of America. 2009 Feb 15; 48(4):476–83. https://doi.org/10.1086/596504 PMID: 19143530. PMCID: PMC3671065.
27. Rodriguez-Arboli E, Mwamelo K, Kalinjuma AV, Furrer H, Hatz C, Tanner M, et al. Incidence and risk factors for hypertension among HIV patients in rural Tanzania—A prospective cohort study. PloS one. 2017; 12(3):e0172089. https://doi.org/10.1371/journal.pone.0172089 PMID: 28273105. PMCID: PMC5342176.
28. Njelekela M, Muhihi A, Aveika A, Spiegelman D, Hawkins C, Armstrong C, et al. Prevalence of Hypertension and Its Associated Risk Factors among 34,111 HAART Naive HIV-Infected Adults in Dar es Salaam, Tanzania. Int J Hypertens. 2016; 2016:5958382. https://doi.org/10.1155/2016/5958382 PMID: 27872756.
29. Peck RN, Shedafa R, Kalluvya S, Downs JA, Todd J, Suthanthiran M, et al. Hypertension, kidney disease, HIV and antiretroviral therapy among Tanzanian adults: a cross-sectional study. BMC medicine. 2014 Jul 29; 12:125. https://doi.org/10.1186/s12916-014-0125-2 PMID: 25070128. PMCID: PMC4243281.

30. Kagaruki GB, Mayige MT, Ngadaya ES, Kimaro GD, Kalinga AK, Kilale AM, et al. Magnitude and risk factors of non-communicable diseases among people living with HIV in Tanzania: a cross sectional study from Mbeya and Dar es Salaam regions. BMC public health. 2014 Sep 02; 14:904. https://doi.org/10.1186/1471-2458-14-904 PMID: 25183300. PMCID: PMC4161834.

31. Bloomfield GS, Hogan JW, Keter A, Sang E, Carter EJ, Velazquez EJ, et al. Hypertension and obesity as cardiovascular risk factors among HIV seropositive patients in Western Kenya. PloS one. 2011; 6(7): e22288. https://doi.org/10.1371/journal.pone.0022288 PMID: 21779407. PMCID: PMC3136516.

32. Okello S, Kanyesigye M, Muyindike WR, Annex BH, Hunt PW, Haneuse S, et al. Incidence and predictors of hypertension in adults with HIV-initiating antiretroviral therapy in south-western Uganda. J Hypertens. 2015 Oct; 33(10):2039–45. https://doi.org/10.1097/HJH.0000000000000657 PMID: 26431192. PMCID: PMC4700387.

33. Sander LD, Newell K, Ssebbowa P, Serwadda D, Quinn TC, Gray RH, et al. Hypertension, cardiovascular risk factors and antihypertensive medication utilisation among HIV-infected individuals in Rakai, Uganda. Tropical medicine & international health: TM & IH. 2015 Mar; 20(3):391–6. https://doi.org/10.1111/tmi.12443 PMID: 25430847. PMCID: PMC4308448.

34. Kwarisiima D, Balzer L, Heller D, Kotwani P, Chamie G, Clark T, et al. Population-Based Assessment of Hypertension Epidemiology and Risk Factors among HIV-Positive and General Populations in Rural Uganda. PloS one. 2016; 11(5):e0156309. https://doi.org/10.1371/journal.pone.0156309 PMID: 27232186. PMCID: PMC4883789.

35. Kavishe B, Biraro S, Baisley K, Vanobberghen F, Kapiga S, Munderi P, et al. High prevalence of hypertension and of risk factors for non-communicable diseases (NCDs): a population based cross-sectional survey of NCDS and HIV infection in Northwestern Tanzania and Southern Uganda. BMC medicine. 2015 May 29; 13:126. https://doi.org/10.1186/s12916-015-0357-9 PMID: 26021319. PMCID: PMC4476208.

36. Mateen FJ, Kanters S, Kalyesubula R, Mukasa B, Kawuma E, Kengne AP, et al. Hypertension prevalence and Framingham risk score stratification in a large HIV-positive cohort in Uganda. J Hypertens. 2013 Jul; 31(7):1372–8; discussion 8. https://doi.org/10.1097/HJH.0b013e328360de1c PMID: 23615323.

37. Barnighausen T, Welz T, Hosegood V, Batzing-Feigenbaum J, Tanser F, Herbst K, et al. Hiding in the shadows of the HIV epidemic: obesity and hypertension in a rural population with very high HIV prevalence in South Africa. J Hum Hypertens. 2008 Mar; 22(3):236–9. https://doi.org/10.1038/sj.jhh.1002308 PMID: 18046436.

38. Malaza A, Mossong J, Barnighausen T, Newell ML. Hypertension and obesity in adults living in a high HIV prevalence rural area in South Africa. PloS one. 2012; 7(10):e47761. https://doi.org/10.1371/journal.pone.0047761 PMID: 23082211. PMCID: PMC3474786.

39. Rabkin M, Mutiti A, Chung C, Zhang Y, Wei Y, El-Sadr WM. Missed Opportunities to Address Cardiovascular Disease Risk Factors amongst Adults Attending an Urban HIV Clinic in South Africa. PloS one. 2015; 10(10):e0140298. https://doi.org/10.1371/journal.pone.0140298 PMID: 26447777. PMCID: PMC4598081.

40. Muronya W, Sanga E, Talama G, Kumwenda JJ, van Oosterhout JJ. Cardiovascular risk factors in adult Malawians on long-term antiretroviral therapy. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2011 Nov; 105(11):644–9. https://doi.org/10.1016/j.trstmh.2011.07.016 PMID: 21924753.

41. Divala OH, Amberbir A, Ismail Z, Beyene T, Garone D, Pfaff C, et al. The burden of hypertension, diabetes mellitus, and cardiovascular risk factors among adult Malawians in HIV care: consequences for integrated services. BMC public health. 2016 Dec 12; 16(1):1243. https://doi.org/10.1186/s12889-016-3916-x PMID: 27955664. PMCID: PMC5153818.

42. Magodoro IM, Esterhuizen TM, Chivese T. A cross-sectional, facility based study of comorbid non-communicable diseases among adults living with HIV infection in Zimbabwe. BMC research notes. 2016 Aug 02; 9:379. https://doi.org/10.1186/s13104-016-2187-z PMID: 27484005. PMCID: PMC4969634.

43. Dimala CA, Atashili J, Mbuagbaw JC, Wilfred A, Monekosso GL. Prevalence of Hypertension in HIV/AIDS Patients on Highly Active Antiretroviral Therapy (HAART) Compared with HAART-Naive Patients at the Limbe Regional Hospital, Cameroon. PloS one. 2016; 11(2):e0148100. https://doi.org/10.1371/journal.pone.0148100 PMID: 26862763. PMCID: PMC4749660.

44. Nsagha DS, Assob JC, Njunda AL, Tanue EA, Kibu OD, Ayima CW, et al. Risk Factors of Cardiovascular Diseases in HIV/AIDS Patients on HAART. Open AIDS J. 2015; 9:51–9. https://doi.org/10.2174/1874613601509010051 PMID: 26587072. PMCID: PMC4645867.

45. Ngatchou W, Lemogoum D, Ndobo P, Yagnigni E, Tiogou E, Nga E, et al. Increased burden and severity of metabolic syndrome and arterial stiffness in treatment-naive HIV+ patients from Cameroon. Vasc Health Risk Manag. 2013; 9:509–16. https://doi.org/10.2147/VHRM.S42350 PMID: 24043942. PMCID: PMC3772749.

46. Diouf A, Cournil A, Ba-Fall K, Ngom-Gueye NF, Eymard-Duvernay S, Ndiaye I, et al. Diabetes and Hypertension among Patients Receiving Antiretroviral Treatment Since 1998 in Senegal: Prevalence and Associated Factors. ISRN AIDS. 2012; 2012:621565. https://doi.org/10.5402/2012/621565 PMID: 24052880. PMCID: PMC3767342.

47. Gueye NFN, Ka D., Tall A.B., Ndiaye K., Ndiaye A.A., Cisse V.M.P., Guindo A., Badiane N.M.D., Diop S.A., Manga N.M., Ndour C.T. and Seydi M. Prevalence of Hypertension and Associated Factors in Patients Living with HIV Followed at the Ambulatory Treatment Center (CTA) of Fann National University Hospital in Dakar. Health. 2017; 9:727–37.

48. Ballah Akawu Denue, Pharm Jamil Muazu, Wadzani Gashau, Daniel Nkami MBO, Nnenna Anthony Ajayi. Effects of highly active antiretroviral therapy (HAART) on blood pressure changes and its associated factors in HAART naive HIV-infected patients in North eastern Nigeria. Archives of Applied Science Research, 2012, 4 (3):1447–1452.

49. Muhammad S, Sani MU, Okeahialam BN. Cardiovascular disease risk factors among HIV-infected Nigerians receiving highly active antiretroviral therapy. Niger Med J. 2013 May; 54(3):185–90. https://doi.org/10.4103/0300-1652.114591 PMID: 23901181. PMCID: PMC3719245.

50. Ogunmola OJ, Oladosu OY, Olamoyegun AM. Association of hypertension and obesity with HIV and antiretroviral therapy in a rural tertiary health center in Nigeria: a cross-sectional cohort study. Vasc Health Risk Manag. 2014; 10:129–37. https://doi.org/10.2147/VHRM.S58449 PMID: 24672244. PMCID: PMC3964169.

51. Hendriks ME, Wit FW, Roos MT, Brewster LM, Akande TM, de Beer IH, et al. Hypertension in sub-Saharan Africa: cross-sectional surveys in four rural and urban communities. PloS one. 2012; 7(3): e32638. https://doi.org/10.1371/journal.pone.0032638 PMID: 22427857. PMCID: PMC3299675.

52. Guwatudde D, Nankya-Mutyoba J, Kalyesubula R, Laurence C, Adebamowo C, Ajayi I, et al. The burden of hypertension in sub-Saharan Africa: a four-country cross sectional study. BMC public health. 2015 Dec 05; 15:1211. https://doi.org/10.1186/s12889-015-2546-z PMID: 26637309. PMCID: PMC4670543.

53. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014 Aug 30; 384(9945):766–81. https://doi.org/10.1016/S0140-6736(14)60460-8 PMID: 24880830. PMCID: PMC4624264.

54. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013 Aug 3; 382 (9890):427–51. https://doi.org/10.1016/S0140-6736(13)60937-X PMID: 23746772.

55. Benzekri NA, Seydi M, NDoye I, Toure M, Kiviat NB, Sow PS, Hawes SE, and Gottlieb GS. HIV and the dual burden of malnutrition in Senegal, 1994–2012. International Journal of STD and AIDS. In Press.

56. United Nations. The Millennium Development Goals Report 2015. Available at: http://www.un.org/millenniumgoals/reports.shtml

57. United Nations Population Fund (2014). Programme of Action of the International. Conference on Population and Development. Available at: https://www.unfpa.org/publications/international-conference-population-and-development-programme-action

58. World Health Organization (2015). Global Strategy for Women's, Children's and Adolescents Health 2016–2030. Available at: http://www.who.int/life-course/partners/global-strategy/en/

59. Cottingham J, Germain A, Hunt P. Use of human rights to meet the unmet need for family planning. Lancet. 2012 Jul 14; 380(9837):172–80. https://doi.org/10.1016/S0140-6736(12)60732-6 PMID: 22784536.

60. World Health Organization. Family planning in sub-Saharan Africa: progress or stagnation? John G Cleland, Robert P Ndugwa, & Eliya M Zulu. Bulletin of the World Health Organization 2011; 89:137–143. https://doi.org/10.2471/BLT.10.077925 PMID: 21346925

61. Cavallaro FL, Benova L, Macleod D, Faye A, Lynch CA. Examining trends in family planning among harder-to-reach women in Senegal 1992–2014. Sci Rep. 2017 Jan 20; 7:41006. https://doi.org/10.1038/srep41006 PMID: 28106100. PMCID: PMC5247687.

62. Arrey WT, Dimala CA, Atashili J, Mbuagbaw J, Monekosso GL. Hypertension, an Emerging Problem in Rural Cameroon: Prevalence, Risk Factors, and Control. Int J Hypertens. 2016; 2016:5639146. https://doi.org/10.1155/2016/5639146 PMID: 28053779. PMCID: PMC5178358.

63. Fezeu L, Kengne AP, Balkau B, Awah PK, Mbanya JC. Ten-year change in blood pressure levels and prevalence of hypertension in urban and rural Cameroon. J Epidemiol Community Health. 2010 Apr; 64 (4):360–5. https://doi.org/10.1136/jech.2008.086355 PMID: 19692732. PMCID: PMC3094348.

64. Olack B, Wabwire-Mangen F, Smeeth L, Montgomery JM, Kiwanuka N, Breiman RF. Risk factors of hypertension among adults aged 35–64 years living in an urban slum Nairobi, Kenya. BMC public

health. 2015 Dec 17; 15:1251. https://doi.org/10.1186/s12889-015-2610-8 PMID: 26679701. PMCID: PMC4683777.

65. World Health Organization (2008). Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health. Geneva, World Health Organization.

66. Bergersen BM. Cardiovascular risk in patients with HIV Infection: impact of antiretroviral therapy. Drugs. 2006; 66(15):1971–87. https://doi.org/10.2165/00003495-200666150-00006 PMID: 17100407.

67. Conseil National de Lutte contre le Sida (2015). Rapport de situation sur la riposte nationale a l'épidémie de vih/sida, Sénégal: 2013–2014.

68. Joint United Nations Programme on HIV/AIDS (UNAIDS). The Gap Report (2014). http://www.unaids.org/sites/default/files/media_asset/UNAIDS_Gap_report_en.pdf.