RELATIONSHIP BETWEEN SOCIOECONOMIC STATUS AND HIV IN WOMEN OF REPRODUCTIVE AGE IN FREE STATE AND WESTERN CAPE PROVINCES OF SOUTH AFRICA

by

Dr. Erick Wekesa Bunyasi

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School of Public Health and Family Medicine, University of Cape Town

Supervisor: Prof. David John Coetzee

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Appreciation

I appreciate my mom Mary, and dad Joseph for their support and sacrifices, my uncle, Geoffrey, for his unfailing confidence in my abilities and always urging me on, and my siblings; Ronald, Martin, Caroline, Lilian, Nancy, Linet and Robert for shared experiences that defined our life

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[Tables in this section were numbered differently, as compared to sections A and B in order to conform to instruction to authors by the *Journal of the International AIDS Society*]

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Declaration

I, **Dr. Erick Wekesa Bunyasi**, student number BNYERI001, hereby declare that the work in this dissertation is based on my original work, except where acknowledgements indicate otherwise, and that this work has not, in whole or in part, been submitted towards another degree, at this University or elsewhere. The University of Cape Town is empowered to reproduce either whole or a portion of this mini-dissertation for purposes of scholarship and research.

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University of Cape Town,

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Acronyms and abbreviations

AIDS	Acquired Immune Deficiency Syndrome
ANC	Antenatal Clinic
CSW	Commercial Sex Workers
DHS	Demographic and Health Survey
FSP	Free State Province
HAART	Highly Active Anti-Retroviral Drugs
HIV	Human Immunodeficiency Virus
IDUs	Injecting Drug Users
IPV	Intimate Partner Violence
IQR	Interquartile range
KZN	*KwaZulu* Natal Province
MC	Voluntary Medical Male Circumcision
MCH/ FP	Maternal and Child Health and Family Planning clinic
MSMs	Men who have sex with men
PCA	Principal Components Analysis
PEARL	PMTCT Effectiveness in Africa, Research and Linkages to HIV Care Study

PMTCT	Prevention of Mother to Child Transmission of HIV
SA	Republic of South Africa
SE	Socioeconomic
SES	Socioeconomic status
SSA	sub-Saharan Africa
STD	Sexually Transmitted Diseases
STI	Sexually Transmitted Infections
UCT	University of Cape Town
UNAIDS	Joint United Nations Programme on HIV/AIDS
US	United States of America
WCP	Western Cape Province
WHO	World Health Organization

Overview of dissertation

Health outcomes generally improve with increasing socio-economic status [SES]. This is referred to as the socioeconomic gradient in health. With regard to HIV, this gradient has been observed to conform to this general pattern and is consistent in developed countries but not in sub-Saharan African [SSA] countries. In SSA, observed patterns include; direct, inverse, lack of association and, dynamic association where the relationship changes over time. In general, literature shows that the relationship between SES as measured by education or asset quintiles and HIV changed from a direct association in early phases of the HIV epidemic to an inverse association in mature epidemics in majority of countries in SSA. In this study, we used a combination of measures of SES including education, assets, employment status and type of occupation to investigate the association between SES and HIV prevalence using data from a study that evaluated effectiveness of prevention of mother to child transmission of HIV program in Western Cape and Free State Provinces of South Africa.

In **Section A** [**Protocol**], we describe our research methodology whereas in **Section B** [**Literature review**] we review and discuss literature on burden of HIV and its transmission, measurement of SES and the relationship between SES and HIV with primary focus on SSA. In **Section C** [**Manuscript**], we present a *'journal-ready'* manuscript that has been aligned to requirements of the *Journal of the International AIDS Society* [***JIAS***]. A summary of these requirements is reported in **appendix 11** with more details available from *http://www.jiasociety.org/*. In keeping with these requirements and for consistency, Vancouver style has been used. Sections are numbered continuously rather than each section starting from 1 for ease of reference using contents table.

SECTION A:

PROTOCOL

Protocol abstract

Background and Rationale: South Africa [SA] is experiencing the highest burden of HIV/AIDS globally. Despite recent progress in HIV prevention, care and treatment, HIV incidence and prevalence still remain high compared to developed countries; and both are higher in females than males. Various studies have demonstrated factors associated with HIV infection. This analysis builds on the body of knowledge of non-biological factors associated with HIV in women of reproductive age in SA. An understanding of demographic and socioeconomic factors contributing to the high HIV prevalence will inform ongoing interventions targeted at HIV control

Methodology: This study will evaluate demographic and socioeconomic factors associated with the high HIV prevalence in South African women in the Western Cape [WCP] and Free State Provinces [FSP]. This will be a secondary analysis of South African data derived from a cross-sectional survey titled 'PMTCT Effectiveness in Africa: Research and Linkages [PEARL] to Care Part II: community survey'. The study's main objective was to estimate 24-month HIV-free survival among HIV-exposed infants born in six representative communities in 4 African countries; SA, Cameroon, Ivory Coast and Zambia, as a way of evaluating effectiveness of PMTCT interventions in these settings. This study received ethical approval from Ethics Review Committees of participating institutions [**appendices 1** and **2,** for South Africa]. Data from South Africa will be analysed to determine socioeconomic factors associated with HIV-serostatus among female respondents of reproductive age in the WCP and FSP. Data will be analysed using univariate and multivariate logistic regression for survey data.

1. Introduction

1.1. Background

In 2013 the estimated national prevalence of HIV among South Africans of all age groups was 12.3% [1]. Disparities in HIV prevalence by age, gender and socioeconomic status [SES] are most marked in individuals between the ages of 20 to 35 years [**Appendix 9**[1]]. In the key age group of adults aged 15–49 years, HIV prevalence is 23.3% in women and 13.3% in men; this highlights the higher burden of HIV among females [1].

Several factors have been advanced to explain the higher HIV prevalence in women. Briefly, biological risk factors, both anatomical and physiological, put women at a higher risk of HIV acquisition due to higher exposed genital surface area and longer duration of contact with semen in the event of unprotected sex with a HIV positive partner. Intergenerational and transactional sex exposes economically vulnerable and dependent younger girls, with less bargaining power for safer sex, to a higher HIV acquisition risk when they engage in unprotected sex for economic reasons. Poverty and lack of economic opportunities in rural areas force both men and women to migrate in search of job opportunities which lead to disruption of conjugal stability and social cohesion that favours concurrency and increased risk of HIV [2 - 4].

Health outcomes generally improve with increasing SES; this is referred to as the socioeconomic gradient in health. However, in SSA studies have shown an association between HIV and both higher and lower SES [5, 6]. SES is a composite measure that typically incorporates social, economic and work status. These indicators are measured by education, income and occupation

respectively. These three indicators are interrelated but do not overlap [7]. Race as a social construct has been associated with differences in SES and health outcomes in South Africa [SA] due to its unique historical and political factors. Race has thus been shown to be a useful proxy for SES in this context [8].The South African Human Sciences Research Council [HSRC] survey of 2008 used race and informal dwellings as a proxy for SES. The higher HIV prevalence of 13.6% among Africans compared to 0.3% among whites, 1.7% among coloureds and 0.3% among Indians [9] was postulated to be associated with SES.

A Ugandan longitudinal population-based study examining the association between SES and HIV incidence, found no significant association between HIV incidence and educational attainment in rural Uganda [10]. Other studies have found a decrease of HIV acquisition risk with increase in women's income [Rwanda] [11], and a decrease in HIV risk with educational attainment of women's partners [Zimbabwe] [12]. Two studies evaluating urban factory workers found a positive association between HIV seroconversion risk and both occupational status [Democratic Republic of Congo] [13] and educational attainment [Tanzania] [14].

A systematic review on SES and HIV seroconversion risk in Eastern, Central and Southern Africa that evaluated 36 studies found no association between SES and HIV infection in 15 studies, a direct association in 12 studies, an inverse association in 8 studies, and mixed results in 1 study. The review recommended use of multiple measures of SES at both individual and community level by new studies because different measures of SES perform differently in relation to health outcomes in areas that have widespread poverty and extreme income inequalities [6]. In our study, we will use a combination of measures of SES that include wealth index, individual

educational attainment, employment status and type of occupation to investigate the association between SES and HIV.

1.2. Rationale

Knowledge of demographic and socioeconomic factors associated with HIV prevalence is vital in ensuring HIV prevention messages are optimized to different sub-groups of the population and to specific provinces based on risk factors for HIV that dominate at those levels. This will enable more targeted and cost-effective use of scarce resources that result in a higher impact.

1.3. Research question

What is the relationship between HIV prevalence in women of reproductive age and SES, as measured by highest level of formal education, employment status, type of occupation and asset index in Free State and Western Cape Provinces of SA?

1.4. Hypothesis

Null hypothesis [H_o]: there is no difference in SES as measured by educational attainment, employment status, type of occupation and asset index between HIV positive and HIV negative women of reproductive age in Free State and Western Cape Provinces of SA.

Alternative hypothesis [H_A]: there is a difference in SES as measured by educational attainment, employment status, type of occupation and asset index between HIV positive and HIV negative women of reproductive age in Free State and Western Cape Provinces of SA.

1.5. Objective

The main objective of this study is to describe the association between SES [as measured by highest level of formal education, employment status, type of occupation and asset index] and HIV in women of reproductive age in the Western Cape and Free State provinces of South Africa through a secondary analysis of *PEARL* community survey data.

2. Methods

2.1. Study design

This study is a secondary analysis of cross-sectional community survey data that was conducted between June 2007 and October 2008 in a number of communities in Western Cape and Free State Provinces of SA. Detailed methodology and results of the parent study have been described elsewhere in detail [15, 16].

2.2. Study population

The population under study is women of reproductive age in the Western Cape and Free State Provinces of South Africa. Only women who were alive at the time of the survey, gave written informed consent, provided demographic, SES and other epidemiological data and whose HIV status was known will be included.

2.3. Sampling strategy

Six sub-districts [service clusters] were randomly selected from both urban and rural settings from WCP and FSP. The catchment areas of all health facilities in these sub-districts were defined and included in the community survey. In total there were 14 health facilities in the six selected service clusters. Each cluster was mapped and a starting point was randomly selected. Sampling began at this point and moved progressively towards the boundaries of the cluster, utilizing a clockwise spiral pattern. Systematic sampling was used and households were selected at pre-determined intervals [15, 16]. Detailed methodology, facility-based components and analysis of the parent study have been reported elsewhere in detail [15-20].

2.4. Sample size estimation

The primary study enrolled 2,029 women, with HIV results available for 1906 women, 378 of whom were HIV positive. Since the primary study sampled women with children younger than 2 years, we presumed that HIV prevalence of women selected in each province will be similar to that of women attending Ante-Natal Clinic [ANC] in each province. HIV prevalence of women attending ANC in WCP and FSP at the time of the survey [2008] was 16.1% and 32.9% respectively [21]. Using the lower prevalence and assuming a design effect of 2 to take account of cluster sampling design effect, a sample size of 1,664 would be required to identify an eight percent difference in HIV prevalence between highest and lowest asset quintiles with 80% power and 95% confidence limit.

2.5. Data management

All data for this study will be derived from the South African component of the PEARL study dataset. No additional data collection will be done.

2.5.1. Exposure variables

Our exposure variables are the proxy variables for SES, namely, education, asset index, type of occupation and employment status.

2.5.1.1. Education

Respondents were asked to report their highest level of education which was reported as a continuous variable, namely, years of school completed. In our analysis education will also be

categorized into primary, secondary and tertiary or college level. These will be used in regression models for survey data to evaluate relationship between education and HIV status.

2.5.1.2. Asset index

No direct questions on income or expenditure were asked. Five household welfare or wealth categories, henceforth called *asset quintiles,* were created based on asset scores derived using a statistical method called *Principal Components Analysis* [PCA]. The statistical method assigns numeric scores to households using data on household ownership of durable goods, such as motorcycle and television, and access to social amenities such as type of toilet facility in the household. This asset score from PCA is a composite SES measure that reflects cumulative living standard of households. It places individual households on a continuous scale of relative wealth within regions, or countries. This method was validated and recommended by Filmer et al. [22] for measurement of SES in households in developing countries and is widely used in national Demographic and Health Survey [DHS] [23] across sub-Saharan Africa [SSA]. PCA has been shown to strongly correlate with health outcomes such as morbidity and mortality [22, 23]. Asset scores derived by this technique can be used in regression models in statistical analysis as continuous variables, percentiles or quintiles. Like in DHS surveys, women were assigned asset scores or quintiles of their households. The five asset quintiles [q1 to q5 with q1='poorest' 20%, q5= 'wealthiest' 20%] will be used in univariate and bivariate analysis as is whereas 4 dummy variables will be created for multivariate analysis as shown in **Table A1**.

Table A1: Indicator or dummy variables for asset quintiles

Quintile category	Dummy variable 1 [DV1]	Dummy variable 1 [DV2]	Dummy variable 1 [DV3]	Dummy variable 1 [DV4]
Poorest quintile [q1] [≤20th *]	0	0	0	0
Second quintile [q2] [>20th-≤40th *]	1	0	0	0
Middle quintile [q3] [>40th-≤60th *]	0	1	0	0
Fourth quintile [q4] [>60th-≤80th *]	0	0	1	0
Highest quintile [q5] [>80th-≤100th *]	0	0	0	1

*Percentile of wealth index score

The first quintile category [*q1*] will be used as the reference category in regression modeling i.e. the exponent of the beta-coefficient in the regression model for *DV1* provides odds ratio for HIV infection for individuals in *q2* compared to *q1*; *DV2* compares *q3* to *q1*; *DV3* compares *q4* to *q1* and *DV4* compares *q5* to *q1*.

2.5.1.3. Occupation

Occupation was re-coded to a nominal response with 8 categories as shown in **appendix 3**. Dummy variables will be created using an approach similar to that used to derive dummy variables for asset quintiles in **table A1**. Group 1 will be used as the reference category.

2.5.1.4. Employment status

Employment status will be coded as a binary variable: employed [1] compared to unemployed [0].

2.5.2. Confounders

Based on literature review and available variables in our dataset, age, marital status and residence type [rural vs urban] are hypothesized as potential confounders. A change in the beta-coefficient [β] of any of the SES proxy variables of more than 10% on inclusion of any of these hypothesized confounders in a regression model indicates presence of confounding and thus need for adjustment.

We will adopt a conceptual framework by Mishra et al [24, 25] to depict hypothesised biomedical and social mediators of the relationship between SES and HIV [figure A2]. **Figure A1** shows a simplified framework, without interactions between determinants and potential feedback mechanisms, of the pathways through which social and economic environment influence basic reproductive rate of HIV infection. As argued by Boerma et al, statistical analyses that include underlying and proximate determinants [shown in **figure A1**] in the same model

without consideration of multilevel structure of the relationship between these determinants and HIV may produce estimates that are misleading or difficult to interpret [25]. This consideration is important in design of analytical plans of studies of this nature.

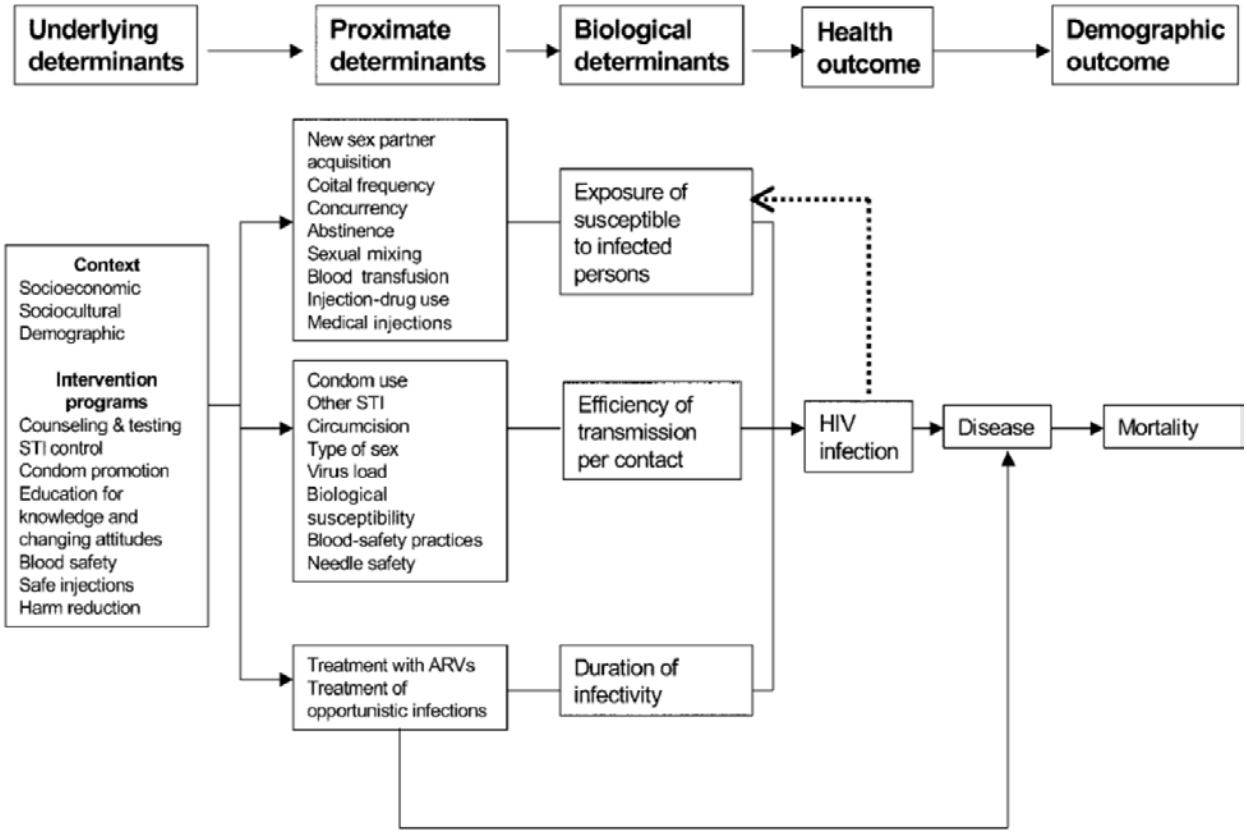

Figure A1: Conceptual framework of hypothesized biomedical and social mediators [see 'proximate determinants'] of the relationship between determinants of HIV and HIV infection [Adopted from Boerma et al [25]].

Key: STI= Sexually Transmitted Infection; ARVs= antiretroviral drugs: SES=socioeconomic status: HIV =Human Immunodeficiency Virus

2.5.3. Outcome variable

The outcome variable is HIV serostatus [HIV positive or HIV negative].

2.6. Data collection

HIV status was determined from a blood specimen. Testing was done anonymously for HIV antibodies using a HIV rapid testing algorithm in place in public health facilities at the time that involved initial screening with *Determine test* [Abbott Laboratories, Chicago, IL]. HIV testing was done off-site at the University of Cape Town and the University of Free State. Mothers were encouraged to seek routine health services at nearest health facilities for HIV counseling and testing to determine their HIV status and HIV care where applicable.

Participant and household level data were collected through an interviewer administered structured questionnaire. This was done by trained nurses and field workers and was captured centrally using *ACCESS* software.

2.7. Reliability and validity of measurements

In the primary study, community sensitization through radio shows, door to door sensitization, meetings with local leaders and distribution of printed material was done to increase knowledge about the survey and reduce non-response bias. A preliminary pilot study of 20 participants was done involving at least 1 rural and 1 urban site per province. Questionnaires were modified based on experience and result of the pilot study and input from experienced field workers and supervisors. This served to improve reliability, validity and general utility of the measurement instruments. The study utilized teams of trained field workers and health care workers [nurses] in data collection. Their recruitment was guided by previous experience in similar research work. Preference in recruitment of field workers was given to women from the same community to ensure sensitivity to local customs during conduct of the study and thus improvement in

response rate. Training was done on questionnaire interview techniques, identification and minimization of bias, handling of media and other general information relating to improvement of validity of exposure and outcome variables of the study. Supervision was provided by trained and experienced nurses. Interviewers were trained to ensure establishment of rapport, privacy and confidentiality before enquiry into questionnaire items of a sensitive nature, especially those relating to sexual history and knowledge, attitudes and practices relating to sexuality and HIV. This served to reduce social desirability bias. Four teams led by a supervisor were in charge of data collection. Questionnaires were manually checked for completeness in the field during conduct of the study to ensure timely correction of missing or discrepant data items. Use of qualified nurses for phlebotomy was vital to ensure a higher phlebotomy success rate. In the event that the mother was not present at the time of the interview or there was no one at home on the first visit, the study team went back at least 3 times in an attempt to trace the selected individual.

2.8. Statistical analysis

Logistic regression for survey data that takes into consideration cluster sampling approach and sampling weights will be used in analysis. All analysis will be carried out using STATA® statistical software version 12.1 for Windows [26].

2.8.1. Univariate and Bivariate data analysis

Univariate exploratory data analysis will be done using histograms and frequency tables for continuous and categorical data respectively. Normally distributed continuous data will be summarized using mean and standard deviation [SD] whereas non-normally distributed

continuous data will be summarized using median and interquartile range [IQR]. Categorical data will be summarized using proportions and 95% confidence interval [CI]. Bivariate exploratory data analysis will be carried out using scatter plots for continuous variables, the box and whisker plots for continuous and categorical variables, and chi-square statistic for categorical variables. Basic descriptive statistics will be described as shown in **table A2** and **figure A2** whereas socio-demographic, health and behavioral characteristics of study participants by asset quintile will be presented as shown in **table A3**.

Table A2: Distribution of socio-demographic variables and basic literacy skills for WCP and FSP [SA] in 2008 [Dummy table]

Variable	**WCP[1] [N [%]]** 802 [42.1]	**FSP[1] [N [%]]** 1104 [57.9]	**TOTAL [N [%]]** 1 906 [100]
Age [median: IQR]	… […; …]	… […; …]	… [IQR: …; …]
Marital status			
- Never married	… […]	… […]	… […]
- Married	… […]	… […]	… […]
- Divorced	… […]	… […]	… […]
- Separated	… […]	… […]	… […]
- Widowed	… […]	… […]	… […]
- Married or lived with a man before; current status unknown[2]	… […]	… […]	… […]
Total	… [100]	… [100]	… [100]
Highest educational level attained			

- Primary	… […]	… […]	… […]
- Secondary	… […]	… […]	… […]
- Tertiary	… […]	… […]	… […]
Total	… [100]	… [100]	… […]
Formal employment status			
- Yes	… […]	… […]	… […]
- No	… […]	… […]	… […]
Total	… [100]	… [100]	… [100]
Occupational group [N [%]] [3]			
- Group 1	… […]	… […]	… […]
- Group 2	… […]	… […]	… […]
- Group 3	… […]	… […]	… […]
- Group 4	… […]	… […]	… […]
- Group 5	… […]	… […]	… […]
- Group 6	… […]	… […]	… […]
- Group 7	… […]	… […]	… […]
- Group 8	… […]	… […]	… […]
Total	… [100]	… [100]	… [100]
Asset score [median: IQR]	… […; …]	…[…;…]	… […; …]
Wealth/Asset quintile[4]			
- Quintile 1	… […]	… […]	… […]
- Quintile 2	… […]	… […]	… […]
- Quintile 3	… […]	… […]	… […]
- Quintile 4	… […]	… […]	… […]

- Quintile 5	… […]	… […]	… […]
Total	… [100]	… [100]	… [100]
Basic literacy skills			
- Able to read whole sentence - Able to read parts of sentence - Can't read whole sentence - No card with required language or blind or visually impaired	… […]	… […]	… […]
Total			

N [%]: N= size of sample in specified analysis; % = percentage [proportion], unless otherwise stated

[1]Provinces in South Africa: WCP=Western Cape Province; FSP=Free State Province

[2]Participant was previously married or cohabited with a man before; but current marital status was not recorded during the survey.

[3]**Occupation categories**: **group1**=managers or employers in a company, NGO or organization; **group2**=farmers; **group3**=government workers; **group4**=healthcare workers; **group5**=secretaries; **group6**=small business owners or traders; **group7**=students; **group8**=other [these includes chefs, domestic workers; shop assistants and any other occupation not fitting in the above specified categories etc.]

[4]Wealth quintiles were derived using Principal Components Analysis [PCA] in STATA Special Edition version 12.1. Wealth quintile categories **First**=Lowest quintile ['Poorest' on a relative asset index scale]; **Second**=Second quintile; **Third**= Middle quintile; **Fourth**=Fourth quintile; **Fifth**=Highest quintile ['Richest' on a relative asset index scale]

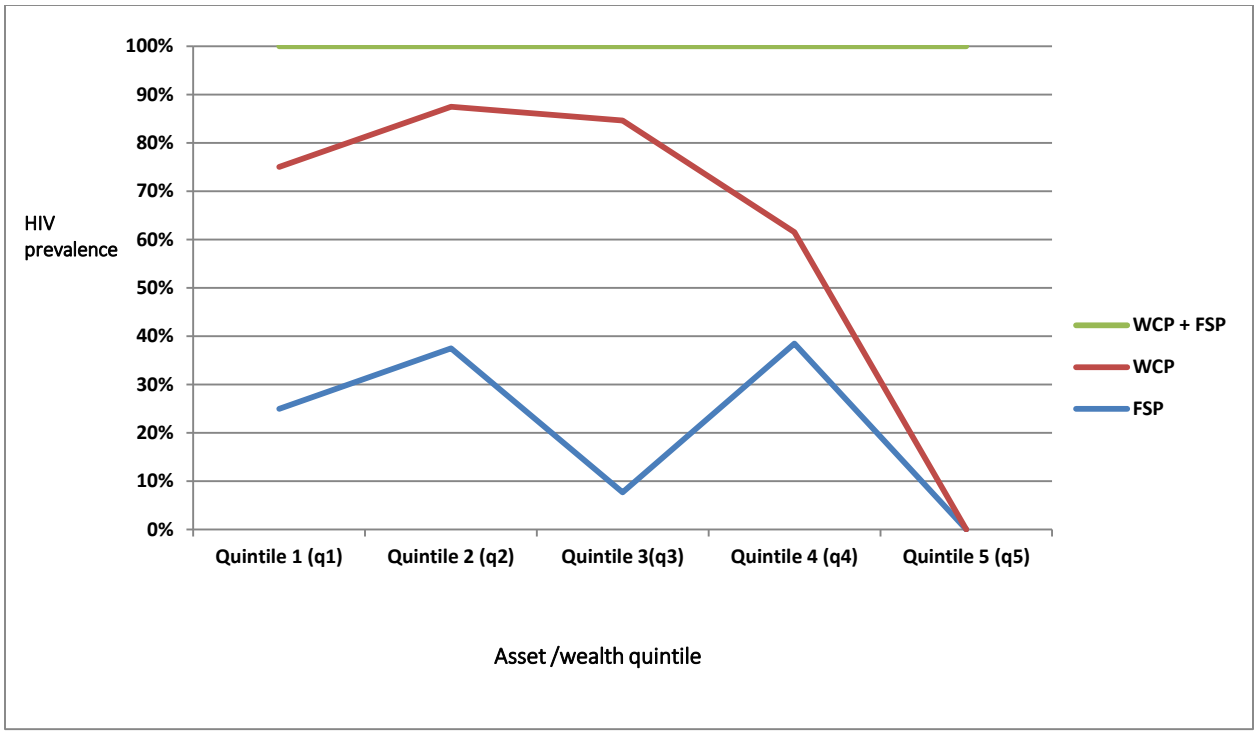

Figure A2: HIV prevalence by wealth quintile and province [Dummy graph]. This figure only depicts how the relationship between asset quintiles and HIV prevalence [by province] will be presented but does not use actual data [i.e. dummy figure].

Table A3: Selected socio-demographic, health and behavioral characteristics of study participants by asset quintile [Dummy table]

Variable	Household Asset/Wealth Quintile [Percent or Number][1]					
	First	Second	Middle	Fourth	Highest	Total
	N[%][Poorest]	N[%]	N[%]	N[%]	N[%][Richest]	N[%]
1. Socio-demographic variables						
Province [2]						

- WCP	… […]	… […]	… […]	… […]	… […]	… [100]
- FSP	… […]	… […]	… […]	… […]	… […]	… [100]
Total	… […]	… […]	… […]	… […]	… […]	… [100]
Cluster/Community [3]						
- Stellenbosch - Mitchell's Plain - Gugulethu - Botshabelo - Mantsopa - Thabo Mofutsanyana	…	…	…	…	…	… [100]
Total						
Age [median [IQR[4]]]	… […;…]	… […;…]	… […;…]	… […;…]	… […;…]	… […;…]
Marital status						
- Never married - Married - Divorced - Separated - Widowed - Married or lived with a man before; current marital status not recorded	…	…	…	…	…	… [100]
Total						
2. Ownership of household assets and access to social amenities						
Main source of drinking water						
- Piped water available in the house - Public tap - Piped water available outside plot - Tube well or borehole	…	…	…	…	…	… [100]

- Tanker truck or cart with small tank or protected well - Other sources [6] **Total**						
Type of toilet facility in the household - Flush or pour flush toilet to piped sewer system - Flush toilet to septic tank or pit - Ventilation Improved Pit [VIP] latrine - Traditional pit latrine or pit latrine with slab or open pit - Bucket toilet - No facility e.g. use of bush or open field - Other **Total**	…	…	…	…	…	… [100]
Household goods ownership - Electricity - Television - Cell phone - Number of cell phones per household[5] [mean [95% CI]] - Refrigerator - Bicycle - Motorcycle - Car	…	…	…	…	…	… [100]
Main material of the floor - Natural floor e.g. earth, mud, dung - Wood Planks - Finished Floor e.g. cement or tiles - Others e.g. category not in any of	…	…	…	…	…	… [100]

the above, or missing observation						
Total						
Food security [past month]						
- Never has enough food to eat - Seldom has enough food to eat - Sometimes has enough food to eat - Usually/always has enough food to eat	…	…	…	…	…	… [100]
Total						
3. Socioeconomic status variables						
Highest educational level attained						
- Primary - Secondary - Tertiary	…	…	…	…	…	… [100]
Total						
Formal employment status						
- Yes - No	…	…	…	…	…	… [100]
Total						
Occupational group [7]						
- Group 1 - Group 2 - Group 3 - Group 4 - Group 5 - Group 6 - Group 7 - Group 8	…	…	…	…	…	… [100]
Total						

4. Basic literacy skills/ability	
Basic literacy skills	
- Can't read	… … … … … … [100]
- Able to read parts of sentence	
- Able to read whole sentence	
- No card with required language or blind or visually impaired	
Total	

Data are number [percent] unless otherwise indicated.

[1] Wealth quintiles will be derived using Principal Component Analysis [PCA] in STATA Special Edition version 12.1. Wealth quintile categories **First**=Lowest quintile ['Poorest' on a relative asset index scale]; **Second**=Second quintile; **Third**= Middle quintile; **Fourth**=Fourth quintile; **Fifth**=Highest quintile ['Richest' on a relative asset index scale]

[2]Provinces in South Africa: **WCP**=Western Cape Province; **FSP**=Free State Province

[3]Cluster refers to a sub-district that was composed of several health facilities [also referred to as 'service cluster' in this study]

[4] IQR=Interquartile range

[5]Proportions were adjusted for survey sampling approach

[6] These includes households with missing responses, those getting water from unprotected wells, protected well, bottled water, surface water [such as river, dam, lake, pond, canal, or irrigation channel], rainwater or other unspecified sources.

[7]**Occupation categories: group1**=managers or employers in a company, NGO or organization; **group2**=farmers; **group3**=government workers; **group4**=healthcare workers; **group5**=secretaries; **group6**=small business owners or traders; **group7**=students; **group8**=other [these includes chefs, domestic workers; machinists; shop assistants and any other occupation not fitting in the above specified categories etc.]

[8] **PMTCT**= Prevention of Mother To Child Transmission of HIV

[9] **HIV**= Human Immunodeficiency virus

[10] **VCT**= Voluntary Counselling and Testing

2.8.2. Multivariate analysis

Logistic regression for survey data will be used to establish both unadjusted and adjusted relationship [adjusted for age, residence type and marital status] between HIV and SES. Prevalence odds ratios [POR] and 95% CI will be reported as shown in **table A4.**

Table A4: Results from multiple logistic regression for survey data, and confounders where indicated, of the relationship between HIV and specific SES proxy variables [dummy table]

Variable	Model 1 [OR: CI]	Model 2 [OR: CI]	Model 3 [OR:CI]	Model 4 [OR: CI]	Model 5 [OR: CI]	Model 6 [OR: CI]
Data points in specified model [N]	N=…	N=…	N=…	N=…	N=…	N=…
Confounders adjusted in specified model[1]						
Age	NA	…[…;…]	NA	… […;…]	NA	… […;…]
Marital status						
▪ never married[2]	NA	1.0	NA	1.0	NA	1.0
▪ married		… […;…]		… […;…]		… […;…]
▪ divorced		… […;…]		… […;…]		… […;…]
▪ separated		… […;…]		… […;…]		… […;…]
▪ widowed		…[…;…]		…[…;…]		…[…;…]
▪ married before[3]		… […;…]		… […;…]		… […;…]
Residence type[4][rural=ref]	NA	… […;…]	NA	…[…;…]	NA	…[…;…]
SES latent variables in specified model						
Years of formal education	…[…;…]	… […;…]	NA	NA	NA	NA

Education category[5]						
▪ Primary	NA	NA	1.0	1.0	NA	NA
▪ Secondary			…[…;…]	…[…;…]		
▪ Tertiary			…[…;…]	…[…;…]		
Formal employment status[6]	NA	NA	NA	NA	…[…;…]	…[…;…]
Asset score[7]	NA	NA	NA	NA	NA	NA
P-value of model	…	…	…	…	…	…
Constant from model	…	…	…	…	…	…

…continuation of **table A4**

Variable	Model 7 [OR: CI]	Model 8 [OR: CI]	Model 9 [OR: CI]	Model 10 [OR: CI]	Model 11 [OR:CI]	Model 12 [OR:CI]
Sample size in specific model	N=…	N=…	N=…	N=…	N=…	N=…
Confounders adjusted in specified model[1]						
Age	NA	…[…;…]	NA	…[…;…]	NA	…[…;…]
Marital status						
▪ never married	NA	1.0	NA	1.0	NA	1.0
▪ married		… […;…]		… […;…]		… […;…]
▪ divorced		… […;…]		… […;…]		… […;…]
▪ separated		… […;…]		… […;…]		… […;…]
▪ widowed		…[…;…]		…[…;…]		…[…;…]
▪ married before[3]		… […;…]		… […;…]		… […;…]
Residence type[2][rural=ref]	NA	…[…;…]	NA	…[…;…]	NA	…[…;…]
SES latent variable in specified model						
Asset score[4] [1st PC]	…[…;…]	…[…;…]	NA	NA	NA	NA
Asset quintile[6]						
▪ Lowest [ref]	NA	NA	1.0	1.0	NA	NA

▪ Second				… […;…]	… […;…]		
▪ Middle				… […;…]	… […;…]		
▪ Fourth				… […;…]	… […;…]		
▪ **Highest**				…[…;…]	…[…;…]		
Occupational group[5]							
▪ **I [ref]**	NA	NA	NA	NA	NA	1.0	1.0
▪ **II**						… […;…]	… […;…]
▪ **III**						… […;…]	… […;…]
▪ **IV**						… […;…]	… […;…]
▪ **V**						…[…;…]	…[…;…]
▪ **VI**						… […;…]	… […;…]
▪ **VII**						… […;…]	… […;…]
▪ **VIII**						… […;…]	… […;…]
P-value of model	…	…	…	…	…	…	…
Constant	…	…	…	…	…	…	…

Key: CI=95% Confidence Interval; **ref**=reference category; **OR**=Odds Ratio**; NA**=Not Applicable; **PC**=Principal Component; … insufficient data to produce estimates in regression model

[1] Only variables meeting criteria for confounders will be adjusted in specific models.

[2]Options: Urban or rural. Baseline comparison group is rural residence

[3]Education: years of formal education was used in the initial model then regression modelling was repeated using education category instead of years of formal education

[4]In the event that a continuous variable [wealth index] is found unsuitable in representing the SES/HIV relationship, i.e. if after modelling diagnostics it is found that the SES/HIV relationship is best represented by modelling that takes consideration of a non-linear relationship, wealth quintile categories, or if not- percentiles, will be used to model the SES/HIV relationship

[5]**I**= Housewife [reference group]; **II**= Farmer or Small business owner or Trader; **III**=Student; **IV**=Healthcare worker or Secretary; **V**=Other.

OR and 95% CI will be presented adjusted for sampling design and clustering at the health facility catchment area level. Wealth index variable will be developed using Principal Components Analysis summarizing household ownership of assets and access to social amenities

2.9. Ethical considerations

The primary study was approved by Institutional Review Boards of the United States Centers for Disease Control and Prevention, University of Alabama in Birmingham, Human Research Ethics Committee of the University of Cape Town [**appendix 1**] and Health Departments of Provincial Government of Free State and Western Cape Provinces of SA. Ethical approval for this study will be sought from the Human Research Ethics Committee of the University of Cape Town. **Table A5** shows timetable of events related to ethical considerations.

Table A5: Timetable of events related to ethical considerations

Documentation required	Time frame
Preparation of research protocol	8-16 weeks [January 2013 to April 2013]
Submission of protocol	Await 4-7 weeks for approval by UCT ERC
Progress and planned activity form	Yearly requirement from 2013 till formal submission of thesis.
Possible amendments to research protocol [as	2-4 weeks

case applies]	
Write up of thesis	12-20 weeks
Review of thesis by external supervisors	8-12 weeks
Avail thesis, and publication after institutional approvals, in UCT library or on UCT electronic platform	April to June 2014

Potential risks: There are no new risks to study participants.

Potential benefits: Our results will be useful to non-governmental organisations involved in HIV prevention and care and the Department of Health's approach at design of HIV prevention messages.

Informed consent: The purpose of the primary study, study procedures, risks, benefits, confidentiality and contact person for the study as well as the fact that participation was voluntary was made known to participants in a language they were comfortable with. Informed written consent was then obtained. All participants were encouraged to go for HIV testing and were referred to local health facilities for individual HIV counseling and testing.

Confidentiality: All HIV testing was done anonymously. After leaving households where blood was taken, names of participants were removed before tests were conducted. All parent study documents, informed consent forms, questionnaires, laboratory results, and electronic records are only identified by coded numbers and will remain confidential and locked in a secure place at

UCT. Such records will only be accessible to authorized personnel. Interviews were carried out in private and confidential environment after comfort, rapport and mutual trust had been established. As frequent as feasible, same sex interviewers were utilized to conduct interviews.

Communication: Publication of results from this analysis will be guided by UCT publication guidelines. This will follow rigorous review by UCT approved post-graduate student supervisors and other peer reviewers before communication of study findings to the public. Published article will also be availed through UCT library and its online platform [table A6].

Table A6: Stakeholder dissemination procedure

Stakeholders	Dissemination procedure
PEARL study PI in South Africa and dissertation supervisor	Frequent contact for guidance and update on study analysis [every 2-4 weeks till submission of thesis]
Avail thesis [and publication following institutional approval] in the UCT library or on its electronic platform	Second quarter of 2014
Epidemiology and surveillance departments of the Western Cape and Free State Provincial Governments	Second to third quarter of 2014
If feasible, report findings in the Western Cape Newsletter and the Western Cape Portal intranet	Second to third quarter of 2014

3. Logistics

3.1. Budget

No direct costs are involved in this study save the author's time and commitment because;

- Analysis is based on secondary data.
- Access to bibliographic references, scientific support and supervision are provided by the University of Cape Town as part of its Master of Public Health degree programme, of which this dissertation constitutes a requirement.

3.2. Project plan

This study is projected to take 18 months as shown in **table A7.**

Table A7: Master's degree thesis work plan

Activity	Timeline																			
	2012		2013												2014					
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Identify research question																					
Write research synopsis																					
Brief literature review for protocol																					
Write draft protocol																					
Draft protocol review by supervisor																					
Submit synopsis to dept head																					
UCT ERC ethical approval																					
Data management																					
Data analysis																					
Dissertation																					

write up																					
Consolidated thesis review by supervisor																					
Thesis revision/edit																					
Thesis submission																					
Thesis review [if required]																					
Thesis accepted																					
Avail thesis in library and DoH, WCP & FSP																					

KEY	
	Timeline within which the activity should be completed
DoH	Department of Health
WCP	Western Cape Provincial Government
FSP	Free State Provincial Government

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SECTION B:

LITERATURE REVIEW

Relationship between Socioeconomic Status and Human Immunodeficiency Virus infection in the Free State and Western Cape Provinces of South Africa

5. Introduction

Studies in developed countries have consistently shown an inverse relationship between socioeconomic status [SES] and morbidity and mortality. This has been observed at all levels of income; with the gradient being less pronounced at higher income levels [1, 2, 3]. This gradient varies depending on the disease, but is present for most major causes of death [3]. A similar consistent inverse relationship has been observed between SES and Human Immuno-deficiency Virus [HIV] infections in developed countries but not in sub-Saharan Africa [SSA] where inconsistent patterns have been observed.

The objectives of this literature review are:

5.1. Objectives of Literature review

- To highlight key features of the global, SSA and South African [SA] HIV epidemic.
- To profile key modes of HIV transmission.
- To summarize literature on key epidemiological determinants of HIV transmission.
- To summarize literature on the association between SES and HIV in SSA.
- To identify opportunities for further research relating to SES and HIV.

5.2. Literature search strategy

A literature search was conducted in '*google scholar'* and '*pubmed*', electronic databases. **Appendix 4** describes the search strategy in more detail. The book, '*HIV/AIDS in SA*' by Karim et al [4] was found to be a useful starting reference for information on HIV/AIDS in SA.

5.3. Quality and Relevance criteria for inclusion of studies

Papers in this review were appraised using '*GRADE Working Group'* recommendations [5]. In brief, the Grading of Recommendations Assessment, Development and Evaluation [GRADE] is a systematic approach of grading quality of evidence and strength of recommendations. Quality of evidence is categorized as high, moderate, low or very low based on assessment of likelihood of bias; inconsistency of results; indirectness and paucity of evidence. Other considerations borne in mind include; risk, inconvenience and costs, importance of outcome that exposure or treatment confers, magnitude of effect, precision of estimate of effect, risks associated with therapy, burdens of therapy, risk of target event and varying values. Items relevant to our study design were applied in our literature review. The GRADE approach is described further at *http://www.gradeworkinggroup.org/* [5].

6. HIV/AIDS

6.1. Burden of HIV/AIDS

6.1.1. The Global and sub-Saharan Africa HIV epidemic

In 2012 35.3 million people were living with HIV globally [6] and by 2012 20 million had already died of AIDS [4]. An estimated 0.8% and 4.9% of individuals between ages 15-49 years globally and in SSA respectively have HIV[7] [**appendices 5** and **6**[7]]. Despite a 33% global reduction in HIV incidence in 2012 compared to 2001[6], two thirds of the global epidemic[7] is in SSA with 25 million prevalent infections [6], yet SSA accounts for only 10% of the world's population. HIV incidence has declined but global HIV prevalence continues to rise because antiretroviral treatment scale-up results in fewer HIV-related deaths [8, 9]. Within countries, specific sub-populations such as, Injecting Drug Users [IDU], young women aged 15-24 years of age, Commercial Sex Workers [CSWs] and Men who have Sex with Men [MSMs] are experiencing a stable or rising incidence of HIV [7, 10].

6.1.2. The South African HIV epidemic

SA experienced one of the fastest growing HIV epidemics with an estimated 6.4 million people living with HIV in 2012[11]. This was 17% of the global burden and the largest number of people living with HIV [4] in any given country. In 2012 SA had a national HIV prevalence of 12.3% [11] and 16.9% [12] in individuals of all age groups and in those aged 15-49 years respectively. HIV prevalence varied by age, gender [**appendix 9**] and province [**appendix 10**] [4].

Prior to 1987, HIV epidemic in SA was predominantly due to subtype B, and was largely concentrated in MSMs and recipients of blood products. The current epidemic, is mainly due to heterosexual transmission, is mainly due to subtype C, and became significant from 1987. There was an exponential growth of the epidemic between 1995 and 2000, with a peak around 1997 and leveling of the epidemic from 2005. This leveling is unlikely to have been due to interventions at the time, considering political and policy positions in place, but was due to natural saturation of the epidemic [4]. The SA Medical Research Council estimates that in 2000, 40% and 25% of mortality between the ages of 15-49 and in all age groups respectively was attributed to HIV/AIDS. The key risk drivers of the HIV epidemic in SA are; migrant labor system, socioeconomic and gender inequalities, high burden of STIs [4], low rates of male circumcision[MC], high levels of sexual partner concurrency, intergenerational sex and failure of past prevention programs and, apartheid and political factors over the last three decades[4]. The role of apartheid and political factors is discussed in **section 7.4.4**.

6.2. HIV transmission

HIV type 1 is responsible for most of the global HIV pandemic with subtype 1A accounting for 12%, subtype 1B 11% and subtype 1C 48% of all cases of HIV. HIV 2 is less transmissible than HIV 1 and is mainly confined to West Africa [13]. HIV transmission occurs mainly via sexual, parenteral or vertical transmission. **Heterosexual transmission** accounts for 85% of the HIV epidemic in SSA [4].

Mother To Child Transmission of HIV accounts for roughly 10% of new cases globally [330 000 infections], 90% of which occur in SSA [7, 14]. This occurs in utero [20%], during delivery [50%] or

breastfeeding [30%]. Without intervention, transmission rates range from 15% in non-breastfed infants to 45% in infants breastfed up to 24 months [15]. With HAART, risk of vertical HIV transmission can be reduced to below 2% [4]. There are 2 million HIV-infected children globally. This is approximately 6% of the global HIV burden [7].

Injecting Drug Use [IDU]: There are 16 million IDUs globally; 3 million of whom are infected with HIV, accounting for 10% and 30% of the HIV burden globally and in countries outside Africa respectively [7, 16, 17]. China, United States, Russian Federation and Brazil have the largest population of IDUs as together they account for 45% of the global population of IDUs [17]. In SSA, there is growing concern about emerging epidemics of HIV among IDUs in several countries [18] such as Kenya, Ghana, Nigeria, Democratic Republic of Congo, Tanzania and South Africa. This has occurred against a backdrop of high HIV prevalence in the general population and a burgeoning number of drug injectors thought to be linked to the role that many African countries play as trans-shipment routes in the global trafficking networks for heroin, cocaine, and other drugs [18]. There are an estimated 1,778,500 IDUs in SSA; 221,000 of whom are HIV-infected [16].

Men who have Sex with Men: A meta-analysis of surveillance data in low- and middle-income countries [LMIC] found that MSMs are 19.3 times more likely to be infected with HIV than men in the general population [19]. In 2012, the highest median HIV prevalence among MSM was reported in Western and Central Africa [19%], and Eastern and Southern Africa [15%], with lower but still high levels of HIV infection reported among MSMs in Latin America [12%], Asia and the Pacific [11%], Western and Central Europe and North America [8%], and the Caribbean [7%][20].

At country level, HIV prevalence among MSMs ranges between 0% and 32.9%, with rates surpassing 20% in Bolivia, Jamaica, Mexico, Myanmar, Thailand, Trinidad and Zambia [20]. In Latin America, up to 50% of HIV infections occur in MSMs [19]. In general, studies show an increasing significance of MSMs in HIV transmission especially in developed countries [7].

7. Risk factors for HIV transmission

The determinants of spread of HIV in a population can be expressed as;

$R_0=\beta CD$: Where R_0=reproductive rate; β=probability of HIV transmission per sexual act, C=rate of contact between HIV infected and susceptible individuals, and D=duration of HIV infectivity.

These factors are in turn influenced by interrelated socio-demographic, biomedical, behavioral, and structural factors shown in **figure B1**. The R_0 for HIV is between 5 and 10[21].

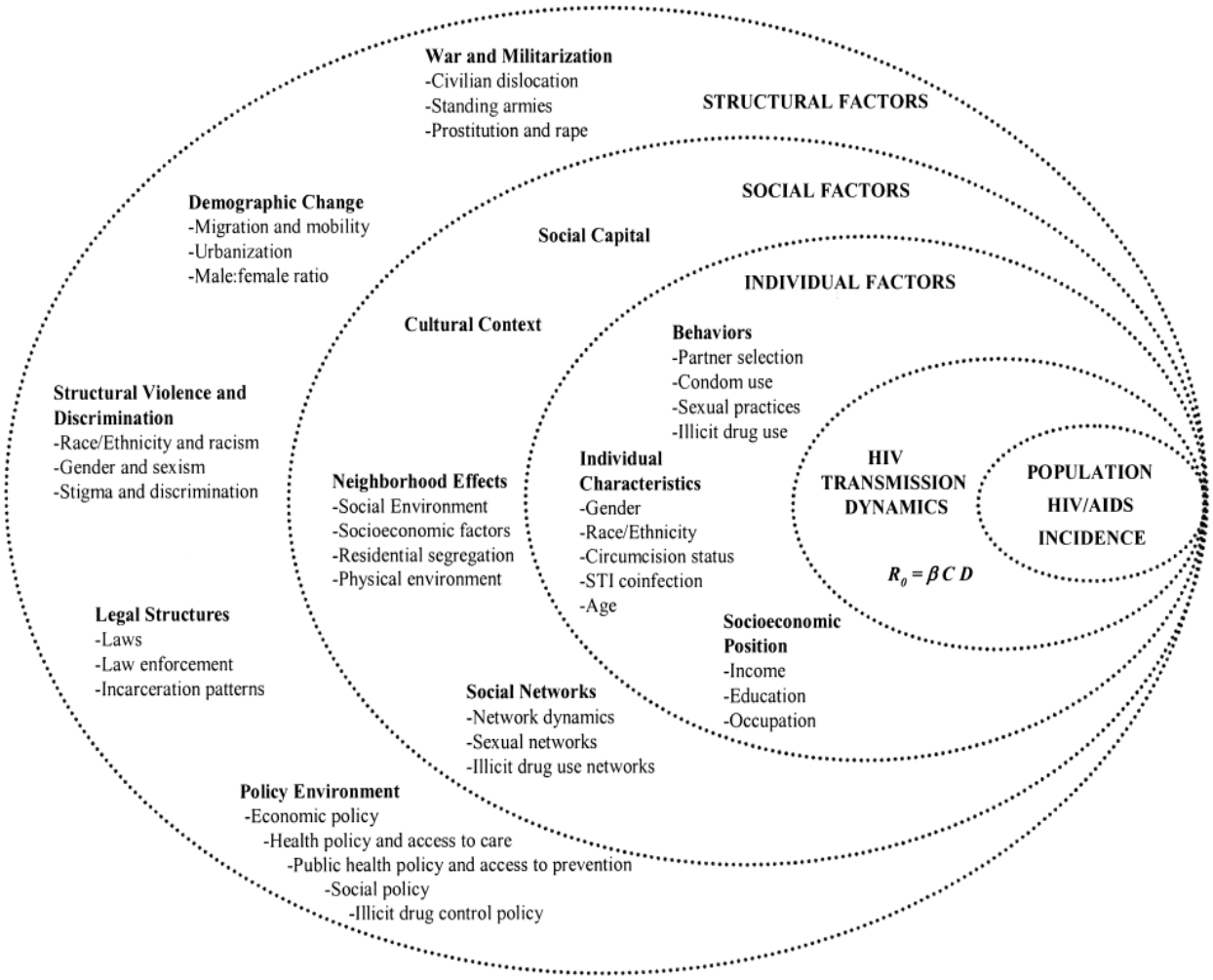


Figure B1: A conceptual framework of social epidemiology of HIV/AIDS [derived from Poundstone et al [22]]. This figure uses a socioecological model to depict determinants of a HIV epidemic. Extensive linkages exist between factors at different levels to give rise to observed epidemic patterns.

7.1. Socio-demographic factors

7.1.1. Age and Gender

Adolescents and young adults aged 15-24 years constitute 45% of new HIV infections globally, with the risk being higher in females than males of corresponding age [10]. A defining characteristic of the HIV epidemic in SSA is the age-sex differences in HIV infections; women acquire infection 5-7 years earlier than men who mainly acquire infection in their mid-twenties [10].

Globally, the percentage of women with HIV infection has remained stable at about 50% for several years [23], with inter-regional variability; 60% in SSA, 45-50% in the Caribbean, 30-40% in Asia and Latin America, and 30% in Eastern Europe and Central Asia [24, 15, 25]. Men have been shown to have more extra-marital partners than women [OR 2.54; p=0.039], but this number reduces with increasing age [OR 0.97, p=0.001][26].

7.1.2. Residence

In SA, HIV prevalence varies significantly across provinces [**Appendix 10**] and type of residence [27]. HIV is highest in urban informal settlements [21.3%], as compared to urban formal settlements [12.1%] or rural areas [8.7%] [28].

7.1.3. Other socio-demographic factors

Marital status, race, religion and alcohol intake

HIV prevalence differs by **marital status** with widowed, separated or divorced individuals having a higher prevalence than single, married or cohabiting individuals [9, 29, 30]. A Kenyan study showed a higher HIV prevalence in Christians [10.3%] than Muslims [3.4%] [29] and a direct relationship between **alcohol intake** and risk of HIV infection [29].

In SA, where **race** has been shown to be a proxy for SES, HIV risk in African women is substantially higher than that in women of other racial groups [31]. HIV prevalence in Africans is 13.6%, as compared to 0.3% in whites, 1.7% in coloureds and 0.3% among Indians [12]. This association is due to confounding effect of SES.

7.2. Biomedical factors

7.2.1. Male Circumcision

Male Circumcision [MC] reduces risk of heterosexual female-to-male transmission of HIV by 50-60% [32-34]. This occurs via [21]:

- Reduction in density of primary target cells [*Langerhan* cells] for HIV transmission concentrated in the foreskin.
- Reduction in risk of ulcerative STIs and micro-traumatic lesions in the foreskin.
- Easier recognition, and thus faster treatment, of genital ulcers in circumcised than uncircumcised individuals [35].

Significant negative association between MC and HIV in Africa exist with countries with MC rates below 30% and above 90% having median HIV prevalence of 17% and 2.9% respectively [21]. However, this association only explains much of the five-fold difference in HIV rates between Southern and Western Africa but not between Southern Africa and Europe which have similar MC rates [36]. Modeling shows that MC roll-out will avert 6 million new infections and save 3 million lives in SSA over the next twenty years [21].

7.2.2. Sexually Transmitted Infections

Classical Sexually Transmitted Infections [STIs] are STIs caused by bacteria, fungi, protozoa or viruses other than HIV. SA has one of the highest prevalence of classical STIs with 49-90% of family planning and antenatal clinic [ANC/FP] attendees having at least one STI [37]. Recruitment of HIV target cells [*T-lymphocytes* and *macrophages*] to the genital tract during inflammation by STIs in HIV-negative individuals, and increased viral shedding in ulcerative STIs [herpes, syphilis, and chancroid] by HIV-positive individuals is associated with increased risk of HIV transmission. HIV transmission is higher for ulcerative than non-ulcerative STIs [gonorrhea, Chlamydia, and trichomoniasis] [up to 5.3 times higher [38]], or other genital infections [bacterial vaginosis and vaginal candidiasis], and for symptomatic than asymptomatic STIs [4, 38, 39]. The proportion of incident HIV infections attributed to STI is high in SSA, with herpes simplex virus [HSV] alone accounting for 25-35% [39, 40] of incident HIV infections.

7.2.3. Stage of HIV disease

High viral load, as occurs in acute HIV infection or advanced HIV, is associated with higher risk of HIV transmission as compared to the chronic asymptomatic phase of HIV [41]. It is estimated that 43.4% of new HIV infections occur during acute HIV infection [41].

7.3. Behavioral factors

The key behavioral factors influencing risk of HIV infection include:

7.3.1. Multiple sexual partnerships

Individuals in SSA have a similar number of lifetime sexual partners as compared to heterosexuals in many developed countries [42, 43]. However, concurrent partnerships are more common in the former than the latter [44]. Increasing evidence shows a direct association between concurrency and more rapid HIV transmission [45, 46]. HIV infection spreads slower in the latter where it is 'trapped' for months or years [46].

Commercial Sex Workers [CSWs] require special mention due to their high HIV prevalence and their special role in HIV spread [47]. Sex work is classified as ''direct'' [open or formal] or ''indirect'' [hidden, clandestine or informal]. The former includes individuals who define themselves as sex workers and earn their living by selling sex. The latter refers to instances where sex work is not the primary source of income. Such individuals work as waitresses, hairdressers, tailors, massage girls, street vendors, or beer promotion girls and supplement their income by selling sex on a regular or occasional basis [48].

A meta-analysis representing 99 878 CSWs from 50 LMIC, showed an overall HIV prevalence of 11·8% [95% CI: 11·6–12·0] and a pooled OR for HIV infection of 13·5 [95% CI: 10·0–18·1] as compared to women of reproductive age in those countries. It showed notable variation by region, reflective of background rates of HIV. In 26 countries with medium or high HIV prevalence, 30·7% [95% CI 30·2–31·3; 8627 of 28 075] of sex workers were HIV-positive with an OR for infection of 11·6 [95% CI 9·1–14·8] [48]. The vaginal microbicide trial conducted in CSW in SA between 1996 and 1999 showed a HIV prevalence in CSW of 51% [95% CI: 47–56%] and an annual incidence of HIV infection of 18% [95% CI: 13–23%] [49]. In SSA, prevalence of commercial sex work ranges between 0.4% and 4.3% in capitals and urban areas. Studies show a continued role of CSW in HIV transmission even in countries with generalised epidemics [48, 50].

7.3.2. Intergenerational sex

Age-disparate sexual relationships are relationships where the age gap between partners is at least 5 years whereas in intergenerational relationships the gap is at least 10 years [51]. Besides economic dependence, these relationships are driven by social, physical and psychological benefits [51]. Age disparity and economic dependence compromise women's ability to negotiate safe sex [52-54]. A study in Botswana showed that every 1 year increase in age disparity is associated with a 28% increase in odds of having unsafe sexual practices [55]. In SA, a nationally representative sample showed a 40-70% higher HIV risk in age-disparate as compared to non-age-disparate relationships [31, 53, 56].

7.3.3. Intimate Partner Violence [IPV]

A multi-country WHO study in LMIC [Bangladesh, Brazil, Ethiopia, Japan, Namibia, Peru, Samoa, Serbia and Montenegro, Thailand, and Tanzania] showed lifetime prevalence of physical or sexual partner violence or both to be between 15%-71% [57]. 2 sites had prevalence of less than 25%, 7 sites had prevalence between 25%-50%, and 6 sites had prevalence of between 50% and 75% [57]. A Tanzanian study showed risk of IPV to be higher in age-disparate than in non-age disparate relationships [OR=4.7; CI; 1.95 - 11.40]; in HIV positive than HIV negative women [OR=2.63; CI:1.23 - 5.63]; in women with secondary education [or less] than those with post-secondary education [OR=5.15; 95% CI: 1.06, 25.05]; in older women [OR >10] than younger women; and in women whose partners were polygamous than those whose partners were monogamous [OR=5.09; 95% CI; 1.85, 13.99] [58]. IPV was less in unmarried and non-cohabiting women as compared to married women [OR=0.12: 95% CI; 0.04; 0.35].

The higher risk of HIV transmission in relationships with IPV is due to; forced and violent sexual intercourse, poor negotiation of safe sex and the fact that women in violent relationships are less likely to disclose their HIV status, to seek HIV counseling, testing and care, and to adopt HIV prevention interventions such as PMTCT services [58].

7.3.4. Unsafe sexual practices

Consistent condom use remains low in SSA despite its demonstrated effectiveness in HIV prevention and high levels of knowledge on HIV/AIDS [59]. Consistent condom use with all non-spousal partners remains low in SSA at 11-24% [60]. In SA, condoms are not used in up to 40% of recent sex episodes [4].

7.3.5. Other risky sexual behaviors

Up to 62% of 15-24 year old individuals have had sexual debut in SA, with 11% of men and 6% of women having had sex by 15 years ['early sexual debut'] [4]. Early sexual debut is associated with higher risk of HIV transmission [9].

7.4. Structural factors

Structural factors refer to 'physical, social, cultural, organizational, community, economic, legal, or policy features of the environment that impede or facilitate persons' efforts' [61] to avoid HIV infection. Key structural factors include; economic development and disparities, gender-based inequalities and violence, societal norms, population movement and mobility, public policies and, stigma and discrimination [62].

7.4.1. Discrimination

Gender inequality, violation of human rights and discrimination as occurs in sub-populations that have been marginalized socially, culturally, and often economically, such as IDUs, CSWs, migrants and MSMs is associated with higher risk of HIV [63].

7.4.2. Gender inequality

Unequal power relationships render women into a subordinate position that makes them socially and financially dependent on men, with limited access to resources, finances, employment, education and healthcare. Thus, higher household wealth may not equate with better quality of life for women in settings with gender inequality. For example, a wealthy sexual partner may

have more access to transactional sex, concurrent sexual partners and other risky behaviours which in turn increase women's vulnerability to HIV [24].

7.4.3. Migration

'Circular' migration between urban centers in SSA, especially mines for work in Southern Africa, and rural homes contributes to separation from socio-cultural norms that guide behaviour [64] and conjugal instability which favours concurrency and transactional sex that in turn promotes STI transmission including HIV. Migration contributed to the magnitude and rapidity of spread of HIV epidemic in Southern Africa[4] by increasing sexual networking[65-67] and transactional sex which in turn increased risk of HIV transmission by as much as 2.4 times in migrant as compared to non-migrant men[68]. Mobile individuals are harder to reach for HIV preventive care or treatment services [69].

7.4.4. Political factors and policy environment

There was lack of comprehensive HIV/AIDS policies by successive governments early in the HIV epidemic in SA that led to slow adoption of HIV prevention programmes [4, 70]. Racial segregation, entrenched gender inequality and disparities in provision of education and health facilitated spread of HIV [70]. Apartheid led to inequalities and segregation in access to health, education, economic opportunities and social amenities. This coupled with AIDS denialism by key political leaders and influential policy makers in late 1990s and early 2000s led to poor policies for prevention and control of HIV. There was, for example, opposition to use of HAART and resistance to introduction and promotion of PMTCT and other HIV prevention programs by

political leaders including the minister of health in early 2000s which facilitated spread of HIV [71].

8. Socioeconomic Status

'Socioeconomic position' , rather than SES, is gaining wider acceptance as the more appropriate term to encompass resource-based measures [such as income and wealth], social disadvantage and prestige-based measures [defined as rank or status in a social hierarchy] that influence an individuals' access to health. We adopted Grotto et al.'s definition of SES as 'socially derived economic factors that influence positions held by individuals or groups within stratified structure of society' [72, 73].

Common measures of SES include; educational attainment, income, employment status, type of occupation and measures of wealth or poverty. Other proxy measures of SES include race, expenditure and, residence [urban or rural dwelling] [74]. Although SES has been studied extensively, there is no standard measure or consensus on how to quantify it [74]. In SA, race and informal dwelling have been shown to be useful proxies for SES due to historical and political factors. It is largely agreed that some indicators most widely used to quantify SES in high-income countries like household and individual income perform poorly in contexts with widespread poverty [72]. SSA countries experiencing fast rates of globalisation that have wide economic inequality such as SA, SES has been hypothesized to relate similarly to health as it does in industrialized countries [75]. Different measures of SES relate to health differently depending on; setting, racial or ethnic group, degree of income inequality, gender and socio-cultural or ethnic background. SES can change over an individual's lifetime [76].

9. Relationship between household SES and HIV in SSA

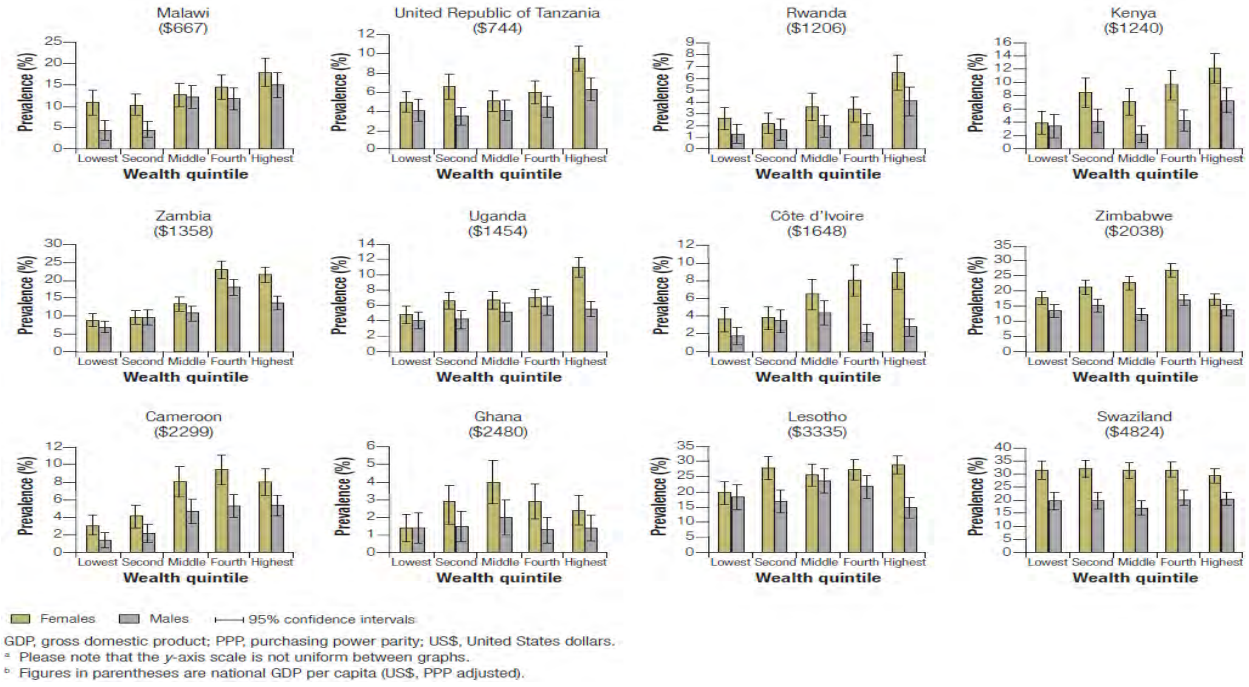
It is often asserted that AIDS is at the core of a 'vicious circle' in which impact of AIDS increases poverty, whereas poverty increases vulnerability to HIV infection [63]. In high income countries there is a well established inverse association between SES and HIV whereas in developing countries no consistent pattern has been observed across all countries. However, increasing evidence at individual and national level indicates that wealthier countries in SSA and relatively wealthier individuals within these countries are also at a heightened risk of HIV infection, which many often underestimate [Figure B2 and table B1] [77, 78]. Table B1, and figure B2, shows results of the association between wealth and HIV by a study that showed;

- a direct association for both men and women [unless otherwise specified] between HIV and wealth in Malawi, United Republic of Tanzania [2003/2004], Rwanda, Kenya [women], Zambia, Uganda, Ivory Coast [women], Cameroon, Lesotho [women];
- lack of or absence of a clear association in Zimbabwe [men], Ghana, Swaziland, and Lesotho [men]; and a
- mixed association in Zimbabwe [women], Ivory Coast [men], Tanzania [2007/2008] and Kenya [men].

Table B1: Relationship between HIV prevalence and wealth quintile in SSA [Parkhurst et al [78]]

Country and year of survey	Wealth quintile	Women			Men		
		Prevalence (%)	95% CI	χ^2 test for trend	Prevalence (%)	95% CI	χ^2 test for trend
Malawi, 2005[25]	Lowest	10.9	8.0–13.8	14.80 ($P<0.001$)	4.4	2.1–6.7	37.85 ($P<0.001$)
	Second	10.3	7.8–12.8		4.6	2.7–6.5	
	Third	12.7	10.0–15.4		12.1	9.4–14.8	
	Fourth	14.6	11.8–17.4		11.7	9.0–14.4	
	Fifth	18.0	14.7–21.3		14.9	11.9–17.9	
United Republic of Tanzania, 2003–04[32]	Lowest	2.8	1.8–3.8	90.81 ($P<0.001$)	4.1	2.7–5.5	37.11 ($P<0.001$)
	Second	4.6	3.3–5.9		4.3	3.0–5.6	
	Third	6.8	5.3–8.3		4.3	3.0–5.6	
	Fourth	10.9	9.1–12.7		7.7	6.1–9.3	
	Fifth	11.4	9.8–13.0		9.4	7.8–11.0	
United Republic of Tanzania, 2007–08[33]	Lowest	5.0	3.9–6.1	22.67 ($P<0.001$)	4.1	3.0–5.2	10.86 ($P=0.001$)
	Second	6.6	5.3–7.9		3.5	2.5–4.5	
	Third	5.1	4.0–6.2		4.1	3.0–5.2	
	Fourth	6.0	4.9–7.1		4.5	3.4–5.6	
	Fifth	9.5	8.2–10.8		6.3	5.1–7.5	
Rwanda, 2005[26]	Lowest	2.6	1.7–3.5	26.82 ($P<0.001$)	1.3	0.5–2.1	15.42 ($P<0.001$)
	Second	2.2	1.4–3.0		1.7	0.8–2.6	
	Third	3.6	2.5–4.7		2.0	1.1–2.9	
	Fourth	3.4	2.3–4.5		2.1	1.2–3.0	
	Fifth	6.5	5.0–8.0		4.1	2.9–5.3	
Kenya, 2003[27]	Lowest	3.9	2.2–5.6	42.86 ($P<0.001$)	3.4	1.7–5.1	10.68 ($P=0.001$)
	Second	8.5	6.2–10.8		4.2	2.4–6.0	
	Third	7.1	5.0–9.2		2.2	0.9–3.5	
	Fourth	9.7	7.4–12.0		4.3	2.7–5.9	
	Fifth	12.2	9.9–14.5		7.3	5.5–9.1	
Zambia, 2008[15]	Lowest	8.8	7.0–10.6	126.51 ($P<0.001$)	6.8	5.2–8.4	42.68 ($P<0.001$)
	Second	9.6	7.8–11.4		9.6	7.4–11.8	
	Third	13.3	11.2–15.4		10.7	8.7–12.7	
	Fourth	22.9	20.5–25.3		18.1	15.9–20.3	
	Fifth	21.6	19.5–23.7		13.6	11.7–15.5	
Uganda, 2004–05[34]	Lowest	4.8	3.7–5.9	47.88 ($P<0.001$)	4.0	2.9–5.1	6.39 ($P=0.012$)
	Second	6.6	5.5–7.7		4.2	3.2–5.2	
	Third	6.7	5.5–7.9		5.1	4.0–6.2	
	Fourth	7.0	5.9–8.1		5.9	4.7–7.1	
	Fifth	11.0	9.7–12.3		5.5	4.5–6.5	
Côte d'Ivoire, 2005[31]	Lowest	3.6	2.3–4.9	32.06 ($P<0.001$)	1.7	0.7–2.7	0.07 ($P=0.798$)
	Second	3.8	2.5–5.1		3.4	2.1–4.7	
	Third	6.5	4.8–8.2		4.3	2.9–5.7	
	Fourth	8.0	6.2–9.8		2.1	1.1–3.1	
	Fifth	8.8	7.1–10.5		2.7	1.7–3.7	
Zimbabwe, 2005–06[30]	Lowest	17.7	15.6–19.8	0.52 ($P=0.470$)	13.4	11.2–15.6	0.66 ($P=0.416$)
	Second	21.1	18.8–23.4		15.1	12.9–17.3	
	Third	22.7	20.4–25.0		12.2	10.2–14.2	
	Fourth	26.8	24.6–29.0		17.1	15.3–18.9	
	Fifth	17.1	15.3–18.9		13.5	11.6–15.4	
Cameroon, 2004[18]	Lowest	3.1	2.0–4.2	35.79 ($P<0.001$)	1.4	0.5–2.3	24.14 ($P<0.001$)
	Second	4.1	2.8–5.4		2.2	1.2–3.2	
	Third	8.1	6.4–9.8		4.7	3.3–6.1	
	Fourth	9.4	7.7–11.1		5.3	4.0–6.6	
	Fifth	8.0	6.5–9.5		5.3	4.1–6.5	
Ghana, 2003[29]	Lowest	1.4	0.6–2.2	1.12 ($P=0.286$)	1.4	0.5–2.3	0.12 ($P=0.730$)
	Second	2.7	1.6–3.8		1.5	0.6–2.4	
	Third	4.0	2.8–5.2		2.0	1.0–3.0	
	Fourth	2.9	1.9–3.9		1.3	0.6–2.0	
	Fifth	2.4	1.6–3.2		1.4	0.7–2.1	
Lesotho, 2004[23]	Lowest	19.6	15.8–23.4	8.03 ($P=0.005$)	18.3	14.2–22.4	0.19 ($P=0.665$)
	Second	27.9	24.2–31.6		16.8	13.0–20.6	
	Third	25.5	21.8–29.2		23.7	19.7–27.7	
	Fourth	27.3	23.9–30.7		21.6	17.8–25.4	
	Fifth	28.9	25.8–32.0		14.8	11.4–18.2	
Swaziland, 2006–07[29]	Lowest	31.6	28.2–35.0	1.15 ($P=0.283$)	19.8	16.5–23.1	0.56 ($P=0.455$)
	Second	32.1	28.8–35.4		19.8	16.6–23.0	
	Third	31.5	28.4–34.6		17.0	14.4–19.6	
	Fourth	31.8	28.9–34.7		21.1	18.4–23.8	
	Fifth	29.4	26.7–32.1		20.4	17.8–23.0	

CI, confidence interval.



GDP, gross domestic product; PPP, purchasing power parity; US$, United States dollars.
[a] Please note that the *y*-axis scale is not uniform between graphs.
[b] Figures in parentheses are national GDP per capita (US$, PPP adjusted).

Figure B2: Prevalence of HIV infection by wealth quintile and gender in 12 SSA countries [Derived from Parkhurst et al [78]]. This figure presents the association between HIV prevalence and asset quintiles at country level. See text for description of this relationship.

Table B2 summarises findings of some studies that have reported data on the relationship between SES and HIV.

Table B2: A select number of studies evaluating relationship between SES and HIV in SSA

-Study, year of publication -Country -Sample size	Population	Study design	Measure of SES used	Adjustments in statistical analysis	Nature of association with HIV[a]
a. Studies showing a mixed pattern of association between SES and HIV					
Wojcicki et al., 2005[76]. Eastern, Central and Southern Africa 30 CS, 5 Cohort/Nested CC and 1 CC study	Female adults [NR]	Systematic review	Education Employment	Age[e]	**12 studies:** Direct **15 studies:** None **8 studies:** Inverse **1 study:** mixed [f]
Hargreaves et al., 2002.[79] Zimbabwe, Zambia, Ethiopia, Tanzania, Uganda 27 studies	M & F 15-49 yrs	Systematic review	Education	Age[e]	**12 studies:** Direct **14 studies:** None **1 study:** Inverse

Hargreaves et al., 2002.[80] **Kenya** **2000**	M & F 15-49 yrs	Cross-sectional study	Education Employment Assets	Age Ethnicity	**M** 15-24: Direct **M** 25-29: **None** **F** 15-24: Inverse **F** 25-49: Direct
Bärnighausen et al., 2007.[69] **South Africa** **3325**	F 15-49; M 15-54	Cohort study	Assets Education [b] Expenditure	Age, sex, wealth, residence type, migration & marital status.	**Assets:** -Higher risk for middle 40% on the wealth scale as compared to lower quintile [RH 1.70]. Wealthiest 30% and poorest 30% showed no difference. **Education:** -Inverse **Household expenditure:** -**None**
Piot et al.,2007[63] **NA** **NA**	M and F adults	NA [This is a commentary]	Education Employment Assets Occupation	NA	Variable association depending on setting
Fox et al., 2012 [26] **16 countries** [i]	M and F adults	Cross-Sectional using DHS data	Assets Education	Education Age Gender	Direct in poorer regions Inverse in richer

133,568				Marital status Regional wealth Country wealth	regions
Rodrigo et al.,2009[24] **Global review with focus on SSA** NR	M & F adults [Age NR]	Systematic review	Assets Education	Varied by included paper	Assets, Education: More papers report an inverse [20] assoc than a direct [6] assoc.
b. Studies showing a positive association between SES and HIV					
Mishra et al., 2007[81] **DHS data for 8 SSA countries** [c] **NR**	**M**:15-49 y **F:**15-49y	Cross-sectional	Assets	A range of social & biomedical mediators [b]	Direct
Parkhurst et al., 2009[78] **12 countries** [h]	M & F 15-49 yrs	Cross-sectional	Assets	None	**7 countries:** Direct in both M & F **2 countries:** Direct in F, no assoc. in M **3 countries: No assoc**
Fox et al.,2010[77] **SSA** **NA**	M & F adults [Age NR]	NA [This is a commentary]	Assets	NA	**SSA**: Direct
Magadi et al.,	F :15-49;	Cross-sectional	Assets	A range of social &	**Assets**: Direct

2010[9] **SSA: DHS dataset for 20 countries** [j] **171,536**	M:15-59		Education	biomedical mediators [k]	**Education**: Direct
Johnson et al., 2003[29] **Kenya: DHS data** **F: 3,273** **M: 2,941**	F :15-49; M: 15-54	Cross-Sectional [nationally representative survey]	Assets Education	No. of sexual partners Age Marital status Residence type [g] Alcohol use Religion Province Sexual debut	**Assets**: Direct for both M & F. **Education**: None
Quigley et al., 1997[82] **Tanzania** **1416**	F :15-54; M: 15-54	Case -Control	Education Occupation	Age group Type of residence	**Occupation:** Fishermen, manual workers, office workers at higher risk than farmers. **Education:** **M**: None **F**: Direct
c. Studies showing a negative association between SES and HIV					
Hargreaves et al., 2007[83] **South Africa** **3881**	M & F 14-35 yrs	Cohort study	Assets Education	-Age, -marital status, -residence, -trial arm,	**Assets:** **M**: None **F**: None **Education:**

				F:-history of birth	M: None F: Inverse
Johnson et al., 2009[31]. South Africa 99,153	F 15-49 yrs attending ANC	Cross-Sectional [repeated nationally representative surveys]	Education [High vs Primary school]	-Race, syphilis, no of pregnancy, -age of sexual partner Province	15-24 yrs: Inverse between 2001 & 2005 25-49 yrs: None
Gillespie et al., 2007[84] SSA NA	M & F adults [Age NR]	Commentary	Assets Education	NA	Assets: Inverse Education: Inverse
d. Studies showing a changing association over time [i.e. Dynamic social gradient in HIV]					
Hargreaves et al., 2013[85] NA NA	NA	Commentary	NA	NA	<1996 most studies found a direct relationship whereas ≥1996 most studies found an inverse relationship.
Hargreaves et al., 2010[86] Tanzania 26, 476	M & F 15-49 yrs	Cross-sectional: Compared 2003/4 & 2007/8 in same source population	Education	Age Sex Residence[urban/rural] Household wealth	HIV prevalence was stable among those with no formal education[~4%], whereas it fell steeply among those with secondary

					education[8% to 2%]
Hargreaves et al., 2008.[87] **Zimbabwe, Zambia, Malawi, Tanzania, Uganda 36 studies >200,000**	M & F 15-49 yrs	Systematic review	Education	Age Ethnicity Setting	**20 studies:** Direct **44 studies:** None **8 studies:** Inverse Studies **<** **1996:** mainly found either No or Direct assoc. Studies **≥** **1996:** mainly found inverse assoc.
MMbaga et al., 2007[88] **Tanzania 2680**	M & F 15-44 yrs	Cross-sectional: Compared 1991 & 2005 in same source population	Education	Ever use of condoms Number of sexual partners	**Both M and F:** Direct in 1991 Inverse in 2005
Hargreaves et al., 2002**[79] Uganda, Zambia and Thailand [Sub-group analysis*]**	M & F 15-49 yrs	Systematic review	Education	Age[e]	**Uganda, Zambia and Thailand**: **subgroup-analysis**: Pattern of new HIV infections is **changing towards** a greater burden among the less educated; and reduction in burden among the more

					educated
Victora et al.,2000[89] NA NA	NA	Commentary	NA	NA	Reading suggests HIV prevalence **will fall faster** among the wealthier **than** among the poorer.
*Parkhurst et al., 2009[78] 12 countries [h] R [m]	F: 15-49 yrs	Cross-sectional	Assets	None	**Tanzania: Sub-group analysis** for women showed Direct assoc. for 2003/2004 and **no assoc.** for 2007/2008
e. Studies showing no association between SES and HIV					
Meier et al.,2006[35] Kenya 150	Adult M [Age NR]	Cross-sectional	Assets	Hygiene indicators [L]	Assets: **None**

Key

The above table shows a select number of studies that showed different associations between socioeconomic status and HIV in different sub-populations in a number of settings in SSA. '**Direct association**' refers to a finding of a predominant direct or 'positive' association between socioeconomic status and HIV where richer individuals are at a higher risk of HIV than poorer individuals as shown in 19 sub-populations [marked in **red** colour]. '**Inverse association**' refers to a finding of a higher risk of HIV in the relatively worse off/'poorer' individuals. The table shows this finding in 13 sub-populations [marked in **green** colour]. '**No association**' refers to research findings that showed no relationship between socioeconomic status and HIV [marked in **blue** colour]. The table shows this finding in 13

sub-populations marked in black and bold. A **mixed association** refers to a finding of both high and low risk across socioeconomic gradient in different sub-populations.

Rel. =relationship; m=men; f=female; y=years; AIS=Aids Indicator survey; DHS=Demographic and Health Surveillance; prev=prevalence; f/up=follow up; RH=Relative Hazard; OR=Odds ratio; CS=Cross Sectional study; CC=Case Control Study; Assoc=association; Edu=education; employ=employment status; Assets=Household wealth quintiles/ Asset based wealth index; Sig=Significant association; Insig =Insignificant association; M=Male; F=Females; Yrs=Years; GP= general population; NR=Exact figure not reported; residence=rural/urban

[a] The observed relationship between measure of SES [education, assets, occupation, employment status] and HIV

[b] Household wealth, age, ethnicity, religion, urban/rural residence, geographical region, education, occupation, media exposure, marital status, duration of union, number of years at current place of residence, alcohol use at last sex, HIV prevention method, knowledge of own HIV status, age at sexual debut , number of lifetime sexual partners, STI treatment, average community level wealth.

[C] Ke=Kenya 2941, 3285; Tz=Tanzania 4774, 5973; Ug=Uganda 8298, 10 227; Ma=Malawi 2404, 2864; Le=Lesotho 2246, 3032; Ca=Cameroon 5094, 5287; Gh=Ghana 4274, 5331; Bu=Burkina Faso 3418, 4223. The figures are for men and women respectively.

[d] edu$=Education

[e] All studies adjusted for Age but some studies had variable additional adjustments

[f] association was negative for single women but positive for married women

[g] Residence type/setting: Urban or rural

[h] Cameroon, Ivory coast, Ghana, Kenya, Lesotho, Malawi, Rwanda, Swaziland, the United Republic of Tanzania, Uganda, Zambia and Zimbabwe. Analysis was done by country for each of the 12 countries

[I] Senegal, Niger, Ethiopia, Guinea, Mali, Burkina Faso, Ghana, Rwanda, Ivory Coast, Cameroon, Kenya, Tanzania, Malawi, Zimbabwe, Lesotho, Swaziland.

[J] Burkina Faso, Cameroon, Ivory Coast, Democratic Republic of Congo, Ethiopia, Ghana, Guinea, Kenya, Liberia, Lesotho, Malawi, Mali, Nigeria, Rwanda, Senegal, Sierra Leone, Swaziland, Tanzania, Zambia, Zimbabwe.

[K] Stepwise model building strategy using; Age, residence type, education, sex of head of household, religion, circumcision status, wealth asset quintile, media exposure status, HIV/AIDS awareness level, HIV/AIDS stigma, history of HIV test status, knowledge of someone with HIV/AIDS, marital status, age at first marriage, age at first sex, risky sexual behavior, premarital sex, multiple sexual partnerships, contextual factor [region, and country]

[L] The range of hygiene indicators included: number of times one bathes in a day; amount of water used per bath session; time spent bathing per bathing session; frequency of change of underwear; whether bathing occurs immediately after sex; number of individuals sharing a bathroom.

9.1. Education and HIV/AIDS in SSA

A systematic review by Hargreaves et al. demonstrated a time trend in the association between educational attainment and HIV in SSA. In the review, a smaller proportion of studies published after 1995 showed a direct association between education and HIV as compared to those published before 1995. On the other hand, the proportion of studies showing an inverse association has been increasing over time from early 1990s [78,90] .Other studies have indicated a similar changing trend in mature epidemics [**Figure B3**] [87, 88, 91-95]. A similar dynamic pattern was observed in SA in a nationally representative population sample of women aged 15-24 years attending ANC between 2000-2005, where the relationship between educational attainment and HIV changed from a direct[2000] to an inverse relationship[2002-2005] [31].

The predominant direct association between HIV and education prior to 1995 was hypothesised to be due to the fact that more educated individuals are wealthier, more mobile and more likely to have broader sexual networks [9,79]. The change over time was attributed to better awareness, faster adoption of safer sexual practices and greater access to preventive and curative health services by more educated individuals as compared to less educated individuals [96]. The long time lag in the change of association from direct to inverse was hypothesized to be due to slow or insufficient integration of sex education in school curriculum early in the HIV epidemic in most African countries [79,97].

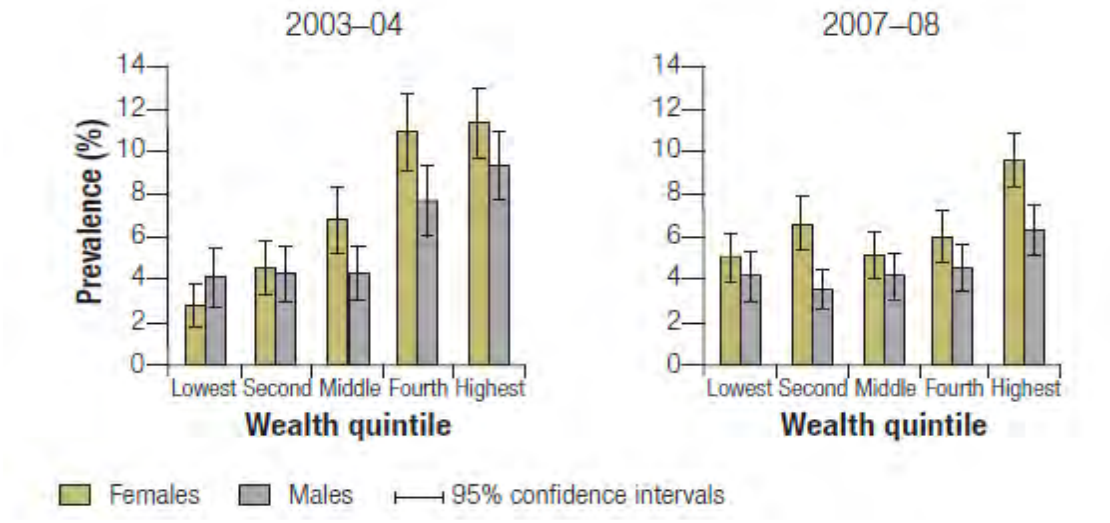


Figure B3: Changing nature of relationship between SES and HIV prevalence in the same population over time [2003/04 vs. 2007/08] in Tanzania [Parkhurst et al] [78]. This figure uses data from the United Republic of Tanzania to demonstrate how HIV prevalence changed with maturity of HIV epidemics in some countries across sub-Saharan Africa.

Other hypotheses hold that more education may be associated with either an increase or a decrease in risk of HIV infection depending on balance of different influences on behaviour by SES [79]. Education is associated with later sexual debut and marriage [98,99], and may facilitate changes in behaviour in response to health promotion as happened in Uganda [92,94] and Zambia [91]. However, individuals of higher SES, particularly men, have greater disposable income, more leisure time, increased ability to travel and higher opportunity to use CSW [82,100] or multiple sexual partners [101].

9.2. Wealth or poverty and HIV/AIDS in SSA

The association between poverty or wealth, as measured by ownership of assets, and HIV/AIDS in SSA is complex with evidence for **direct**, **inverse**, **mixed** and **dynamic** association over time. Marked heterogeneity in methodology, population and study findings makes comparison of studies or meta-analysis difficult to conduct.

9.2.1. Direct relationship

The few studies showing evidence for a direct association have large sample sizes with nationally representative samples and are mainly cross sectional DHS surveys as compared to studies showing an inverse association [24]. Being wealthier may lead to reckless lifestyle and risky sexual relationships as wealthier people, particularly men, are more mobile, more likely to have multiple sexual partners, more likely to engage in casual sex, tend to live in urban areas where HIV prevalence is higher. Wealthier individuals also lived longer with HIV than poorer individuals due to better health particularly in the era before wide and free availability of anti-retroviral drugs in public health facilities [24, 80, 81].

9.2.2. Inverse relationship

Some studies show that individuals of low SES are at a disproportionately higher risk of HIV infection as the epidemic matures [102]. Lower SES is associated with earlier sexual debut, marriage and risky sexual behaviours including transactional sex and reduced ability to negotiate safe sex due to economic dependence [84, 103, 104], and male-migrancy for labour, for example in the mining industry that is associated with higher rates of STIs including HIV [105]. These studies argue that wealthier individuals tend to be more educated, have better knowledge of HIV prevention, are more likely to receive healthcare, more likely to use condoms, less likely to use alcohol when having sex, and are more likely to be circumcised: factors that reduce their risk as compared to poorer individuals.

9.2.3. Mixed relationship depending on context

Other authors have argued that credible evidence exists for both arguments [as discussed in **sections 9.2.1** and **9.2.2**]. In conclusion, they note that there are more papers that support an inverse association than any of the other associations and highlight that while wealth may increase risk for both sexes, poverty places women at a special disadvantage [24]. Other authors have argued for different or varying effects of marital status, partner's SES, and region of residence on risk of HIV in women of low SES [76].

9.2.4. Dynamic relationship

More recently some authors, such as Hargreaves et al., [85] have hypothesized a dynamic relationship where declining HIV prevalence in wealthy groups occurs simultaneously with increasing prevalence in the poorer [78] [**Figure B4**]. Poverty has been hypothesized to increase

risky behaviours such as transactional sex and substance abuse [24] whereas wealth equates with more opportunities for transactional sex, extramarital relationships, less rigid sexual norms and deviation from traditional values [24] and higher rates of partner change [95]. However, the richer and better educated were hypothesized to have better access to reproductive health care and condom use [84].

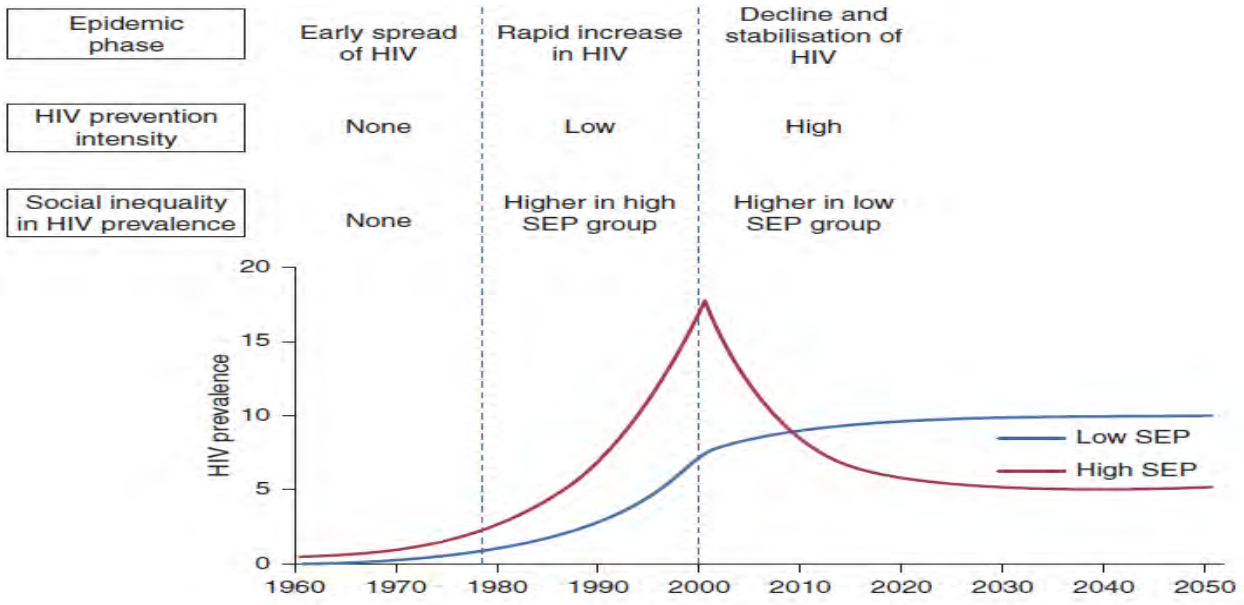


Figure B4: Dynamic relationship between relative wealth and risk of HIV infection over time [Hargreaves et al., [85]]. This figure depicts the hypothesis of changing HIV prevalence with maturity of epidemics that has been fronted by some authors. This relationship has come to be termed 'the inverse equity hypothesis'.

9.3. Occupational status and HIV/AIDS in SSA

HIV prevalence is high in CSWs [discussed in **section 7.3.1**], fishermen [106], migrant labourers [discussed in **sections 7.4.3**], military personnel and long distance truck drivers [82]. Fishermen have HIV prevalence of up to 30% [107].

A systematic review of studies from Africa and South East Asia showed that 42% of fishermen engage in transactional sex and 48% do not use condoms with CSWs. 90% had multiple sexual partners and only 7% used condoms with their regular sexual partners. High mobility that makes them to spend time away from their wives, peer norms that encourage risk taking, and common abuse of alcohol were cited as key contextual risk factors for HIV infection [107].

A South African study showed a high HIV prevalence among long distance truck drivers of 56%. These drivers had high risk sexual behaviours; 66% had STIs in preceding 6 months, 37% always stopped for sex with CSWs, 29% never used condoms with CSW and 71% had low condom use in general. In addition, only 13% used a condom in their last sexual encounter, 42% practiced anal sex, all frequently travelled to various provinces across SA and 65% travelled to neighbouring countries; all activities that increase risk of HIV transmission [49].

There is little reliable information on level of HIV infection among uniformed military personnel because few countries conduct and publicise systematic screening and public health surveillance reports among the military [108]. However, between 1993 and 1998, the Congolese, Angolan, Ugandan, Zambian, Namibian, Malawian, and Zimbabwean military officers were reported to have a HIV prevalence of between 40% and 80% with prevalence in the military in most countries being twice the national average in civilian populations [109]. This was attributed to

high STI prevalence of up to two to five times that of civilian populations in respective countries and more frequent multiple sexual partnerships [109].

9.4. Employment status and HIV/AIDS in SSA

As discussed in **section 7.4.3**, migration is a key factor that has contributed to the rapid spread of HIV epidemic in SA. Several studies have shown that individuals who are more mobile, usually rural men seeking employment in urban industrial and mining centers, are at a higher risk of HIV than people in more stable living arrangements [64, 68,110,111]. The high unemployment rate in Southern Africa has led to male migration to mines in SA, Zambia and Zimbabwe [64]. Rising unemployment and social inequalities leave some groups, especially poor women living around mines, extremely vulnerable to risky sexual practices such as transactional sex [105].

10.Contextual socioeconomic factors and risk of HIV transmission

'Contextual' socioeconomic factors for HIV transmission refers to socioeconomic factors at geographic or population level that influence individual health and behaviour [9,112]. At country level in SSA, there is only a weak direct association between national wealth and HIV prevalence but a strong direct association between income inequality and HIV prevalence **[Figure B5]** [113, 114]. Furthermore, wealthier countries in SSA such as SA and Botswana experienced fast growing HIV epidemics [26]. In view of this, some researchers have argued that inequality in wealth, rather than absolute poverty, may be more important in explaining why some countries in SSA have higher rates of HIV infection[26, 63] and more rapidly growing HIV epidemics[26],

although the exact mechanism through which this occurs remains unclear. Studies show that inequality causes an increase in transactional sex, concurrency and migration for economic reasons [26]. At a national scale, lack of finances restricts development, educational opportunities, employment and access to healthcare, and increases likelihood of untreated STIs. On the other hand, higher income and development may result in urban congestion, more migrant labour and transactional sex [24].

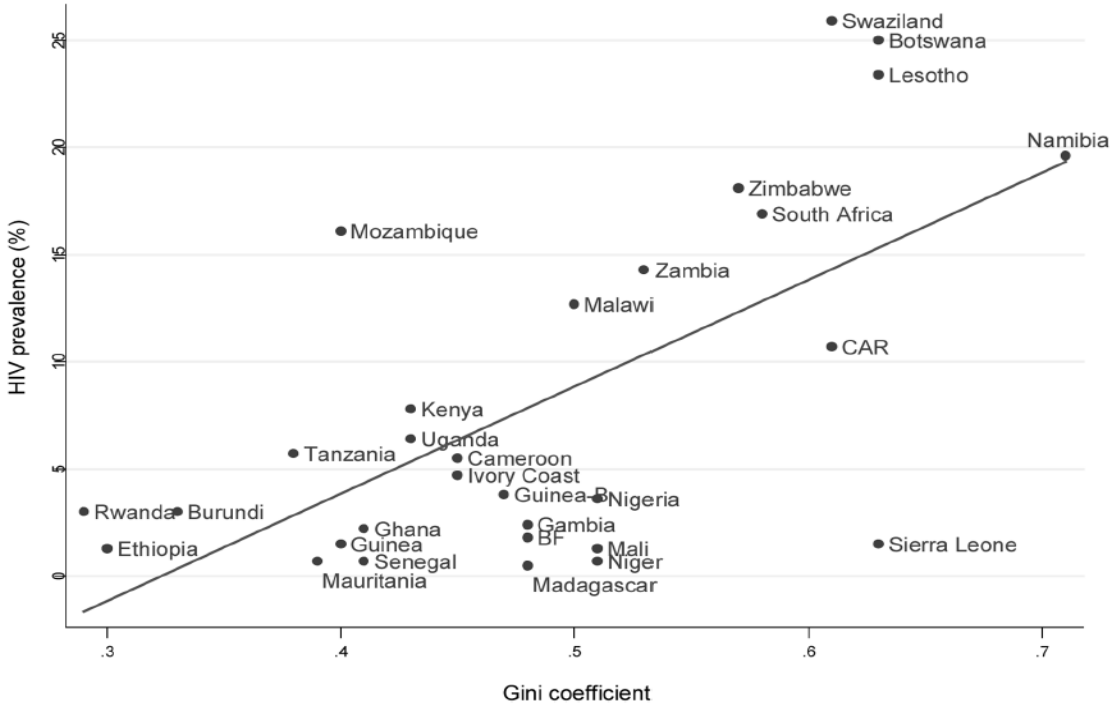


Figure B5: HIV prevalence by *Gini* coefficient in SSA [Fox et al.[77]]. ***Gini* coefficient** is a measure of income inequality within a country or region that typically ranges from **0**[most equal] to **1**[most unequal]. This figure shows the weak direct association between national wealth and HIV prevalence.

11. Relationship between SES and risk factors for HIV in SSA

SES interacts with various risk factors for HIV in a number of ways. These relationships are highlighted below.

11.1. SES and rural vs urban residence

The odds of being in an extramarital partnership in rural areas increase with an individual's wealth unlike in urban areas. Wealthier individuals tend to be more educated and more likely to live in urban areas where prevalence of HIV is higher. Economically driven migration to urban centers increases likelihood of extramarital affairs and transactional sex by migrant men who have left their wives in rural areas. Poor women in urban centers and near mines are also more likely to engage in transactional sex [26].

11.2. SES and gender norms

Gender norms refer to 'appropriate' behaviours, beliefs, attitudes and conduct attributed to gender in specific societies [24]. Women in some societies are at a greater disadvantage due to extreme poverty, subservient gender norms and fewer privileges regarding education and employment. These factors push them into risky transactional sexual relationships [24]. Furthermore, some customs and beliefs, such as wife inheritance, polygamy and having sex with virgins as a cure for HIV place women at increased risk of HIV as they either have less freedom in choosing their partners, initiating and pacing sexual activity or negotiating safer sex [24].

11.3. SES and risk perception

There is wide variation in female literacy levels in SSA, but in Southern African countries which have higher HIV prevalence, literacy level is generally above 80%. Education, urban residence and employment are associated with better knowledge of HIV [24]. However, better awareness of HIV has been shown not to necessarily translate to accurate risk perception and avoidance of risky sexual behaviour [24].

11.4. SES and Sexually Transmitted Infections

Hunter et al cites chronic unemployment, increase in single parent households, transactional sex, and 'circular' migration between urban and rural homes as key social drivers of concurrency and STIs including HIV [105, 115].

11.5. SES and factors lowering immunity

Strength of immune system is affected by nutrition, infections and parasites. Worms cause malnutrition through malabsorption and intestinal bleeding. Infectious and parasitic diseases and malnutrition create an environment of enhanced risk for HIV [116]. For instance, malnutrition, particularly involving vitamin A-deficiency, is associated with increased risk and slower healing of genital ulcers and cervical shedding of Herpes Simplex Virus type 2 which in turn increase risk of HIV transmission[117,118]. Malnutrition and Vitamin A deficiency is commoner among poorer individuals and is more prevalent in developing than developed countries [119].

11.6. SES and Male Circumcision

Wealthier men are more likely than poorer men to be circumcised [81] as shown by a Tanzanian study early in the HIV epidemic [82]. This was the case especially before wide promotion and free availability of MC in public health facilities as a preventive approach to reduce risk of HIV transmission following trials in Kenya [33], SA [34] and Uganda [32]. The relationship between MC and risk of HIV transmission is discussed in **Section B 7.2.1**.

11.7. SES and age

Young women [15-24 years] are often economically dependent on older men in age-disparate relationships which increase their risk of HIV as discussed in **Section B 7.3.2**.

11.8. SES and concurrency

A systematic review of DHS data from 16 SSA countries showed a direct association between wealth and HIV infection in poorer regions [mainly rural settings] and an inverse association in wealthier regions [mostly urban settings] [26]. It hypothesized that income inequality increases migration for economic reasons, concurrency and transactional sex between wealthier and poorer individuals. It postulated that the social gradient in HIV infection was reversing from a direct to an inverse relationship as discussed in **Section B 9.2.4**. It showed an increasing risk of HIV among the relatively poor [26], a finding collaborated by other studies as already discussed in **Section B 5.2.4** [76, 78]. It showed that sexual concurrency was more common in wealthier individuals in rural areas as compared to those in urban areas [26]. In the systematic review, when education was used as a measure of SES, there was a direct relationship between education and number of extra-marital partners [OR for primary and secondary education versus

no formal education was 1.57 and 1.94 respectively, with a p-value of less than 0.01 for each point estimate][26]. This association was observed in both rural and urban residents. In this study, wealthier men were more likely to report more than 2 concurrent sexual partners, to be mobile, to have more lifetime sexual partners and to have casual sex than poorer men [26]. Consistently across countries in this study, wealthier individuals started cohabiting at an older age, were more likely to use condoms and were less likely to be in polygamous unions as compared to poorer individuals [26].

11.9. SES and Intimate Partner Violence

Low SES is associated with higher incidence of Intimate Partner Violence [IPV] and in turn higher risk of HIV through direct and indirect means. IPV reduces ability to negotiate for safe sex and causes breaches in vaginal epithelium following forced sex which increases risk of HIV transmission. Furthermore, poorer women are more likely to be forced into early marriage and to be subjected to sexual violence by their sexual partners. Poverty prevents female children from being educated which limit their ability to find employment. This further strengthens economic dependence which makes it hard for them to leave violent sexual partners. Inability to find useful employment may also push women into prostitution where sexual rights of women are violated and exposure to high risk sexual acts and STI is high[24].

12. Heterogeneity in study findings

Reasons for heterogeneity in study findings in the relationship between SES and HIV include:

- Variation in measure of SES: variation in measure of SES for example whether the study used education, assets, income or expenditure may explain some heterogeneity. Different measures of SES have been shown not to perform identically within the same population especially in SSA [120].
- Differences in study population [76], for example most at risk populations [MARPS] have higher HIV prevalence than the general population [12].
- Differences in methodology for instance statistical adjustment for varying number of confounders by studies and, sometimes, erroneous adjustment for intermediary variables [termed 'over-adjustment'; for example adjusting for sexual behaviour and STIs] [76].
- Variation in sampling frames where some studies recruited nationally representative samples while others only recruited from small geographic regions within countries. The former has more heterogeneity in SES especially in countries with high economic inequalities than the latter. This influences observed relationship [85].
- Other methodological differences for example results could vary by setting [urban versus rural settings], stage of maturity of the HIV epidemic versus specific time the study was conducted, age and gender [79].
- Real differences due to differences in population groups and health indicator being studied.

A new hypothesis by Victora et al. [89]; 'inverse equity hypothesis' suggests that new infections will increasingly concentrate among those of lower SES. It postulates that scale-up of HIV prevention interventions would benefit higher SES groups faster than it does individuals of lower SES. HIV incidence and later prevalence would thus fall fastest among individuals of higher SES as compared to those of lower SES [85].

13.Research gap

Heterogeneity in results of studies on the association between SES and HIV warrants more research to determine reasons why there are inconsistencies in findings from different population sub-groups, gender and regions for example when different approaches of measuring SES [e.g. education, assets, type of employment and occupation] are used [9]. The high variability in study findings also requires more research to refine and standardize measurement approaches for SES for use in low and middle income countries and to determine the association between SES and HIV in different settings and in the same settings over time as the HIV epidemic matures across SSA. Suggested research includes establishment and refinement of guidelines to inform choice of assets and social amenities to include in PCA model to make it more sensitive to changes in SES with time or subtle differences in SES between households. This will reduce the observed variability in sensitivity of PCA in assigning asset scores and standardize choice of assets or social services to include in PCA models particularly where data is obtained from both urban and rural areas. The current PCA approach does not incorporate differential weights to assets or social amenities based on residence, rural or urban, yet this would be important. Lastly, prospective cohort studies that measure HIV incidence over time will help unravel difficulty of establishing temporality inherent in cross-sectional studies.

14.Conclusion

Studies suggest varying relationship between SES and risk of HIV infection in SSA; direct, inverse, no relationship and mixed relationship [9]. As put by Parkhurst, "a nuanced approach is one that does not assume that either wealth or poverty alone leads to risky sexual behaviours, but that both wealth and poverty may have associated risks and protective effects in different contexts and individuals" [78]. Literature shows that in early phases of HIV epidemics in most sub-Saharan African countries, HIV infections were mainly concentrated in individuals of higher SES, in whom it later fell fastest [90]. In mature epidemics, HIV infections increasingly concentrate in individuals of lower SES and progressively reduce in those of higher SES [85, 89]. This has come to be known as the 'inverse equity hypothesis' [89]. To develop better-targeted HIV prevention interventions, recognition of multiple ways in which underlying structural factors can manifest themselves as risks for HIV infection in different settings and at different times is imperative. Context- and sub-population-specific risks should be made targets of HIV prevention initiatives, such as design and delivery of HIV prevention messages, to ensure higher impact [78]. This realization is the motive underlying our research objective: understanding the relationship between HIV and SES, using a variety of SES measurement approaches, in a specific setting in SA.

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SECTION C:

MANUSCRIPT AND APPENDICES

16. Manuscript and appendices

This manuscript meets the requirements set out in the instructions for authors by the *Journal of the International AIDS Society* [***JIAS***], a peer-reviewed journal with a topical interest in HIV/AIDS. Briefly, the journal requires that; the manuscript should be in any easily readable format with a font size of 12 with line spacing of 1.5; UK English; tables and figures should be inserted within text with no limit on number of tables and figures; and references should be in *Vancouver* style, but with square brackets. The manuscript must contain line numbers to facilitate editors' and reviewers' comments and the text should be set unjustified to the left. The Abstract and body of manuscript should not exceed 350 and 3500 words respectively. A comprehensive extract of these instructions is found in **appendix 11**. Figures 1 and 2 in the manuscript are presented in color rather than in black and white for readability; and table IV, which is longer than one page, is embedded in text rather than added as an appendix for ease of reading and reference. Line spacing is set to 2.0 for readability, and to conform with the rest of the thesis that used a line spacing of 2.0 that was defined as a requirement by the Faculty of Health Sciences.

Relationship between Socioeconomic Status and Human Immunodeficiency Virus infection in the Free State and Western Cape Provinces of South Africa

Erick Wekesa Bunyasi[1§*]

[1]School of Public Health and Family Medicine, University of Cape Town, Cape Town, South Africa

[§] Corresponding author: Erick Wekesa Bunyasi

Institute of Infectious Diseases and Molecular Medicine, Room S1.02 Werner and Beit South Building, Faculty of Health Sciences, University of Cape Town, Anzio Road, Observatory 7925, Cape Town, SOUTH AFRICA

Phone: +27 74 707 1833

E-mail: bnyeri001@myuct.ac.za

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Keywords: Socioeconomic status, Human Immunodeficiency virus, education, occupation, assets

Abstract

Introduction: Incidence and prevalence of Human Immunodeficiency Virus [HIV] infections is highest in sub-Saharan Africa. Literature has shown varied association between socioeconomic status and HIV across settings and within settings over time in SSA. Our objective was to determine this association in women of reproductive age from Free State and Western Cape Provinces

Methods: We conducted secondary analysis of data from a serological community survey from Free State and Western Cape Provinces of SA. We included 1906 women with known HIV status and socio-demographic data. Socio-economic status was measured by household assets, educational level, employment status and type of occupation. Based on literature review and available data, we controlled for confounding effect of age, marital status and type of residence [urban vs. rural] and adjusted for stratified multi-stage cluster sampling used in recruitment of study participants.

Results: In adjusted analysis, every one year of formal education was associated with a 6% reduction in risk of being HIV positive [adjusted Odds Ratio [aOR] 0.94 [95% CI 0.89; 0.99]][p-value=0.031]. There was no significant association between HIV and employment status, asset score or occupation in adjusted analysis; aOR 0.69[95% CI: 0.24; 1.98] p-value=0.381, [aOR 0.81[95% CI: 0.53; 1.25] p-value=0.214 and aOR 2.00[95% CI: 0.87; 4.60] p-value=0.083 respectively, as was the case in crude analysis. Our study was under-powered to evaluate the relationship between HIV prevalence and occupation, employment status or asset score.

Conclusions: The significant inverse relationship between prevalent HIV infection and formal education underscore the need to promote formal education of the girl child in these provinces as an additional approach and a key structural intervention in reducing incident HIV infections. More importantly, approaches for HIV prevention such as tailored HIV prevention messages that promotes couple HIV counseling and testing, promotion of practice of safe sex, social marketing and increase of access and acceptability of female condoms, avoidance of sexual partner concurrency and others, need to be delivered in multiple local languages in an approach that appeals and is easily understood by semi-illiterate women. This is required in order to sustain and improve gains already made in the fight against HIV.

Introduction

According to UNAIDS estimates, more than 34 million people are infected with human Immunodeficiency virus [HIV], with sub-Saharan Africa [SSA] bearing 69% of this burden [1]. Despite current advances in HIV prevention, care and treatment, incidence remains high at 2.5 million cases per year globally [1].

Health outcomes generally improve with increasing socioeconomic status [SES]. However, studies have shown that HIV is associated with both higher and lower SES groups in SSA [2,3]. SES is a composite measure that typically incorporates social, economic and employment status and is measured by education, income and occupation respectively which are interrelated but do not completely overlap [4]. Race as a social construct is associated with differences in SES and health outcomes in South Africa [SA] due to its unique historical and political factors and is used as a proxy for SES in research to monitor social and health inequities and progress in equitable

distribution of public resources [5]. The higher HIV prevalence of 13.6% among Africans compared to 0.3% among whites, 1.7% among coloureds and 0.3% among Indians in SA [6] has thus been postulated to be associated with SES.

A systematic review of the association between SES and HIV in SSA evaluated thirty six studies and found no association in fifteen, a direct association in twelve, an inverse association in 8 and a mixed association in one study. It recommended use of multiple measures of SES at both individual and community level since different measures of SES perform differently in relation to health outcomes in settings with widespread poverty and wide income inequality like SA[2]. We used a combination of measures of SES to investigate the association between SES and HIV prevalence.

Methods

This study is a secondary analysis of cross-sectional community survey data from the Prevention of Mother to Child Transmission [*PMTCT] of HIV, Effectiveness in Africa and, Research and Linkages to HIV Care* [*PEARL] Study* which was conducted between June 2007 and October 2008 in Western Cape [WCP] and Free State Provinces [FSP] of SA. PEARL study was a multi-country PMTCT program evaluation study that used a two-stage cluster sampling approach to evaluate effectiveness of PMTCT interventions. Detailed methodology and results of this study have been reported elsewhere [7-12].

Our study population is women of reproductive age in WCP and FSP. We restricted our analysis to women who consented to HIV testing and provided data on SES. Determine HIV-1 rapid

antibody test was used for initial HIV testing in keeping with national guidelines. SES was measured by 4 proxy variables namely highest level of education, employment status, type of occupation and asset score derived from household ownership of durable goods and access to social amenities using the Principal Components Analysis [PCA] statistical method that is widely used in *Demographic and Health Surveys [DHS]* [13,14]. This method creates a continuous scale of relative wealth that strongly correlates with health outcomes such as morbidity and mortality [13,14]. We adopted a conceptual framework by Mishra et al [15,16] to depict biomedical and social mediators for the relationship between SES and HIV.

HIV status was modelled as a dependent variable, first in models with each of the proxies of SES to determine crude association then in models controlling for confounding to determine adjusted association between SES and HIV prevalence. Based on literature review and available data, age, marital status and type of residence [rural vs urban] were hypothesized as confounders and controlled for in analysis [3].

We first described characteristics of research participants then explored the relationship between HIV and SES. We computed means and standard deviations or medians and inter-quartile ranges [IQR] for continuous variables and percentages for categorical variables. We used logistic regression for survey data to determine the crude and adjusted relationship between SES and HIV prevalence. All analyses were carried out in *STATA*® statistical software version 12.1 for Windows [17]. Ethical approval for this study was obtained from the Human Research Ethics Committee, University of Cape Town.

Results

Our study consisted of 1 906 women with known HIV status, 42% of whom were from WCP. The median age for the sample was 25 years [IQR: 21- 30] whereas this was 26 years [IQR: 22 - 31] and 24 years [IQR: 21 - 30] for WCP and FSP respectively [Table I]. The proportion of women who were either married or cohabiting at the time of the study was 43% for the 2 provinces and 45.5% and 41.1% for WCP and FSP respectively. More than 83% of women had completed at least secondary education in each of the provinces, but the proportion with tertiary education and that in employment differed significantly by province. Tables I and II shows socio-demographic variables by province and asset quintile respectively.

108 **Table I:** Distribution of socio-demographic variables and basic literacy skills for WCP and FSP [SA] in 2008

109 **N** [**%**]: N= size of sample in specified analysis; % = percentage or proportion unless otherwise stated

Variable	WCP[1] [N [%]] 802 [42.1]	FSP[1] [N [%]] 1104 [57.9]	WCP&FSP [N [%]] 1 906 [100]
Age [median: IQR]	26 [22; 31]	24 [21; 30]	25 [IQR: 21; 30]
Marital status			
- Never married	395 [50.5]	547 [49.6]	942 [50.0]
- Married	305 [39.0]	318 [28.8]	623 [33.1]
- Divorced	11 [1.4]	11 [1.0]	22 [1.2]
- Separated	13 [1.7]	56 [5.1]	69 [3.7]
- Widowed	7 [0.9]	35 [3.2]	42 [2.2]
- Married or lived with a man before; current status unknown[2]	51 [6.5]	136 [12.3]	187 [9.9]
Total	**782 [100]**	**1103 [100]**	**1885 [100]**
Highest educational level attained			
- Primary	91 [11.4]	171 [15.7]	262 [13.9]
- Secondary	592 [74.3]	866 [79.4]	1,458 [77.2]
- Tertiary	114 [14.3]	54 [4.9]	168 [8.9]
Total	**797 [100]**	**1091 [100]**	**1888 [100]**
Formal employment status			
- Yes	245 [30.6]	131 [11.9]	376 [19.7]
- No	556 [69.4]	973 [88.1]	1529 [80.3]
Total	**801 [100]**	**1104 [100]**	**1905 [100]**
Occupational group [N [%]] [3]			
- Group 1	48 [19.6]	9 [6.8]	57 [15.1]
- Group 2	1 [0.4]	25 [18.9]	26 [6.9]
- Group 3	7 [2.9]	9 [6.8]	16 [4.3]
- Group 4	8 [3.3]	1 [0.8]	9 [2.4]
- Group 5	10 [4.1]	3 [2.3]	13 [3.5]
- Group 6	6 [2.4]	17 [12.9]	23 [6.1]
- Group 7	3 [1.2]	9 [6.8]	12 [3.2]

- Group 8	162 [66.1]	59 [44.7]	221 [58.6]
Total	**245 [100]**	**132 [100]**	**377 [100]**
Asset score [median: IQR]	1.55 [-0.19; 2.17]	-0.48[-1.55;0.38]	0.04 [-1.17; 1.55]
Wealth/Asset Quintile[4]			
- Quintile 1	104 [13.2]	275 [25.0]	379 [20.0]
- Quintile 2	76 [9.6]	301 [27.4]	377 [20.0]
- Quintile 3	94 [11.9]	284 [25.8]	378 [20.0]
- Quintile 4	204 [25.8]	177 [16.1]	381 20.2]
- Quintile 5	312 [39.5]	63 [5.7]	375 [19.8]
Total	**790 [100]**	**1100 [100]**	**1, 890 [100]**
Basic literacy skills			
- Able to read whole sentence	737 [91.9]	798 [72.3]	1535 [80.5]
- Able to read parts of sentence	42 [5.2]	22. [19.9]	262 [13.8]
- Can't read whole sentence	10 [1.3]	75 [6.8]	85 [4.5]
- No card with required language or blind or visually impaired	13 [1.6]	11 [1.0]	24 [1.2]
Total	**802 [100]**	**1104 [100]**	**1,906 [100]**

Legend

[1]Provinces in South Africa: **WCP**=Western Cape Province; **FSP**=Free State Province

[2]Participant has previously married or cohabited with a man before; but current marital status was not recorded during the survey. **WCP**=Western Cape Province; **FSP**=Free State Province

[3]**Occupation categories**: **group1**=managers or employers in a company, NGO or organization; **group2**=farmers; **group3**=government workers; **group4**=healthcare workers; **group5**=secretaries; **group6**=small business owners or traders; **group7**=students; **group8**=other [these includes chefs, domestic workers; machinists; shop assistants and any other occupation not fitting in the above specified categories]

[4]Wealth quintiles were derived using Principal Components Analysis [PCA] in *STATA* Special Edition version 12.1. Wealth quintile categories **First**=Lowest quintile ['Poorest' on a *relative* asset index scale]; **Second**=Second quintile; **Third**= Middle quintile; **Fourth**=Fourth quintile; **Fifth**=Highest quintile ['Richest' on a *relative* asset index scale]

122 **Table II:** Selected socio-demographic, health and behavioural characteristics of study participants by asset quintile

123 N [%] = Number [percent] unless otherwise stated.

Variable	Household Asset/Wealth Quintile [Percent or Number][1]					
	First N[%][Poorest]	Second N[%]	Middle N[%]	Fourth N[%]	Highest N[%][Richest]	Total N[%]
1. Socio-demographic variables						
Province [2]						
- WCP	104 [13.2]	76 [9.6]	94 [11.9]	204 [25.8]	312 [39.5]	790 [100]
- FSP	275 [25.0]	301 [27.4]	284 [25.8]	177 [16.1]	63 [5.7]	1,100 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.1]**	**375 [19.8]**	**1,890 [100]**
Cluster/Community [3]						
- Stellenbosch	8 [5.6]	16 [11.2]	22 [15.4]	31 [21.7]	66 [46.1]	143 [100]
- Mitchell's Plain	17 [5.5]	9 [2.9]	11 [3.6]	64 [20.8]	207 [67.2]	308 [100]
- Gugulethu	79 [23.3]	51 [15.0]	61 [18.0]	109 [32.2]	39 [11.5]	339 [100]
- Botshabelo	103 [19.9]	155 [30.0]	165 [31.8]	74 [14.3]	22 [4.2]	519 [100]
- Mantsopa	43 [31.2]	42 [30.4]	31 [22.5]	18 [13.0]	4 [2.9]	138 [100]
- Thabo Mofutsanyana	129 [29.0]	104 [23.5]	88 [19.9]	85 [19.2]	37 [8.4]	443 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**375 [19.7]**	**1,890 [100]**
Age [median [IQR[4]]]	25.0 [21.0;30.0]	25.0 [20.0;30.0]	24.0 [21.0;29.0]	25.0 [21.0;31.0]	26.0 [22.0;30.5]	25.0 [21.0;30.0]
Marital status						
- Never married	156 [16.7]	195 [20.9]	206 [22.1]	204 [21.8]	173 [18.5]	934 [100]
- Married	129 [20.9]	105 [17.0]	103 [16.7]	119 [19.3]	161 [26.1]	617 [100]
- Divorced	6 [27.3]	2 [9.0]	6 [27.3]	4 [18.2]	4 [18.2]	22 [100]
- Separated	19 [27.6]	18 [26.1]	15 [21.7]	13 [18.8]	4 [5.8]	69 [100]
- Widowed	11 [26.2]	11 [26.2]	6 [14.3]	11 [26.2]	3 [7.1]	42 [100]
- Married or lived with a man before; current marital status not recorded	56 [30.3]	45 [24.3]	37 [20.0]	25 [13.5]	22 [11.9]	185 [100]
Total	**377 [20.2]**	**376 [20.1]**	**373 [20.0]**	**376 [20.1]**	**367 [19.6]**	**1,869 [100]**
2. Ownership of household assets and access to social amenities						
Main source of drinking water						
- Piped water available in the house	22 [2.9]	41 [5.4]	92 [12.1]	237 [31.2]	368 [48.4]	760 [100]
- Public tap	91 [52.0]	43 [24.6]	30 [17.1]	11 [6.3]	0 [0]	175 [100]
- Piped water available outside plot	240 [26.3]	287 [31.5]	253 [27.7]	126 [13.8]	6 [0.7]	912 [100]
- Tube well or borehole	11 [64.6]	3 [17.7]	2 [11.8]	1 [5.9]	0 [0]	17 [100]
- Tanker truck or cart with small tank or protected well	6 [85.7]	1 [14.3]	0 [0]	0 [0]	0 [0]	7 [100]
- Other sources [6]	9 [47.3]	2 [10.5]	1 [5.3]	6 [31.6]	1 [5.3]	19 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**375 [19.7]**	**1,890 [100]**

Type of toilet facility in the household						
- Flush or pour flush toilet to piped sewer system	56 [5.3]	104 [9.9]	196 [18.6]	330 [31.3]	367 [34.9]	1,053 [100]
- Flush toilet to septic tank or pit	60 [32.3]	56 [30.1]	47 [25.3]	17 [9.1]	6 [3.2]	186 [100]
- Ventilation Improved Pit [VIP] latrine	28 [32.5]	36 [41.9]	17 [19.8]	5 [5.8]	0 [0.0]	86 [100]
- Traditional pit latrine or pit latrine with slab or open pit	81 [37.0]	59 [26.9]	63 [28.8]	16 [7.3]	0 [0.0]	219 [100]
- Bucket toilet	121 [40.0]	112 [37.1]	54 [17.9]	13 [4.3]	2 [0.7]	302 [100]
- No facility e.g. use of bush or open field	25 [78.1]	6 [18.8]	1 [3.1]	0 [0.0]	0 [0.0]	32 [100]
- Other	8 [66.7]	4 [33.3]	0 [0.0]	0 [0.0]	0 [0.0]	12 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**375 [19.7]**	**1,890 [100]**
Household goods ownership						
- Electricity	286 [16.0]	372 [20.8]	376 [21.0]	381 [21.2]	375 [21.0]	**1,790 [100]**
- Television	159 [10.4]	286 [18.7]	340 [22.3]	367 [24.0]	375 [24.6]	**1,527 [100]**
- Cell phone	294 [17.9]	306 [18.7]	342 [20.9]	349 [21.3]	348 [21.2]	**1,639 [100]**
- Number of cell phones per household[5] [mean [95% CI]]	1.4 [1.3;1.5]	1.7 [1.5;1.9]	1.9 [1.6;2.1]	2.0 [1.8;2.3]	2.8 [2.7;2.9]	**2.1 [1.7;2.5]**
- Refrigerator	122 [8.6]	252 [17.8]	309 [21.8]	359 [25.4]	374 [26.4]	**1,416 [100]**
- Bicycle	33 [11.6]	41 [14.4]	35 [12.3]	51 [18.0]	124 [43.7]	**284 [100]**
- Motorcycle	0 [0.0]	3 [10.3]	3 [10.3]	2 [6.9]	21 [72.5]	**29 [100]**
- Car	9 [2.7]	13 [3.9]	22 [6.6]	80 [24.1]	208 [62.7]	**332 [100]**
Main material of the floor						
- Natural floor e.g. earth, mud, dung	184 [76.0]	46 [19.0]	9 [3.7]	3 [1.3]	0 [0.0]	242 [100]
- Wood Planks	4 [23.5]	4 [23.4]	3 [17.7]	3 [17.7]	3 [17.7]	17 [100]
- Finished Floor e.g. cement or tiles	124 [8.2]	302 [20.0]	351 [23.2]	365 [24.1]	371 [24.5]	513 [100]
- Others e.g. category not in any of the above, or missing observation	67 [56.8]	25 [21.2]	151 [12.7]	10 [8.5]	1 [0.8]	118 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**375 [19.7]**	**1,890 [100]**
Food security [past month]						
- Never has enough food to eat	33 [23.6]	29 [20.9]	20 [14.4]	44 [31.7]	13 [9.4]	139 [100]
- Seldom has enough food to eat	56 [49.1]	23 [20.2]	13 [11.4]	21 [18.4]	1 [0.9]	114 [100]
- Sometimes has enough food to eat	194 [25.8]	194 [25.8]	163 [21.6]	150 [20.0]	51 [6.8]	752 [100]
- Usually/always has enough food to eat	96 [10.9]	131 [14.8]	182 [20.6]	166 [18.7]	310 [35.0]	885 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**375 [19.7]**	**1,890** [100]
3. Socioeconomic status variables						
Highest educational level attained						
- Primary	93 [38.1]	51 [20.9]	50 [20.5]	26 [10.7]	24 [9.8]	244 [100]
- Secondary	268 [18.4]	305 [21.0]	314 [21.6]	303 [20.8]	266 [18.3]	1,456 [100]
- Tertiary	10 [6.0]	14 [8.4]	13 [7.8]	48 [28.7]	82 [49.1]	167 [100]
Total	**371 [19.9]**	**370 [19.8]**	**377 [20.2]**	**377 [20.2]**	**372 [19.9]**	**1867 [100]**
Formal employment status						

- Yes	48 [12.9]	43 [11.6]	61 [16.4]	69 [18.6]	151 [40.6]	372 [100]
- No	331 [21.8]	334 [22.0]	317 [20.9]	312 [20.6]	223 [14.7]	1,517 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**374 [19.7]**	**1,889 [100]**
Occupational group [7]						
- Group 1	6 [10.9]	2 [3.6]	8 [14.6]	11 [20.0]	28 [50.9]	55 [100]
- Group 2	14 [53.8]	5 [19.2]	5 [19.2]	1 [3.9]	1 [3.9]	26 [100]
- Group 3	0 [0]	2 [12.5]	1 [6.3]	6 [37.4]	7 [43.8]	16 [100]
- Group 4	0 [0]	1 [11.2]	2 [22.2]	2 [22.2]	4 [44.4]	9 [100]
- Group 5	0 [0]	0 [0]	1 [7.7]	1 [7.7]	11 [84.6]	13 [100]
- Group 6	2 [8.7]	4 [17.4]	7 [30.4]	6 [26.1]	4 [17.4]	23 [100]
- Group 7	2 [16.7]	5 [41.7]	3 [25.0]	2 [16.6]	0 [0]	12 [100]
- Group 8	24 [11.0]	25 [11.4]	33 [15.1]	40 [18.3]	97 [44.2]	219 [100]
Total	**48 [12.9]**	**44 [11.8]**	**60 [16.1]**	**69 [18.4]**	**152 [40.8]**	**373 [100]**
4. Basic literacy skills/ability						
Basic literacy skills						
- Can't read	39 [45.9]	24 [28.2]	15 [17.7]	4 [4.7]	3 [3.5]	85 [100]
- Able to read parts of sentence	100 [38.1]	50 [19.1]	55 [21.0]	38 [14.5]	19 [7.3]	262 [100]
- Able to read whole sentence	236 [15.5]	298 [19.6]	302 [19.9]	337 [22.2]	347 [22.8]	1,520 [100]
- No card with required language or blind or visually impaired	4 [17.4]	5 [21.7]	6 [26.1]	2 [8.7]	6 [26.1]	23 [100]
Total	**379 [20.1]**	**377 [20.0]**	**378 [20.0]**	**381 [20.2]**	**375 [19.7]**	**1,890 [100]**

[1] Wealth quintiles were derived using Principal Components Analysis [PCA] statistical method in *STATA* Special Edition version 12.1. Wealth quintile categories **First**=Lowest quintile ['Poorest' on a *relative* asset index scale]; **Second**=Second quintile; **Third**= Middle quintile; **Fourth**=Fourth quintile; **Fifth**=Highest quintile ['Richest' on a *relative* asset index scale]

[2]Provinces in South Africa: **WCP**=Western Cape Province; **FSP**=Free State Province

[3]Cluster refers to health facility catchment area. Health facility catchment areas were used as primary sampling units during cluster sampling.

[4] IQR=Interquartile range

[5]Proportions were adjusted for survey sampling approach

[6] These includes households with missing responses, those getting water from unprotected wells, protected well, bottled water, surface water [such as river, dam, lake, pond, canal, or irrigation channel], rainwater or other unspecified sources.

[7]Occupation categories: group1=managers or employers in a company, NGO or organization; group2=farmers; group3=government workers; group4=healthcare workers; group5=secretaries; group6=small business owners or traders; group7=students; group8=other [these includes chefs, domestic workers; machinists; shop assistants and any other occupation not fitting in the above specified categories etc.]

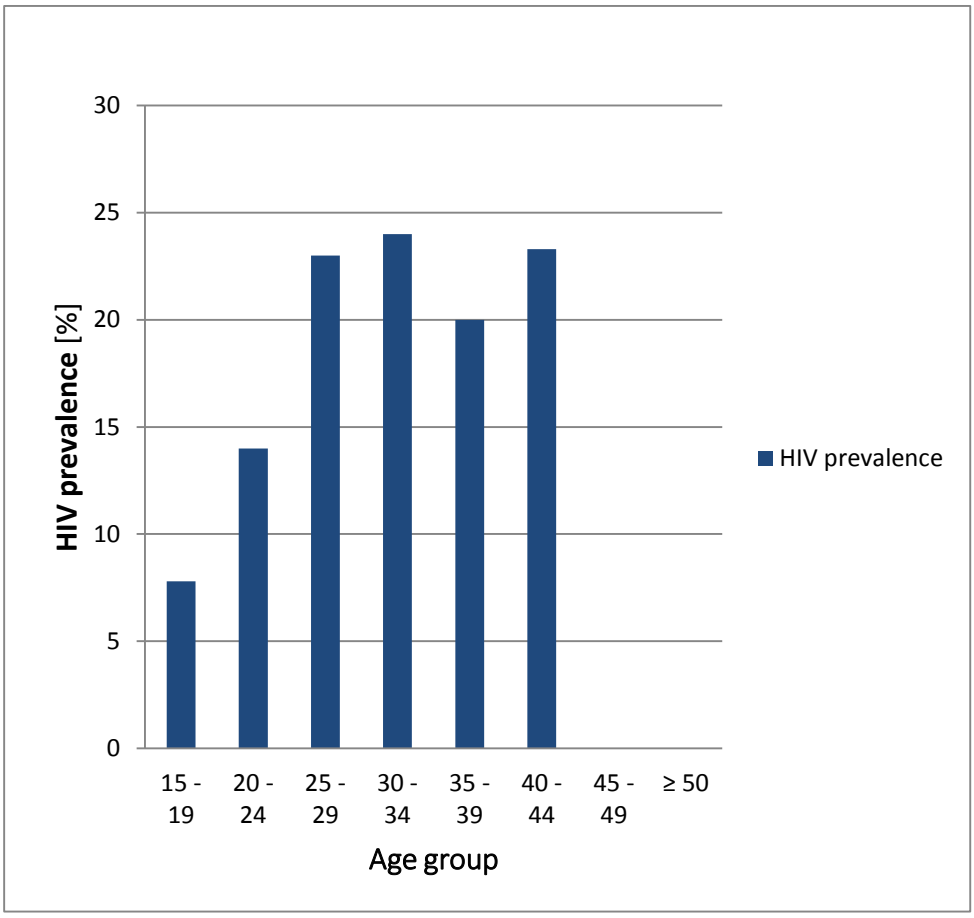
[8] PMTCT= Prevention of Mother To Child Transmission of HIV

[9] HIV= Human Immunodeficiency virus

[10] VCT= Voluntary Counselling and Testing

The mean HIV prevalence was 17.2% [95% CI: 1.9; 32.6]. The prevalence in FSP was almost twice that in WCP. HIV prevalence was highest in women between the ages of 30 and 34 years at 24.0% [Figure 1 and Table III]. Widowed women had the highest HIV prevalence [52.8%] followed by women who had separated [30.5%] and those who had married or cohabited before [19.4%]. Women who had never been married, those who were married, and those who had divorced at the time of the study, had lower HIV prevalence of 16.1%, 15.4% and 11.6% respectively.

151 **Figure 1:** HIV prevalence by age group for women selected in WCP and FSP of SA in 2008



152

153 **Note**: HIV prevalence was adjusted for survey sampling approach to take account of increased design effect due to
154 cluster sampling. There were only 3 women aged 45 to 49 years and only 1 aged more than 50 years. All the 4
155 women were HIV negative. HIV prevalence in both categories was thus '0%'. STATA indicated 'omitted' under
156 standard errors in bivariate analysis, so no confidence interval was provided.

157 In WCP, women from the 2nd and 3rd asset quintiles had the highest HIV prevalence of 23.7% and
158 25.5% respectively whereas those in the 5th asset quintile had the lowest [4.8%] However, in the
159 FSP, HIV prevalence was highest in women in the 1st asset quintile [26.9%] and lowest in those in
160 the 5th asset quintile [15.9%] [**Figure 2**]. 36% of HIV negative women were in the fourth or fifth
161 asset quintile whereas this was only 24% for women who were HIV positive. There was no

difference in asset score between HIV positive and HIV negative women. HIV positive women had a median asset score of 0.39 [IQR -0.93; 0.39] whereas this was 0.39 [IQR -0.41; 1.04] for HIV negative women. Asset score is a score reflecting relative economic status of households derived using Principal Components Analysis statistical method that assigns a relative score based on household ownership of select durable assets [such as TV and motorcycle] and access to social amenities [such as source of drinking water]. Women were assigned household asset scores of their corresponding households as happens in DHS [14]. Our asset score had a range of -5.56 to 2.33 and a median of 0.39 [IQR -0.83 to 1.04]. For utility, besides the continuous asset score, we also classified households into five ordinal asset quintiles or 'wealth categories' as frequently happens in literature employing the PCA approach. This asset score is directly proportional to household economic status, the lower the asset score the 'poorer' a household is and vice versa for a given set of data. Studies have shown a general inverse relationship between asset quintiles and morbidity and mortality [14].

Table III: Socio-demographics and HIV status of participants by province and sub-district [1]

Variable	Number of Observations [N [%]]	HIV STATUS % [95%CI[2]]
1. Socio-demographic variables		
Province [3]		
- WCP	802 [42.1]	13.5 [-23.5; 50.4]
- FSP	1, 104 [57.9]	24.5 [22.6; 26.3]
Total	**1, 906 [100]**	**17.2 [1.9; 32.6]**
Cluster/Community [4]		
- Stellenbosch	144 [7.6]	7.6 [7.6; 7.6]
- Mitchell's Plain	311 [16.3]	2.3 [2.3; 2.3]
- Gugulethu	347 [18.2]	25.9 [25.9; 25.9]
- Botshabelo	520 [27.3]	23.8 [23.8; 23.8]
- Mantsopa	138 [7.2]	25.4 [25.4; 25.4]
- Thabo Mofutsanyana	446 [23.4]	24.9 [24.9; 24.9]
Total	**1, 906 [100]**	**17.2 [1.9; 32.6]**

Age category		
- 15 – 19	287 [15.1]	7.8 [-2.6; 18.2]
- 20 – 24	589 [30.9]	14.0 [-0.5; 28.4]
- 25 – 29	422 [22.1]	23.0 [-3.7; 50.0]
- 30 – 34	265 [13.9]	24.0 [8.6; 39.5]
- 35 – 39	190 [10.0]	20.0 [1.2; 38.6]
- 40 – 44	51 [2.7]	23.3 [1.1; 45.5]
- 45 – 49	3 [0.2]	0 […][8]
- ≥ 50	1 [0.05]	0 […][8]
Total	**1808 [100]**	**17.2 [1.9; 32.6]**
Marital status		
- Never married	942 [50.0]	16.1 [1.2; 30.9]
- Married	623 [33.0]	15.4 [- 4.1; 34.9]
- Divorced	22 [1.2]	11.6 [- 18.0; 41.1]
- Separated	69 [3.7]	30.5 [11.5; 49.6]
- Widowed	42 [2.2]	52.8 [22.9; 82.7]
- Married or cohabited before[5]	187 [9.9]	19.5 [13.1; 25.9]
Total	**1, 885 [100]**	**17.2 [1.9; 32.6]**
Asset Quintile[6]		
- Quintile 1	379 [20.0]	21.6 [13.6; 29.6]
- Quintile 2	377 [20.0]	24.2 [16.7; 31.7]
- Quintile 3	378 [20.0]	24.7 [14.5; 34.9]
- Quintile 4	381 [20.2]	17.6 [0.3; 34.9]
- Quintile 5	375 [19.8]	5.6 [-8.3; 19.5]
Total	**1, 890 [100]**	**17.2 [1.9; 32.6]**
Highest educational level attained		
- Primary	263 [13.9]	20.8 [11.9; 30.0]
- Secondary	1,459 [77.2]	17.9 [3.2; 32.5]
- Tertiary	168 [8.9]	8.9 [- 14.2; 32.1]
Total	**1, 890 [100]**	**17.2 [1.9; 32.6]**
Highest actual educational grade attained		
- Grades 1 – 6	165 [8.7]	22.2 [13.6; 30.9]
- Grade 7	97 [5.1]	18.9 [- 4.3; 42.1]
- Grade 8	138 [7.3]	19.3 [- 2.0; 40.6]
- Grade 9	256 [13.6]	16.5 [- 2.2; 35.2]
- Grade 10	356 [18.9]	16.9 [1.8; 32.0]
- Grade 11	355 [18.8]	25.2 [12.1; 38.4]
- Grade 12	353 [18.7]	12.1 [2.3; 21.8]
- Tertiary/College	168 [8.9]	8.9 [- 14.2; 32.1]
Total/All	**1890 [100]**	**17.2 [1.9; 32.6]**
Formal employment status		
- Yes	376 [19.7]	14.2 [- 9.3; 37.8]
- No	1, 529 [80.3]	18.2 [6.0; 30.4]

Total	**1, 905 [100]**	**17.2 [1.9; 32.6]**
Occupational group [7]		
- Group 1	57 [15.1]	20.2 [- 22.9; 63.4]
- Group 2	26 [6.9]	28.9 [- 0.7; 58.6]
- Group 3	16 [4.2]	20.5 [1.2; 39.8]
- Group 4	9 [2.4]	11.9 [- 19.5; 43.3]
- Group 5	13 [3.5]	…[8]
- Group 6	23 [6.1]	36.3 [- 11.9; 84.6]
- Group 7	12 [3.2]	…[8]
- Group 8	221 [58.6]	11.3 [6.2; 28.9]
Total	**377 [100]**	**14.2 [- 9.5; 37.9][9]**

[1] Crude association adjusted for survey sampling technique to account for higher design effect as a result of survey sampling

[2] CI= 95% confidence interval

[3] Provinces in South Africa: **WCP**=Western Cape Province; **FSP**=Free State Province

[4] Cluster refers to health facility catchment area. Health facility catchment areas were used as primary sampling units during cluster sampling

[5] Married or lived with a man before; current marital status not recorded

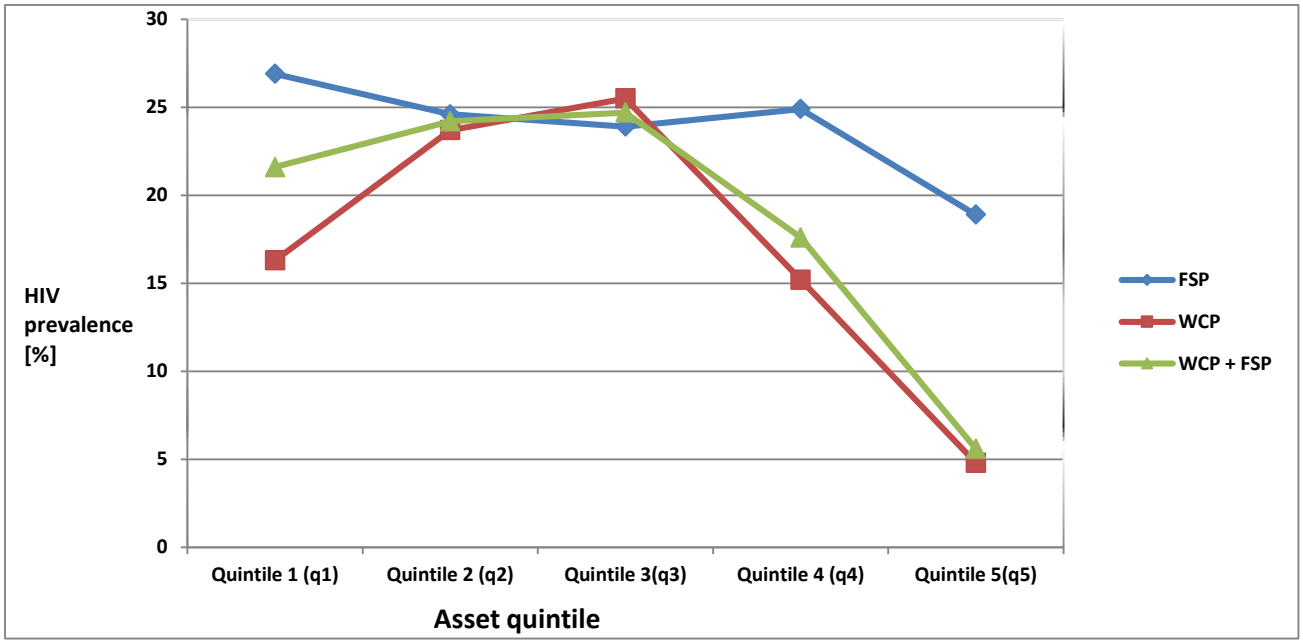
[6] **Asset quintile** = Wealth/Asset Quintile. **Quintile 1** = 'Poorest'; **Quintile 5** = 'Richest' or most relatively well-off.

[7] **Occupation categories**: **group1**=managers or employers in a company, NGO or organization; **group2**=farmers; **group3**=government workers; **group4**=healthcare workers; **group5**=secretaries; **group6**=small business owners or traders; **group7**=students; **group8**=other [these includes chefs, domestic workers; machinists; shop assistants and any other occupation not fitting in the above specified categories etc.]

[8] There were insufficient data points for reliable estimates due to sparse data problem: no estimates from *STATA*

[9] HIV prevalence estimate in this category is different as compared to the overall data because only a few individuals had complete data on type of occupation.

194 **Figure 2:** HIV prevalence by asset quintiles for FSP and WCP and combined [SA] in 2008



195

196 **FSP**=Free State Province; **WCP**=Western Cape Province; SA= South Africa.

197 **Quintile** = Wealth Asset Quintile. **Quintile 1** = Poorest; **Quintile 5** = 'Richest' or most relatively well-off.

198 An inverse relationship was observed between education and HIV prevalence. In bivariate
199 analysis, women with tertiary education [college or university] had the lowest HIV prevalence
200 [**8.9%**] compared to women with primary [**20.8%**] or secondary education [**17.9 %**] [**Table III**]. In
201 adjusted multivariate analysis, each additional year of formal education was associated with a
202 6% reduction in risk of being HIV positive, after adjustment for confounding effect of marital
203 status, rural or urban residence and age [adjusted Odds Ratio [aOR] 0.94 [95% CI 0.89; 0.99]][p-
204 value=0.031] [**table IV**]. However, there was no significant association between HIV and
205 employment status, asset score or occupation in adjusted analysis; aOR 0.69[95% CI: 0.24; 1.98]
206 p-value=0.381, [aOR 0.81[95% CI: 0.53; 1.25] p-value=0.214 and aOR 2.00[95% CI: 0.87; 4.60] p-
207 value=0.083 respectively, as was the case in crude analysis [**table IV**].

208 **Table IV:** Results from logistic regression modeling of the relationship between HIV and SES

Variable	Model 1 [OR: CI]	Model 2 [OR: CI]	Model 3 [OR:CI]	Model 4 [OR: CI]	Model 5 [OR: CI]	Model 6 [OR: CI]
Data points in specified model [N]	N=1888	N=1792	N=1888	N=1792	N=1905	N=1808
Confounders adjusted in specified model[1]						
Age	NA	1.05[1.01;1.10]	NA	1.05 [1.01;1.10]	NA	1.06 [1.00;1.11]
Marital status						
▪ never married[2]	NA	1.0	NA	1.0	NA	1.0
▪ married		0.67 [0.35;1.30]		0.67 [0.35;1.30]		0.68 [0.35;1.31]
▪ divorced		0.40 [0.03;6.21]		0.43 [0.03;6.99]		0.43 [0.03;6.80]
▪ separated		1.47 [0.49;4.39]		1.45 [0.48;4.43]		1.54 [0.52;4.57]
▪ widowed		3.40[1.12;10.37]		3.68[1.23;10.96]		3.70[1.26;10.90]
▪ married before[3]		0.93 [0.33;2.65]		0.94[0.36;2.48]		1.01[0.36;2.84]
Residence type[4][rural=ref]	NA	0.62 [0.15;2.64]	NA	0.62[0.16;2.39]	NA	0.64[0.17;2.32]
SES latent variables in specified model						
Years of formal education	0.92[0.79;1.07]	0.94 [0.89;0.99]	NA	NA	NA	NA
Education category[5]						
▪ Primary	NA	NA	1.0	1.0	NA	NA
▪ Secondary			0.82[0.50;1.36]	1.01[0.67;1.52]		
▪ Tertiary			0.37[0.04;3.87]	0.43[0.07;2.82]		
Formal employment status[6]	NA	NA	NA	NA	0.75[0.24;2.29]	0.69[0.24;1.98]
Asset score[7]	NA	NA	NA	NA	NA	NA
P-value of model	0.182	…	0.634	…	0.510	…

Constant from model	0.33	0.13	0.27	0.10	0.22	0.09

209 …continuation of **table VI**

Variable	Model 7 [OR: CI]	Model 8 [OR: CI]	Model 9 [OR: CI]	Model 10 [OR: CI]	Model 11 [OR:CI]	Model 12 [OR:CI]
Sample size in specific model	N=1890	N=1795	N=1906	N=1809	N=352	N=331
Confounders adjusted in specified model[1]						
Age	NA	1.05[1.01;1.11]	NA	1.05[1.01;1.11]	NA	1.06[1.03;1.10]
Marital status						
▪ never married	NA	1.0	NA	1.0	NA	1.0
▪ married		0.69[0.39;1.24]		0.76[0.46;1.24]		0.38[0.21;0.70]
▪ divorced		0.39[0.02;6.49]		0.41[0.02;7.43]		1.00[…]
▪ separated		1.42[0.50;4.03]		1.37[0.48;3.95]		2.75[0.49;15.38]
▪ widowed		3.44[1.20;9.84]		3.31[1.10;10.00]		5.57[1.35;23.00]
▪ married before[3]		0.84[0.34;2.09]		0.94[0.44;2.01]		0.72[0.09[5.83]
Residence type[2][rural=ref]	NA	0.73[0.32;1.70]	NA	0.79[0.37;1.66]	NA	0.54[0.08;3.67]
SES latent variable in specified model						
Asset score[4] [1st PC]	0.81[0.51;1.29]	0.81[0.53;1.25]	NA	NA	NA	NA
Asset quintile [5]						
▪ Lowest [ref]	NA	NA	1.0	1.0	NA	NA
▪ Second			1.16[0.59;2.28]	1.07[0.59;1.94]		
▪ Middle			1.19[0.52;2.70]	1.21[0.58;2.51]		
▪ Fourth			0.77[0.20;3.05]	0.76[0.20;2.90]		
▪ Highest			0.21[0.01;3.32]	0.21[0.02;2.93]		
Occupational group [6]						
▪ I [ref]	NA	NA	NA	NA	1.0	1.0

▪ II					1.61[0.06;44.87]	0.91[0.08;10.89]
▪ III					1.02[0.20;5.07]	0.81[0.11;5.96]
▪ IV					0.54[0.17;1.69]	0.43[0.09;2.06]
▪ V					1.00[…]	1.00[…]
▪ VI					2.26[0.75;6.80]	1.93[0.84;4.44]
▪ VII					1.00[…]	1.00[…]
▪ VIII					0.51[0.18;1.45]	0.43[0.20;0.91]
P-value of model	0.271	…	0.148	…	…	…
Constant	0.21	0.08	0.28	0.10	0.25	0.12

Key: CI=95% Confidence Interval; **ref**=reference category; **OR**=Odds Ratio**; NA**=Not Applicable; **PC**=Principal Component; … insufficient data to produce estimates in regression model; **FSP**=Free State Province; **WCP**=Western Cape Province; SA= South Africa.

[1] Only variables meeting criteria for confounders will be adjusted in specific models.

[2]Options: Urban or rural. Baseline comparison group is rural residence

[3]Education: years of formal education was used in the initial model then regression modelling was repeated using education category instead of years of formal education

[4]Asset score is a relative scale representing wealth derived using the Principal Components Analysis statistical method that assigns a relative score based on household ownership of assets and access to social amenities like electricity. Our asset score obtained using this method had a range of -5.56 to +2.33 with a mean of 0 and a standard deviation of 1.47. On this scale of relative wealth, the lower the score the 'poorer' or worse off financially a household is. This is the score used in creating "*wealth categories*" or asset quintiles. As indicated this score has been found to be useful in demonstrating ability of the household to access health interventions. An inverse relationship has been shown between this score and morbidity and mortality.

[5]**Asset** q**uintiles** = Wealth Asset Quintiles. **Quintile 1** = Poorest; **Quintile 5** = 'Richest' or most relatively well-off.

[6]**I**= Housewife [reference group]; **II**= Farmer *or* Small business owner *or* Trader; **III**=Student; **IV**=Healthcare worker *or* Secretary; **V**=Other.

OR and 95% CI are presented adjusted for sampling design and clustering at the health facility catchment area level. Wealth index variable will be developed using Principal Components Analysis summarizing household ownership of assets and access to social amenities

Discussion

Using secondary data from PEARL study community survey that sampled representative households from FSP and WCP in South Africa [SA], we evaluated the relationship between SES and HIV prevalence in women of reproductive age. SES was measured by education, employment status, type of occupation and asset quintiles. We observed a significant inverse relationship between risk of HIV acquisition and highest level of formal education. No significant association was observed between risk of HIV and employment status, type of occupation or asset quintile.

We observed an overall HIV prevalence that was lower than that of women attending ante-natal clinic [ANC] services at national level in SA [17.2% vs. 29.3%] [18]. However, since HIV prevalence significantly differs by province [6,18], the corresponding provincial comparisons are more appropriate. Our HIV prevalence estimate for WCP is comparable to that of women seeking ANC services at the time of the survey in WCP [15.3% vs 16.1%][18] whereas that for FSP was significantly lower [24.5% vs. 32.9%] [18]. For FSP, the difference is explained in part by the fact that our sample markedly differed from the actual population demographic distribution. In our FSP sample, 42% of women came from rural settings whereas the actual proportion that is from rural settings is 25% [19]. HIV prevalence in urban settings is higher than that in rural settings, with informal urban settlements in SA having the highest prevalence rate when compared to formal urban settlements [RR=1.8], informal rural settlements [RR=2.5] or formal rural

249 settlements [RR=2.8][20]. Thus, a higher proportion of rural residents in a study sample as it
250 occurred in our case for FSP would lead to a lower HIV point prevalence estimate when
251 compared to the actual prevalence. Furthermore, the inclusion criteria used to recruit our
252 sample targeted women in a community setting who had a child delivery within 2 years before
253 conduct of the survey. Selection bias may occur if women who attend ANC services substantially
254 differ from those who do not seek these services since ANC surveys sample women from ANC
255 service points of public health facilities. Thus ANC HIV prevalence estimate may differ from that
256 of all women in the community setting who would have otherwise sought ANC services.

257 The lower HIV prevalence in WCP as compared to FSP could partly be explained by the fact that
258 each of the following factors associated with a lower HIV prevalence had a proportion that was
259 almost thrice in WCP as compared to FSP [21]; proportion of women with tertiary education,
260 proportion in employment and proportion from the highest quintiles; Q 4 and 5 [table 1].
261 Moreover, about 50% and 42% of women in FSP were from urban informal settlements and rural
262 formal settlements respectively. In WCP, those from urban informal settlements were only 20%,
263 with the rest coming from urban formal settlements. Residents of urban informal settlements
264 have the highest HIV prevalence [21.3% [22]] and incidence [5.1% per annum] and account for
265 29.1% of annual incident HIV infections in SA [23]. Thus, a lower proportion of study participants
266 from informal settlements as the case applies for WCP, would partly explain the reason for a
267 lower HIV prevalence in WCP than FSP.

268 In our study, the proportion of women with secondary education was similar across provinces
269 but that with tertiary education was significantly higher in WCP, a finding also reported by

Statistics SA from the 2001 population census [24]. The Census reported proportion of individuals without formal education to be 16% in FSP but only 5.7% in WCP [24]. Our study showed a significant inverse relationship between level of education and prevalent HIV infection using years of formal education. A similar inverse association in SA was observed by Johnson et al who used data from multiple nationally representative annual cross-sectional ANC surveys over a period of 8 years in women aged between 15 to 24 years attending ante-natal clinics. They reported a change in relationship between education and HIV from a direct [1998-2000] to an inverse relationship [2002-2005][25]. In our study, restricting our analysis to women aged 15 to 24 years showed a stronger beneficial effect of education than that observed in women of all ages. This effect was similar and strong in each of the provinces with a reduction in risk of HIV of between 9% and 26% for every additional year of formal education. Other studies in varied settings have reported a change of the association between education and HIV prevalence from direct to inverse with maturity of HIV epidemic [26-32], including a systematic review[33]. The systematic review showed an overall increase in proportion of studies showing an inverse association with maturity of HIV epidemics across SSA [26]. The change of the association from direct to inverse using education as a measure of SES was hypothesized to be due in part to maturity of HIV epidemic from early phases when infections are concentrated in high risk core groups to advanced phases when HIV becomes a generalized epidemic [34]. Early in the HIV epidemic, concurrency, transactional sex and STIs [35], notably Herpes Simplex Virus type 2 [HSV2], are important risk factors when infections are concentrated in high risk sexual groups, but matter relatively less in advanced epidemics when a much larger proportion of relatively lower risk individuals in the general population are infected [34]. The predominant direct

292 association early in the HIV epidemic is hypothesized to be due to the fact that more educated
293 individuals had greater disposable income, more leisure time, were more mobile and more likely
294 to have broader sexual networks[33,36] including a higher opportunity to seek services of
295 commercial sex workers [37,38] or to have multiple sexual partners[39]. More educated
296 individuals were more likely to be employed and to live in towns where HIV prevalence was
297 higher and concentrated in the early phases of the HIV epidemic; a phase also associated with
298 higher proportion of people in the HIV serological window as compared to the more advanced,
299 mature and stable phases of a HIV epidemic. STI cofactor effect, including prevalence and
300 clustering of both HIV and STIs, among more sexually active individuals in the population are key
301 in initiating and maintaining a rapid HIV epidemic [35]. These attributes put more educated
302 individuals at a higher risk of acquiring HIV early in the epidemic as compared to less educated
303 individuals. The change in association between education and HIV is attributed in part to better
304 awareness, faster adoption of safer sexual practices and greater access to preventive and
305 curative health services by the more educated individuals [40]. The time lag in the change of
306 association was hypothesized to be due to slow and or insufficient integration of health
307 education and other HIV prevention strategies early in the HIV epidemic by most sub-Saharan
308 African countries [33,41]. Of important note is that, early in a HIV epidemic as a result of high
309 HIV incidence, there are more people in the HIV serological window that is associated with a
310 higher risk of HIV transmission due to very high HIV viral loads as compared to the latter phases
311 of a HIV epidemic when HIV is stable and generalized in the general population. The latter is
312 associated with reducing levels of HIV incidence as a result of not only HIV prevention and care
313 interventions but also maturity of the HIV epidemic.

As HIV epidemic matures and more people outside core risk groups get infected, there is increase of HIV burden in stable heterosexual HIV serodiscordant relationships. More than two-thirds of married or cohabiting couples in whom at least one of the partners is HIV infected are in sero-discordant relationships, with women contributing 47% of those who are infected [42]. A large proportion of new HIV-1 infections in mature epidemics occur within sero-discordant couples, with rates of between 55%-93% reported by studies in Zambia and Rwanda [42]. The annual risk of HIV infection for a HIV-negative partner in a sero-discordant union is high, with risk levels of up to 10%. HIV sero-discordancy is a major and thus key contributor to the spread of HIV in SSA. Behavioral interventions such as promotion of use of condoms are less effective in serodiscordant couples in settings where rates of voluntary couple HIV counseling and testing are low and levels of stigma and intimate partner violence are high [42].

The phenomenon where in the early phases of a HIV epidemic, incident HIV infections were concentrated among individuals of higher SES in whom, following response to HIV prevention efforts and maturity of HIV epidemic, HIV incidence fell faster[21] than in individuals of a lower SES, has come to be termed the 'inverse equity hypothesis'[43] by some authors. The hypothesis postulates that new HIV infections, and later prevalence, falls fastest among individuals of higher SES as compared to those of lower SES[44] and that HIV increasingly concentrate in individuals of lower SES[43,44] and progressively reduce in those of higher SES who gain fastest from scale up of HIV preventive and curative interventions.

One of the strengths of our study is that the questionnaire instrument and sampling methodology used to derive our data was similar to that of the widely used DHS surveys. The fact

335 that DHS surveys are conducted across many countries in SSA enable comparison and monitoring
336 of the association between SES and HIV prevalence across countries or within sub-regions in
337 countries over several years as the HIV epidemic matures [45] or as SES proxy variables, such as
338 education of women in sub-regions of developing countries, changes over time. If data is derived
339 from a DHS survey, conduct of a study like ours will be relatively inexpensive as it requires little
340 additional cost or resources, yet it provides key information that can guide design, wording and
341 socio-economic aspects to target in HIV prevention messages relayed to the public through print
342 and electronic media.

343 The variability in the nature of association between SES and HIV observed in cross sectional
344 studies has also been noted in the few cohort studies evaluating this relationship. A cohort study
345 from Zimbabwe showed HIV incidence to be highest in poorer groups [46], one from KwaZulu
346 Natal [SA] showed HIV peaks in the middle wealth classes [3] whereas one from Limpopo [SA]
347 showed no relationship between SES and HIV incidence [47]. Given this high variability, more
348 research is required to refine measurement approaches for SES and to determine the association
349 between SES and HIV in different settings and in the same setting over time as the HIV epidemic
350 matures in more countries in SSA. Suggested research includes formation and refinement of
351 guidelines for choice of assets to include in a PCA model to make it more sensitive to changes in
352 SES. This will reduce the observed variability in sensitivity of PCA in assigning asset scores. Lastly,
353 prospective cohort studies that measure HIV incidence over time will help unravel the difficulty
354 of establishing temporality that is inherent in cross-sectional studies [48]. If confirmed in future
355 studies, our findings suggests the need to re-evaluate whether current HIV prevention efforts
356 meet needs of the least educated [49]. Our findings suggest the need to improve design of HIV

prevention messages for example those that promote voluntary HIV couple counselling and testing so that messages reach and are understood by semi-illiterate individuals in mature HIV epidemics.

Race has been extensively used as a proxy for SES in social epidemiology research in SA to monitor social and health inequities and temporal progress in equitable distribution of public resources [5]. However, the issue of race as a variable is complex due to many variables, and confounders, that explain the observed association between race and HIV including; SES, migrancy, cultural beliefs and other less well investigated factors such as sense of community [50], and sense of coherence [51-53] that require further research.

Observational studies are susceptible to confounding and all known and unknown confounding may not be fully adjusted for during analysis [38]. Lastly, wealth indices based on household assets may not reflect true financial status of women who may have limited access to household finances due to gender inequality. Thus, better measurement approaches are required that reflect the economic standing of women in settings with widespread gender inequality [54].

In many SSA countries, social and cultural influences on girls' behaviour prevent them from making choices that could be protective such as buying condoms, discussing safer sex measures or staying in school. Keeping girls in school reduces their risk of contracting HIV [55]. A SA study showed school drop-outs had higher intergenerational sex, higher lifetime number of sex partners, more frequent sex and higher incidences of unsafe sex as compared to their peers who were still in school [56]. Interventions to keep girls in schools for longer have also been observed to lead to a reduction in pregnancy rates [57]. Schooling affect sexual behaviour through various

mechanisms including changes in socio-cognitive determinants of behaviour such as knowledge and attitudes, influencing of social networks, and by leading to a change in SES [58].

Like our data for educational attainment, the proportion of women in employment differed by province. The HIV prevalence of women in employment was slightly lower than that of women not in employment; however this difference was not statistically significant, a finding observed in both crude and adjusted association. A similar observation was noted for type of occupation in multivariate analysis where there was marginal non-significant beneficial effect against acquisition of HIV by most occupations as compared to managers [or employers] in companies. This association was not statistically significant because our study was under-powered to evaluate the relationship between type of occupation and HIV prevalence due to large missing data points on occupation. Our study had various other limitations. Cross-sectional studies cannot establish temporal or causal relationships [3,38]. HIV has been shown to have a bidirectional relationship with economic status [48]. HIV infection can impoverish individuals of a higher SES, particularly in the era before free and wide availability of antiretroviral therapy in public health facilities [59]. Low SES on the other hand, as the case applies for miners and their marriage and or cohabiting partners in SA, has been associated with risky sexual behaviours such as engagement in sexual concurrency and utilizing services of commercial sex workers which puts them at increased risk of contracting HIV. The impact of such migration on women's, and men's, erosion of sociocultural norms that guide behaviour and its impact on conjugal stability has been studied less extensively [60] and needs further exploration in studies designed specifically for these end-point. Migrant labor system contributed to the magnitude and rapidity of spread of HIV epidemic in Southern Africa [61]. Migrancy increases HIV acquisition risk by as

much as 2.4 times in migrant mine laborers as compared to non-migrant men [62]. Mobile individuals are also harder to reach for HIV preventive care and treatment services [3].

Conclusions

Literature shows varying association between SES and HIV prevalence in SSA. In general, the relationship between SES as measured by education or asset quintiles and HIV changes from a direct association in early phases of a HIV epidemic to an inverse association in mature epidemics in majority of contexts in SSA. The changing association underscores the need for targeted HIV prevention messages in languages that are easily understood by the critical mass of poor semi-illiterate women and individuals at large. These messages should focus on reduction of concurrency, promotion of voluntary couple HIV testing and counseling, strengthening of STI treatment programs, and practice of safe sex. Medium term approaches to reduce HIV incidence include promotion of male circumcision in sexually active adolescent males, promotion of female microbicide research and promotion of girl child education.

Competing interests

The authors declare that they have no competing interests.

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during conception of the study and Dr. Olufunke Alaba, Bosco Odhiambo and Annibale Cois [all from the University of Cape Town] during write up of the study.

Authors' contributions

D.C provided invaluable and consistent oversight in conception, design, data analysis and critical appraisal of the manuscript as the supervisor. E.B. contributed in conception and design of the manuscript and led data analysis and writing of the first draft of the manuscript. All authors read and approved the final manuscript.

Authors' affiliation

[1]School of Public Health and Family Medicine, University of Cape Town, Cape Town, South Africa

List of abbreviations

AIDS, Acquired Immune-Deficiency Syndrome; aOR, adjusted OR; ART, anti-retroviral therapy; CI, Confidence Interval; DHS, Demographic and Health Survey; FSP, Free State Province; HIV, Human Immunodeficiency Virus; OR, Odds Ratio; PCA, Principal Components Analysis; PEARL, PMTCT Effectiveness in Africa, Research and Linkages to Care Study; PMTCT, Prevention of Mother to Child Transmission of HIV; SA, South Africa; SES, Socioeconomic status; SSA, sub-Saharan Africa; UCT, University of Cape Town; UNAIDS, Joint United Nations Programme on HIV and AIDS; WCP, Western Cape Province.

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595

17.Appendices

17.1. Appendix 1: UCT research ethical approval letter for the primary study [*PEARL* study]

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: prewards@curie.uct.ac.za

18 April 2007

REC REF: 155/2007

Dr D Coetzee
Infectious Disease Epidemiology Group
Public Health & Family Medicine

Dear Dr Coetzee

PROJECT TITLE: PMTCT EFFECTIVENESS IN AFRICA: RESEARCH AND LINKAGES TO CARE PART 2: COMMUNITY SURVEY PROTOCOL VERSION 1.0

Thank you for submitting your study to the Research Ethics Committee for review.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Once funding is received, please could you conduct a pilot study which examines the more sensitive areas in this research such as completing questionnaires which include very sensitive and personal information in settings which might lack privacy. Whilst verbal autopsies can yield useful information, they can also arouse painful memories; so, again this is a sensitive area which will need skilled interviews. It would also be useful to learn from a pilot study if participants actually do identify any perceived "social harms" from taking part. This would be asked at the end of the interviews

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

lemjedi

Yours sincerely

A/PROF. M. BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

lemjedi

17.2. **Appendix 2:** UCT research ethical approval letter for this study

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone (021) 406 6338 • **Facsimile** (021) 405 6411
Email: shyrota.thomas@uct.ac.za
Website: www.health.uct.ac.za/research/humanethics/forms

17 September 2013

HREC REF: 564/2013

Prof D Coetzee
Public Health & Family Medicine
Level 5, Falmouth Building

Dear Prof Coetzee

PROJECT TITLE: RELATIONSHIP BETWEEN SOCIOECONOMIC STATUS AND HIV IN THE FREE STATE AND WESTERN CAPE PROVINCES OF SOUTH AFRICA

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study. We acknowledge that the student Erick Bunyasi is also involved as a Master's student on this project.

Approval is granted for one year until the 30th September 2014.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period. (Forms can be found on our website: www.health.uct.ac.za/research/humanethics/forms)

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC. REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN ETHICS
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.
The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

17.3. **Appendix 3:** variables table

This table reflects how our dataset was designed to be coded.

Variable abbreviation [Column heading in *STATA* dataset]	Definition of variable in first column	Variable scale	Range/coding [Code in dataset; definition]
a) Socio-demographic data			
'study_id'	Study number	Discrete	**Integer**; this study number will ensure anonymity of study participants
'strata'	Province	Binary	**1**: WCP **0**:FSP
'cluster'	Community or Health facility catchment area	Nominal	Coded as **1, 2, 3, 4, 5** and **6**. See legend [8] for definition
'Age'	Age at last birth day [in years]	Discrete	Discrete entries, no decimals. Range **14-57**
Age category of respondent. Categories included: 'age1519'; 'age2024'; 'age2529'; 'age3034'; 'age3539'; 'age4044'; 'age4549'; 'age50'	Age band	Ordinal	Each of the options, entered as a column in STATA was coded as an indicator variable [i.e. **1** or **0** as appropriate]. See legend [6] for definitions
'Marital_status'	Marital status	Nominal	**1**=never married **2**=married **3**=divorced **4**=separated **5**=widowed **6**=married or cohabited before **7**=missing or no entry
'partner_lives_where'	Whether participant lives with partner or not	nominal	**Code in dataset Definition** **8783**:lives together **8782**:lives somewhere else **9091**:missing answer

'partner_no'	Number of sexual partners	ordinal	1396:One other 4199:2 other 11055:3 or more other 8072:don't know
'residence_type'	Residence type	nominal	Each of the 6 clusters will be assigned a label with one of the following; Urban formal; urban informal; Rural formal; rural informal
'residence_group'	Residence type	binary	1:urban 2:rural
'dec_ownhealth'	Who in the household has a say on key household decision: own healthcare	Nominal	No Code in dataset Definition 1. 9830;Respondent 2. 8586;Husband/sexual partner 3. 9662;Someone else, other than 1 & 2 4. 9575;Respondent + Someone else 5. 8031;Decision not made/NA 6. 9091; Missing answer
'dec_large'	Who in the household has a say on key household decision: making large household purchases	Nominal	No Code in dataset Definition 1. 9830;Respondent 2. 8586;Husband/sexual partner 3. 9662;Someone else, other than 1 & 2 4. 9831;Respondent + Someone else 5. 8031;Decision not made/NA 6. 9091;Missing answer
'dec_sch'	Who in the household has a say on key household decision: regarding schooling	Nominal	No Code in dataset Definition 1. 9830;Respondent 2. 8586;Husband/sexual partner 3. 9662;Someone else, other than 1 & 2

			4. **9831**;Respondent + Someone else 5. **8030**;Decision not made/NA 6. **9091;**Missing answer
'dec_childh'	Who in the household has a say on key household decision: on healthcare of the children	Nominal [see 'range' for codes to be used]	**No** **Code in dataset** **Definition** 1. **9830**;Respondent 2. **8586**;Husband/sexual partner 3. **9662**;Someone else, other than 1 & 2 4. **9831**;Respondent + Someone else 5. **8031**;Decision not made/NA 6. **9091**;missing answer
'anc_clinic_po'	Name of ANC clinic attended	nominal	Oral response of clinic recorded as a nominal response and as checked from card as 'anc_clinic_record'
b) Variables used as proxies of socioeconomic status			
'education_level'	Highest level of education/ school completed	ordinal	**Code in dataset; Definition** **9464**:primary **9591**:secondary **8572**:higher **9091**;missing answer
Highest grade of education attained by respondent. Options included: ***'edu_grade1_6'; 'edu_grade7'; 'edu_grade8'; edu_grade9'; 'edu_grade10'; edu_grade11'; edu_grade12' and 'edu_subcollege'***	Actual grade of education attained	binary	Each of the options was coded as an indicator variable [i.e. **1** or **0**]. See legend [1] for definitions
'Employment'	Employment status	Binary	**1**:Employed **0**:Unemployed
Occupation of the respondent. Options	Occupation type	Nominal	Each of the options was coded as an indicator variable [i.e. **1** or **0**]. See

included: 'occup1'; 'occup2'; 'occup3'; 'occup4'; 'occup5'; 'occup6'; 'occup7'; 'occup8'			legend [2] for definitions
Type of water accessible for drinking by the household. Options included: *'pipe_in'; 'pipe_public'; 'pipe_out'; 'borehole'; 'h20_tank'; 'other'*	Assets owned by the family/respondent: source of drinking water for the household	Nominal [see 'range' for codes to be used]	Each of the options was coded an indicator variable [i.e. **1** or **0**]. See legend **[3]** for definitions
Type of toilet facility accessible to the household. Options included; *'toilet_sewer'; 'toilet_tank'; 'toilet_latrine'; 'toilet_vip'; 'toilet_bucket'; toilet_bush'; 'toilet_other'*	Assets owned by the family/respondent: type of toilet facilities in the household	Nominal [see 'range' for codes to be used]	Each of the options was coded an indicator variable [i.e. **1** or **0**]. See legend **[4]** for definitions
Other household assets. Namely; *'electricity'; 'tv'; 'radio'; 'phone'; 'fridge'; 'bicycle'; 'no_of_phones'; 'motorcycle'* and *'car'*.	Household goods ownership [as listed]	All binary, save number of cell phones which was continuous.	Each of the options was coded an indicator variable [i.e. **1** or **0**] save number of cell phones in household [5].
Main floor in household *'floor'*	Main material of the floor in the household	Nominal	Coded as; **9283**=Natural floor [earth, mud, dung], **8149**=finished floor [cement, tiles], **9814**=wood planks, **9424**=other
Type of floor of main house in household = *'goodfloor'*	Main material of the floor	Binary	Coded as '**1**' for finished floor [tiles, wood planks, cement floor] or '**0**' for unfinished floor [earth, dung, mud]

'food'	Food security over the past month as measured by the question: **In the past month, would you say that this household?**	Nominal [see codes under 'range' for options of response]	No Code in dataset Definition 1. **9782**; Usually has enough food to eat 2. **9667**; Sometimes has enough food to eat 3. **9627**; Seldom has enough food to eat 4. **9289**; Never has enough food to eat
'literacy_allgps'	Ability to read basic sentences prepared in local languages such as 'parents love their children', 'farming is hard work', 'the child is reading a book', and 'children work hard at school'.	Ordinal[see codes under 'range']	No Code in dataset Definition 1. **3**; Can't read 2. **2**; Able to read parts of sentence 3. **1**; Able to read whole sentence 4. **4**; No card with required language or blind/visually impaired
'pc1'	Household asset score derived using principal component analysis	Continuous	Continuous, from negative to positive
'Wi'	Asset quintile i.e. 5 ordinal categories of household welfare derived from asset score	Ordinal	Coded as; **1, 2, 3 4, 5**. See legend [7] for definition
c) Laboratory results			
'hiv'	HIV test result	Binary	Code Definition **1**:Positive **0**:Negative
'syphilis_test'	Syphilis test result	nominal	9818:Positive 9309:Negative 9091:missing 8072:don't know

Key: Lpg: Liquefied Petroleum Gas used for cooking, **HIV**: Human Immunodeficiency virus, **IPT:** Intermittent Preventive Therapy used for malaria prevention in pregnancy, **ANC**: Antenatal clinic, **FP:** Family planning, **IUCD:** Intra-Uterine Contraceptive Device, **CD:** Condom, **LAM:** Lactational Amenorrhea

[1] *'edu_grade1_6'*= grades 1-6*; 'edu_grade7'*=grade 7*; 'edu_grade8'*=grade 8*; 'edu_grade9'*=grade 9*; 'edu_grade10'*=grade 10*; 'edu_grade11'*=grade 11*; 'edu_grade12'*=grade 12' *and 'edu_subcollege'*=college level education

[2] **Occupation categories**: **group1**=managers or employers in a company, NGO or organization; **group2**=farmers; **group3**=government workers; **group4**=healthcare workers; **group5**=secretaries; **group6**=small business owners or traders; **group7**=students; **group8**=other [these includes chefs, domestic workers; machinists; shop assistants and any other occupation not fitting in the above specified categories etc.]

[3] **Water accessible for household use**: '**pipe_in'**=Piped water into the house; '**pipe_out'**= Piped water outside but available within plot; ['**pipe_pubic'**= Public tap; '**borehole**'= Tube well or borehole ; '**h2o_tanker'** = Tanker truck or cart with small tank or protected well; '**other_h2o'**= Other sources i.e. data points with missing responses, those getting water from unprotected wells, bottled water, surface water [river, dam, lake, pond, canal, or irrigation channel], surface water, protected well, rainwater, or other unspecified sources.

[4] Flush toilet to piped sewer system = *'toilet_sewer';* Flush toilet to pit or tank=*'toilet_tank';* Traditional pit latrine=*'toilet_latrine';* Ventilation Improved Pit latrine =*'toilet_vip';* Bucket toilet *'toilet_bucket';* No facility, bush or field =*'toilet_bush';* Other: includes public flush toilet and missing responses=*'toilet_other'*

[5] Number of cell phones in household. Options included; 1 cell phone; 2 cell phones; 3 cell phones; 4 cell phones; more than 4 cell phones; don't know; don't want to tell

[6]**Age categories**; 'age1519'='age 15 – 19'; 'age2024'='age 20-24'; 'age2529'='age 25-29'; 'age3034'='age 30-34'; 'age3539'=age 35-39; 'age4044'=age 40-44; 'age4549'=age 45-49; 'age50'= age 50 and above.

[7]Wealth quintiles derived using Principal Components Analysis [PCA] in *STATA* Special Edition version 12.1. Wealth quintile categories **1**=First or Lowest quintile ['Poorest' on a *relative* asset index scale]; **2**=Second quintile; **3**= Middle quintile; **4**=Fourth quintile; **5**=Highest quintile ['Richest' on a *relative* asset index scale]

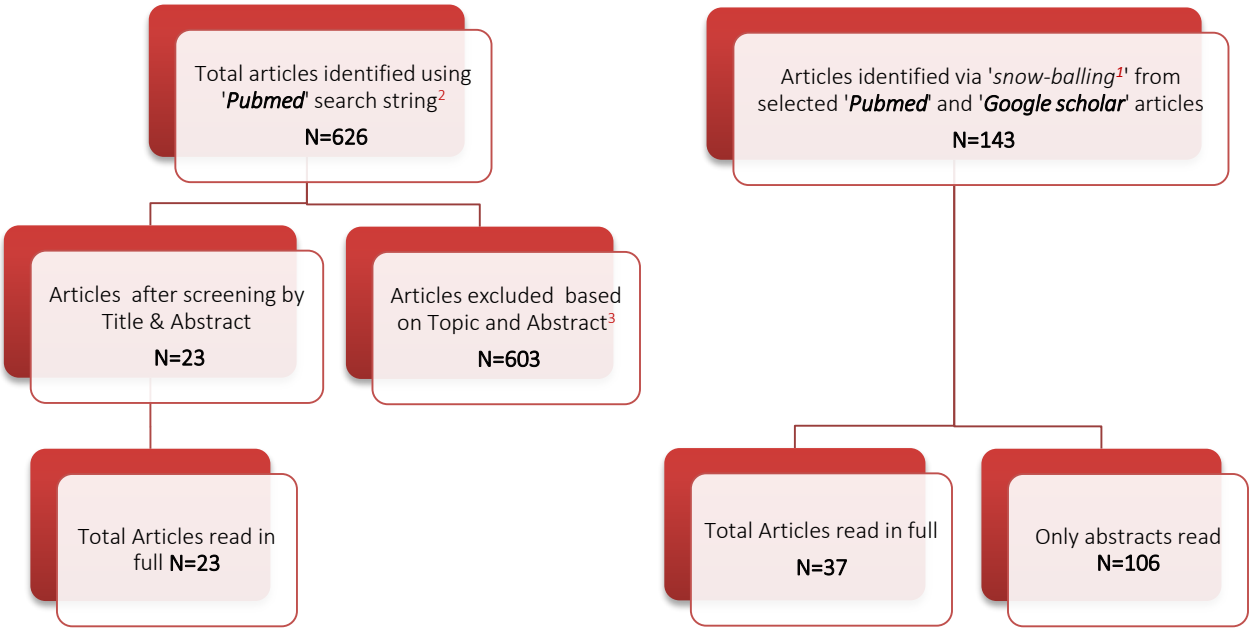
8 **1**=Stellenbosch **2**=Mitchell's plain **3**=Gugulethu **4**=Botshabelo **5**=Mantsopa **6**=Thabo Mofutsanyana

17.4. Appendix 4: Search strategy for literature review

The literature search was carried out using the following approaches:

a. Literature search strategy in '*Pubmed*' database.

Literature search in *Pubmed* was limited to articles published in English between November 1st, 1983 and November 1st, 2013, predominantly in adult participants of either or both gender. Initial screening was based on title and abstract to identify relevant papers that were fully read.



Summary of screening procedure for articles from '*Pubmed*' and from '*snow-balling*'[1]

[1]'*Snow-balling*'= Identification of articles using bibliography and authors of articles already identified via '*Pubmed*' and '*Google scholar*'. Our search string is defined in the next paragraph. Reasons for exclusion of articles based on abstract were; articles not relevant to sub-Saharan Africa context, study population exclusive to most at risk populations [MARPS] only, study population including only children, articles evaluating effect of HIV on SES, articles evaluating

specific educational programs or other research end-points not of primary interest to our research question.

The initial literature search on '***Pubmed***' was done using the following search string;

> *'[[[[[HIV[Title] AND education[Title]] OR occupation[Title]] OR employment[Title]] OR wealth[Title]] OR assets[Title]] AND HIV[Title] AND [['1983/11/01'[PDAT] : '2013/11/01'[PDAT]] AND 'humans'[MeSH Terms] AND English[lang]]'*

b. Search strategy on '*Google Scholar*'

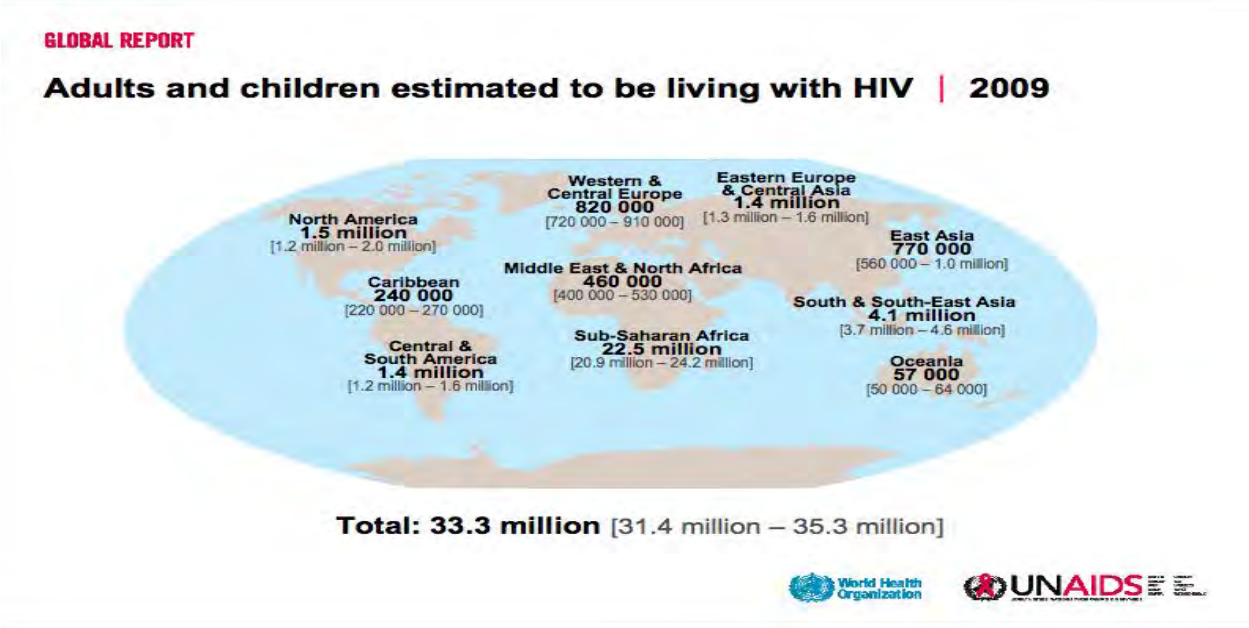
Each of the search terms below was used one at a time to search for articles in '*Google Scholar*' that were relevant to the research question, on October 1st 2013.

- 'Socioeconomic status and HIV in Africa'
- 'Wealth and HIV in Africa'
- 'Assets and HIV in Africa'
- 'Occupational status and HIV in Africa'
- 'Employment status and HIV in Africa'
- 'Education and HIV in Africa'
- 'Socioeconomic status, education, employment, occupation, wealth, assets and HIV in sub-Saharan Africa'

c. Search strategy using bibliography of selected papers

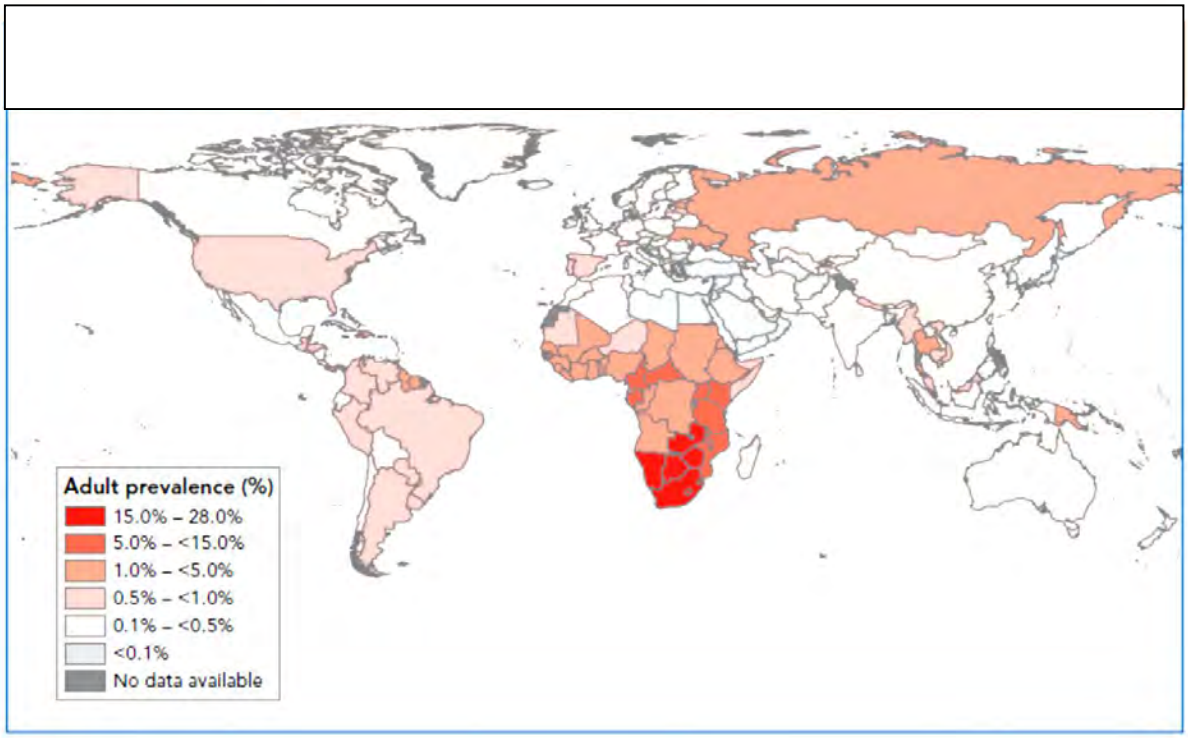
Further literature search was conducted [in '***Google scholar***' and '***Pubmed***'] using authors and bibliographies of articles selected using strategies ***a*** and ***b*** that were found relevant to our research question.

17.5. **Appendix 5:** Regional HIV estimates



Source: UNAIDS

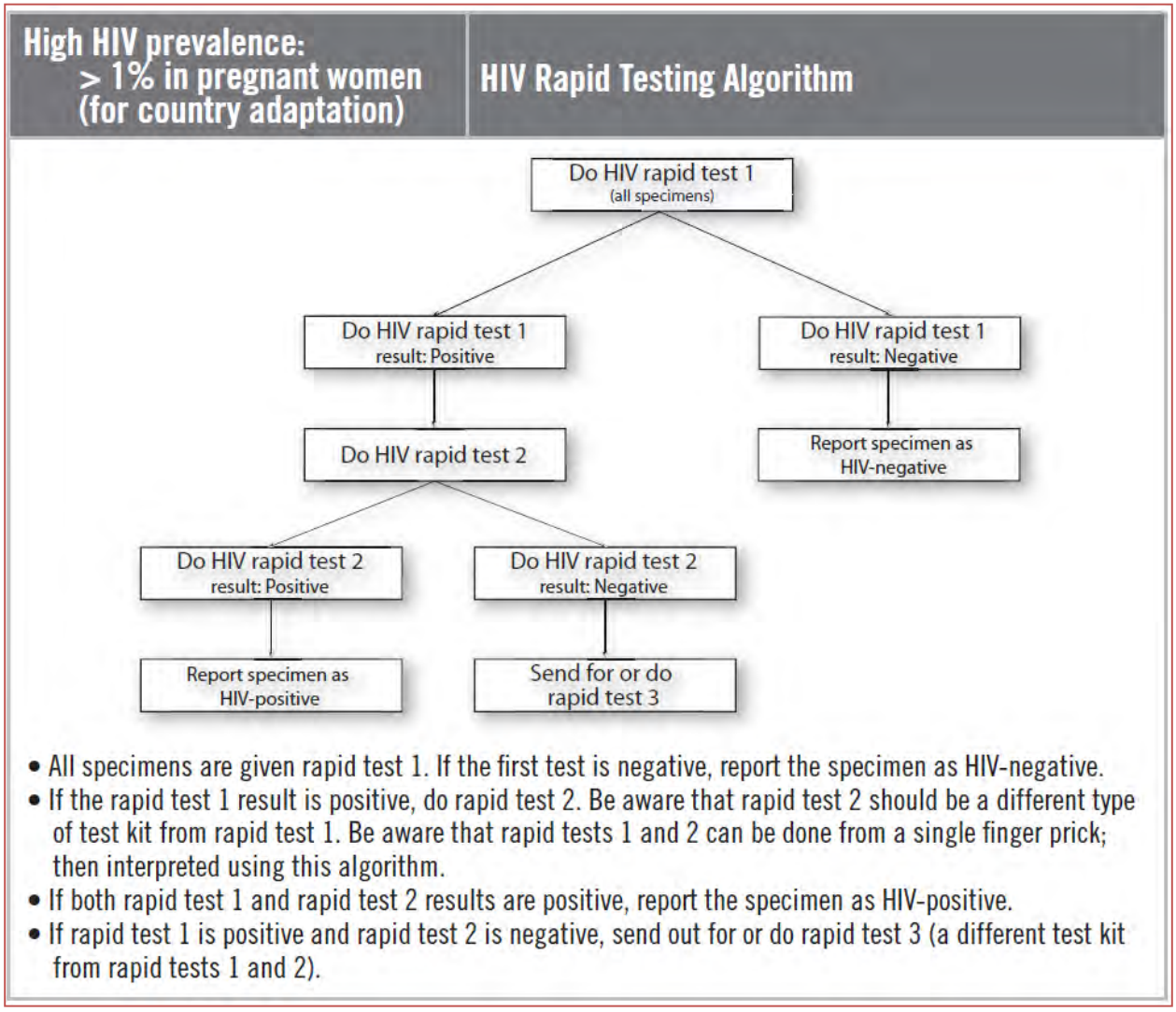
17.6. **Appendix 6:** Prevalence of HIV infection by country



Source: UNAIDS

17.7. **Appendix 7:** WHO HIV rapid testing algorithm for adults

[Source: WHO website [1]]



17.8. **Appendix 8:** WHO clinical staging of HIV/AIDS[2]

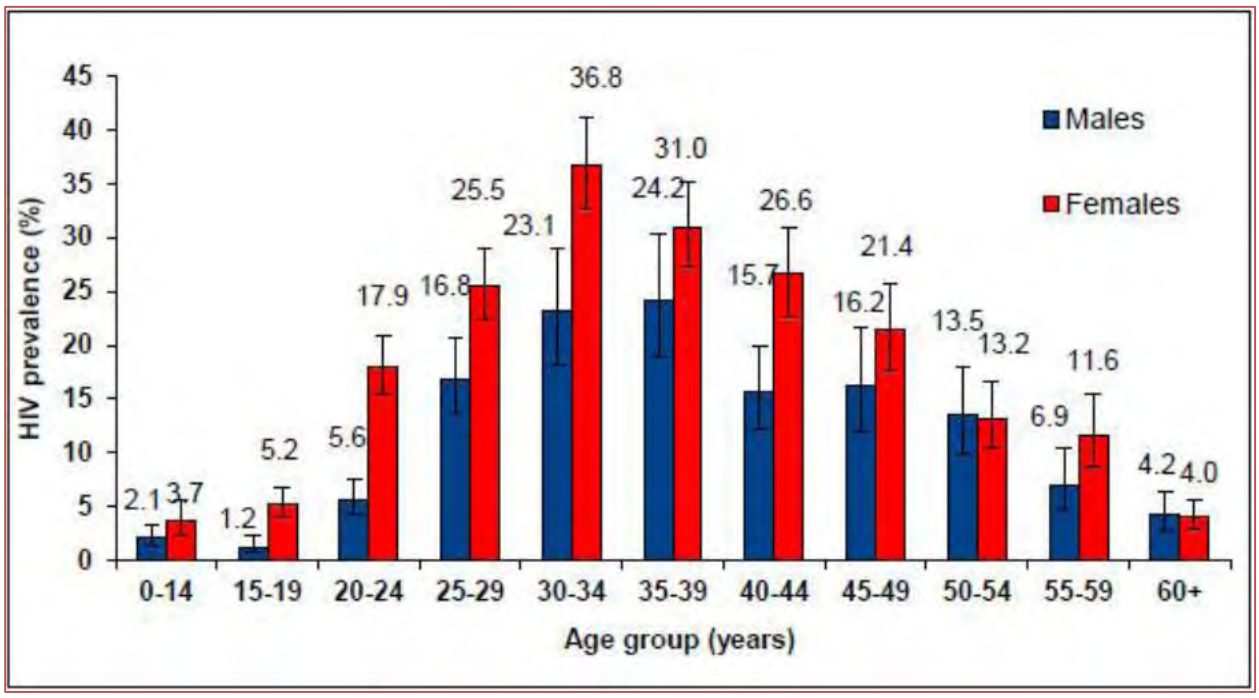
WHO[2] clinical staging of HIV/AIDS
WHO clinical stage I
▪ Asymptomatic ▪ Persistent generalized lymphadenopathy
WHO clinical stage II
▪ Moderate unexplained weight loss [<10% of presumed or measured body weight] ▪ Recurrent respiratory tract infections [sinusitis, tonsillitis, otitis media and pharyngitis] ▪ Herpes zoster ▪ Angular cheilitis ▪ Recurrent oral ulceration ▪ Papular pruritic eruptions ▪ Seborrhoeic dermatitis ▪ Fungal nail infections
WHO clinical stage III
▪ Unexplained severe weight loss [>10% of presumed or measured body weight] ▪ Unexplained chronic diarrhoea for longer than one month ▪ Unexplained persistent fever [above 37.6°C intermittent or constant, for longer than one month] ▪ Persistent oral candidiasis ▪ Oral hairy leukoplakia ▪ Pulmonary tuberculosis [current] ▪ Severe bacterial infections [such as pneumonia, empyema, pyomyositis, bone or joint infection, meningitis or bacteraemia] ▪ Acute necrotizing ulcerative stomatitis, gingivitis or periodontitis ▪ Unexplained anaemia [<8 g/dl], neutropaenia [<0.5 × 10^9 per litre] or chronic thrombocytopaenia [<50 ×

10^9 per litre]

WHO clinical stage IV

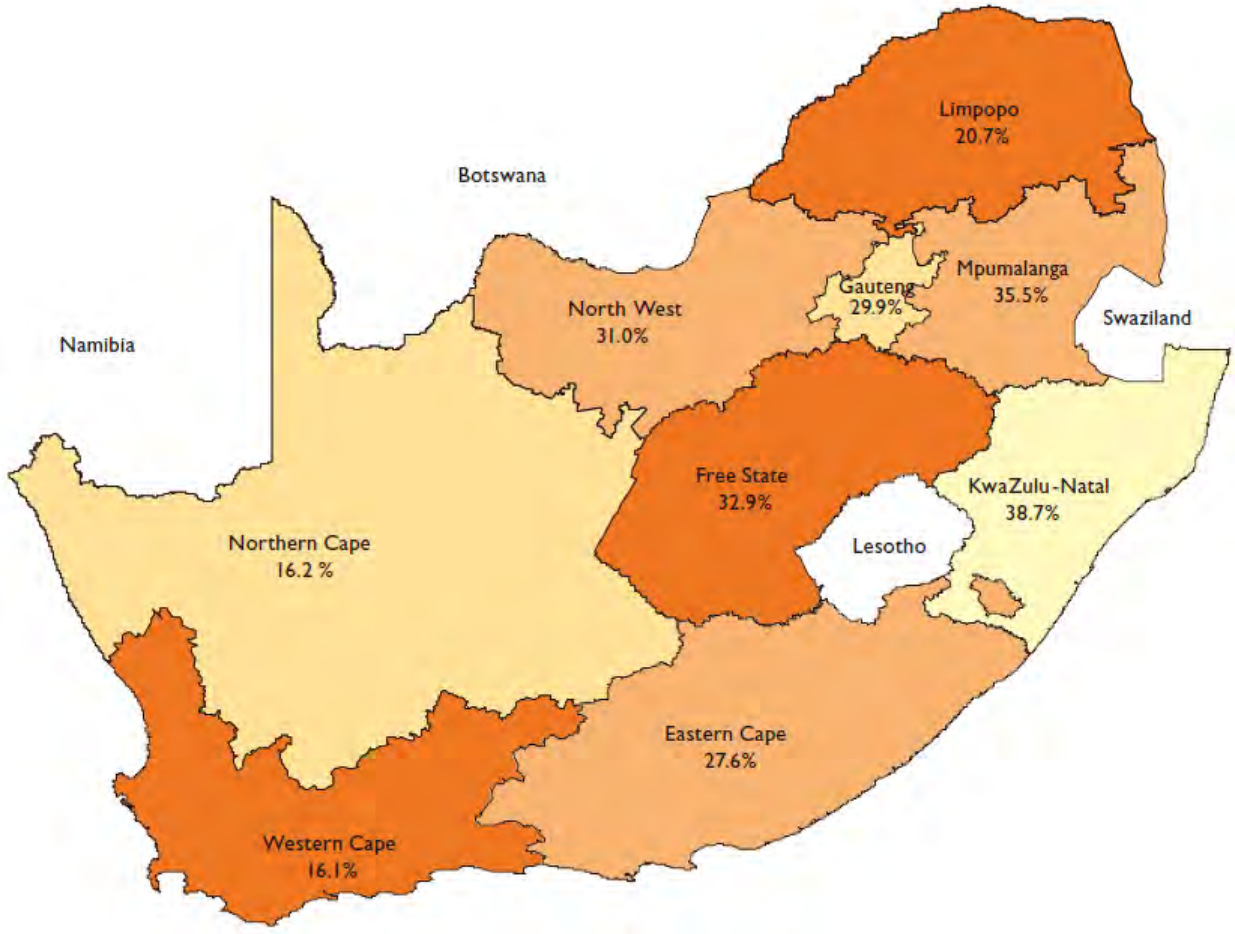
- HIV wasting syndrome
- Pneumocystis pneumonia
- Recurrent severe bacterial pneumonia
- Chronic herpes simplex infection [orolabial, genital or anorectal of more than one month's duration or visceral at any site]
- Oesophageal candidiasis [or candidiasis of trachea, bronchi or lungs]
- Extrapulmonary tuberculosis
- Kaposi's sarcoma
- Cytomegalovirus infection [retinitis or infection of other organs]
- Central nervous system toxoplasmosis
- HIV encephalopathy
- Extrapulmonary cryptococcosis including meningitis
- Disseminated non-tuberculous mycobacterial infection
- Progressive multifocal leukoencephalopathy
- Chronic cryptosporidiosis [with diarrhea]
- Chronic isosporiasis
- Disseminated mycosis [coccidiomycosis or histoplasmosis]
- Recurrent non-typhoidal Salmonella bacteraemia
- Lymphoma [cerebral or B-cell non-Hodgkin] or other solid HIV-associated tumours
- Invasive cervical carcinoma
- Atypical disseminated leishmaniasis
- Symptomatic HIV-associated nephropathy or symptomatic HIV-associated cardiomyopathy

17.9. **Appendix 9:** HIV prevalence by age and sex in South Africa [2012]



Source: 6th South African AIDS Conference [3], 2013

17.10. Appendix 10: HIV prevalence in antenatal women by province in SA[4]



17.11. Appendix 11: Summary of instructions to authors by the Journal of the International AIDS Society [Available at http://www.jiasociety.org/]

The Journal of the International AIDS Society [**JIAS**] welcomes submissions on HIV-related topics from various disciplines and accepts submissions of original research articles, short reports, reviews, debates, commentaries, and letters to the editor and viewpoints. Please read carefully through instructions for authors and prepare your manuscript according to the guidelines; structure your manuscript based on the chosen article category. Manuscripts that do not follow instructions may be returned to the authors for re-formatting. Submissions must be an original contribution, and the authors must guarantee that the content has not been previously published and is not considered for publication elsewhere. The JIAS levies a publication fee on all accepted articles to fund open-access publications. For information on editorial policies and processes, see our website [http://www.jiasociety.org/].

Aims and scope

The journal welcomes submissions on HIV-related topics from across all scientific disciplines, including but not limited to:

- Basic and biomedical sciences
- Behavioural sciences and epidemiology
- Clinical sciences
- Health economics and health policy
- Operations research and implementation sciences
- Social sciences and humanities, including political sciences and media

The journal places high priority on submissions from operational research and implementation science as publication of such material can provide valuable information on various algorithms for monitoring and providing support for comprehensive, yet affordable and sustainable prevention, treatment and care programmes in different contexts. Submission of HIV research carried out in low- and middle-income countries [LMIC] is strongly encouraged. JIAS accepts submissions in categories of research, short report, review, debate, commentary and letter to the editor.

Ethical policies

JIAS is a member of the Committee on Publication Ethics [COPE] and endorses the World Association of Medical Editors' [WAME's] policy statement on geopolitical intrusion on editorial decisions. All submitted manuscripts are scanned for plagiarism and may be rejected if significant overlap with other published material is detected. Work presented in submitted manuscripts may not have been previously published; nor may the same manuscript be submitted for consideration to another journal simultaneously. Any misconduct by authors in reporting their data, for example, falsification, will lead to rejection of their manuscript and other consequences decided on by the editors. Please see COPE and International Committee of Medical Journal Editors [ICMJE] for further information on ethical issues in publishing.

Authorship

It is understood that all authors listed on submitted manuscripts have read and agreed to its content, and meet the authorship requirements as detailed by ICMJE. In brief, contributors can be listed as authors if they: 1] have made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; AND 2] have been involved in drafting

the manuscript or revising it critically for important intellectual content; AND 3] have given final approval of the version to be published. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content. Acquisition of funding, collection of data, or general supervision of the research group, alone, does not justify authorship. All contributors who do not meet the criteria for authorship should be listed in the 'Acknowledgements' section. Examples of those who might be acknowledged include a person who provided purely technical help or writing assistance, or a head of department, who provided only general support.

Ethical approval

Experimental research described in the manuscript must have been performed with the approval of an appropriate ethics review board. Research carried out on humans must be in compliance with the Helsinki Declaration, and any experimental research on animals must have followed internationally recognized guidelines. A statement on the ethical aspects, including the consent procedure followed, must be included in the Methods section of the manuscript. The Editors may reject manuscripts where the research has not been carried out within an ethical framework. For all articles that include information or photographs relating to individuals, written and signed consent from each patient to publish must also be made available if requested by editors. Confidentiality of study participants must be ensured at all stages of research and reporting.

Competing interests

Authors are required to submit a statement on competing interests, which exist when personal or financial relationships with persons or organizations may influence interpretation of data or

how author's work is presented. In brief, all financial competing interests must be disclosed in this statement [reimbursements, fees, funding, salary payments from or ownership of any stocks or shares in an organization that may in any way gain or lose financially from the publication of the manuscript, either now or in the future, or applications for patents relating to the content of the manuscript], as well as non-financial competing interests [such as political, personal, religious, ideological, academic and/or intellectual interests] that are related to the work submitted. The competing interest statement should be included in the manuscript and will be published in the final article. If no competing interests exist, please state in this section, 'The author declare that they have [or The author declares that he/she has] no competing interests.'

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Legal responsibility to ensure that no material is published that infringes copyright or that includes libellous or defamatory content lies with JIAS. If a manuscript is judged by the journal editors to include potentially libellous content, authors will be requested to adjust wording as necessary.

Commercial writers and editors

The involvement of scientific [medical] writers or anyone else who assisted with the preparation of the manuscript content should be acknowledged, along with their source of funding, as described in the European Medical Writers Association [EMWA] guidelines on the role of medical writers in developing peer-reviewed publications.

MANUSCRIPT PREPARATION

Standards of reporting

JIAS endorses international standards of reporting. Please see the Uniform Requirements for

Manuscripts Submitted to Biomedical Journals guidelines produced by ICMJE as a reference standard of reporting. Authors are also referred to the EQUATOR network website for further information on the available reporting guidelines for health research, and the MIBBI Portal for prescriptive checklists for reporting biological and biomedical research where applicable. A number of checklists are available for various study designs, including randomized controlled trials [CONSORT], systematic reviews [PRISMA], observational studies [STROBE], meta-analyses of observational studies [MOOSE] and diagnostic accuracy studies [STARD]. For systematic reviews, an additional file should be provided by the authors listing all details concerning the search strategy. Please refer to the Cochrane Reviewers' Handbook for an example of how a search strategy should be presented.

Guidelines on mutation nomenclature are provided by the Human Genome Variation Society, and authors should use the recommended gene name by referring to the appropriate genetic nomenclature database, for example, HUGO for human genes, and the International Committee on Standardized Genetic Nomenclature for Mice. When describing human phenotypes, please use standardized terms, such as those proposed by the Elements of Morphology working group [see http://research.nhgri.nih.gov/morphology/index.cgi]. Contributions from pharmaceutical companies or other commercial organizations should follow the Good Publication Practice guidelines for pharmaceutical companies, which also apply to any companies or individuals that work on industry-sponsored publications, such as freelance writers, contract research organizations and communications companies. JIAS supports international standards of reporting of trials, in particular, prospective registering and numbering of clinical trials. Clinical trials are defined by the World Health Organization as all phase I to IV trials, which are research studies

that prospectively assign human participants or groups of humans to one or more health-related interventions to evaluate the effects on health outcomes. Trials need to be registered prior to submission in a suitable, publicly available registry. Links to existing registries can be found through ICMJE or through the primary registers that participate in the WHO International Clinical Trials Registry Platform. The trial registration number should be included as the last line of the manuscript Abstract.

File formats

Accepted files formats are *OpenOffice*, *Microsoft Word, RTF or WordPerfect*; in addition, a *PDF* copy of the manuscript needs to be prepared. Tables and figures should be inserted in the main text.

Style and language

Additional files, such as supporting information or large datasets, can be submitted in any file format and should be uploaded as a separate file. Footnotes are not allowed. Use line spacing of 1.5 and an easily readable font, for example, Times New Roman, size 12. Do not use underlining, but use of bold and italics is acceptable. Set the text unjustified to the left and use portrait page setup. Your manuscript must contain line numbers to facilitate editors' and reviewers' comments. All submissions must be in UK English [International] and UN-accepted terminology should be followed. No capitalization should be used except for grammatically correct use, official names and titles, and abbreviations. Acronyms should be used sparingly, and not in headings or in the Abstract. Only commonly known acronyms may be used, and they should be spelt out at first use followed by abbreviation in brackets. SI units should be used, with litre and molar being permitted.

Cover letter

In the cover letter, please explain why your manuscript should be published in the journal. If necessary, address any issues relating to JIAS editorial policies and declare any competing interests. One can suggest potential peer reviewers for the manuscript: they should be experts in the field and should be able to provide an objective assessment of the manuscript. Any suggested peer reviewers should not have published with any of the authors of the manuscript within the past five years, should not be current collaborators, and should not be members of the same institution. Suggested reviewers will be considered alongside potential reviewers identified by the editorial team. Members of the International AIDS Society receive a 15% discount on the publication fee. Authors should include their valid membership number in the cover letter upon submission.

Title page

On the title page, one should mention the title of the manuscript, list all authors' names in full, and list any study groups if applicable. Each authors' affiliation should be numbered in superscript consecutively and listed underneath, including department, institution, city and country. The corresponding author should be marked with the symbol § in superscript and full contact details should be provided, including a telephone number with country code. Authors who have contributed equally to the work should be marked with the symbol * in superscript. Deceased authors should be marked with the symbol ^ in superscript. The email addresses of all authors should be listed by their initials. A list of six to eight keywords should be provided, preferably alternate words to those found in the abstract in order to improve search hits for the article in repositories.

Abstract

The Abstract should not exceed 350 words and should be structured according to the headings of the selected article category, excluding the heading and discussion for research articles. Avoid using abbreviations and do not cite references in the abstract. If you are reporting results from a controlled health care intervention, please include your trial registry, together with your unique identifying number at the end of the abstract. For randomized controlled trials, follow the CONSORT extension for abstracts.

Main text

Information relating to the category that this manuscript qualifies for submission [behavioural sciences and epidemiology] is provided below whereas information for articles in other categories can be found on the journal website at www.jiasociety.org.

Article category; Research - full reports of data from original research studies

- Sections to be included [headings]; introduction, methods, results, discussion and conclusions.
- Word limit: 3500 words
- Number of figures and tables: unlimited
- Additional files: yes

Article sections

Introduction

This section should introduce the topic to readers without specialist knowledge in that area and

must clearly outline current state of knowledge in the field, motivation and aim of the study or article.

Methods

This section should include all information necessary to repeat the study, in particular, study design, data collection and analysis, clarifying choice of methods that were made. If applicable, one should describe setting of the study, dates the study was conducted, and the sample or participants, as well as necessary power calculations and materials, including statistical packages, used. Interventions and programmes should be described in detail. Generic names for drugs or any molecules should be used. All studies involving humans or animals require a statement on ethical approval, and for the former, the consent procedure that was followed. Please include the names of the ethics review board[s] that approved the study. If the research study was specific to one sex/gender, the reasons for this should be clearly stated.

Results

This section should include only data and findings from the authors' study. Presentation of statistical results should mention confidence intervals and levels of significance where appropriate. Quotes from qualitative study participants of less than three lines should be quoted in the text using quotation marks. For quotes longer than three lines, place the quote in a separate, indented paragraph and introduce it with a colon. No quotation marks are needed in this case. Details of the participant can be added in round brackets following the quote, but should not contain identifiable information to ensure confidentiality. Clarifications within the quotation should be placed in square brackets. Submitting authors are strongly encouraged to include data disaggregated by sex [and, whenever possible, by race] and provide a

comprehensive analysis of gender and racial differences. The authors should include the number and percentage of men, women and, if appropriate, transgender persons who participated in the research study. Anatomical and physiological differences between men and women [height, weight, body fat-to-muscle ratios, cell counts, hormonal cycles, etc.], as well as social and cultural variables [socio-economic, education, access to care, etc.], should be taken into consideration in the presentation of data and/or analysis of the results.

Discussion

In the discussion section, one should discuss main findings and place these within context of current body of knowledge in the field. Limitations of the study, for example, selection bias, can also be discussed, and should address how these influence the results and conclusions. If statistically significant differences were found between men and women or between different racial or cultural groups in the effects of the studied intervention, the implications, if any, for clinical and/or public health should be adequately discussed.

Conclusions

In this section, state key messages from the study and explain their importance and relevance, as well as implications. Future studies and recommendations can be included in this section. The conclusions drawn must be strictly based on the data provided.

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Figures should be integrated into the text at appropriate places. They should be cropped as closely as possible and have the header: 'Figure 1. Title of figure'. All figures need to be cited in the text in consecutive order. Legends should be provided underneath the figures, listing any abbreviations or meanings of symbols used. If several figures are included, please ensure that

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