

# Decomposing Education-Based Inequalities in Pre-Exposure Prophylaxis Knowledge for HIV Prevention Among Women in Cote d'Ivoire

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**Background:** Antiretroviral chemoprophylaxis is a promising strategy for preventing the spread of human immunodeficiency virus (HIV). The knowledge of pre-exposure prophylaxis (PrEP) is required for intervention uptake and adherence to prevent the spread of HIV. This study aimed to decompose education-based inequalities in PrEP knowledge for HIV prevention among reproductive-aged women in Cote d'Ivoire.

**Methods:** A cross-sectional study design with a nationally representative sample of 12,934 women aged 15–49 years was analyzed from the 2021 Cote d'Ivoire Demographic and Health Survey. The survey was conducted between September to December, 2021. The outcome variable was the knowledge of PrEP for HIV prevention. Statistical analysis was conducted using percentage, concentration index, and Lorenz curve. The level of significance was set at  $p < 0.05$ .

**Results:** A weighted prevalence of 14.5% (95% CI: 12.5–16.3%) was estimated for PrEP knowledge for HIV prevention. Overall, educated women had a higher knowledge of PrEP for HIV prevention (Conc. Index = 0.225; SE = 0.012;  $p < 0.001$ ). Across the levels of women's characteristics, the results showed higher PrEP knowledge for HIV prevention among educated women. Education (Contri: 40.7327%,  $E_c$ : 0.5390), exposure to internet (Contri: 20.1039%,  $E_c$ : 0.3484), place of residence (Contri: 12.9801%,  $E_c$ : -0.0537), household wealth (Contri: 10.0062%,  $E_c$ : 0.0642) and religion (Contri: 5.7509%,  $E_c$ : 0.0354) were positive contributors to PrEP knowledge for HIV prevention. On the other hand, age (Contri: -8.8298%,  $E_c$ : -0.0950) and region (Contri: -3.5942,  $E_c$ : -0.0768) were negative contributors to PrEP knowledge regarding HIV prevention among women of reproductive age in Cote d'Ivoire.

**Conclusion:** There is limited knowledge of PrEP for HIV prevention among women in Cote d'Ivoire. Educated women had greater knowledge of PrEP for HIV prevention. The results of this study could guide interventions targeted to enhance the knowledge of PrEP as an HIV prevention option.

**Keywords:** ivory coast, Sub-Saharan Africa, PrEP, women, HIV/AIDS

## Background

In 2022, 39 million individuals worldwide were living with HIV, 1.3 million contracted the virus for the first time, 630,000 people lost their lives to AIDS-related illnesses, and 29.8 million people received antiretroviral medication.<sup>1</sup> Pre-exposure prophylaxis (PrEP) was introduced globally as an HIV prevention strategy in 2012.<sup>2</sup> The US Food and Drug Administration (FDA) approved the use of Truvada for PrEP on July 16, 2012, marking a significant milestone in HIV prevention efforts worldwide.<sup>2</sup> Since its global introduction, PrEP has seen varying degrees of adoption and implementation worldwide. As of 2022, approximately 1.6 million individuals were using PrEP globally.<sup>3</sup> The uptake of PrEP has been significant in high-income countries and among key populations at substantial risk of HIV, such as men who have sex with men, sex workers, and people who inject drugs.<sup>3</sup> HIV/AIDS continues to be a global public health challenge with a significant impact on sub-Saharan Africa (SSA).<sup>4</sup> While progress has been made in combating the epidemic, women in this region still bear a disproportionate burden of HIV infection.<sup>5,6</sup> Though PrEP has emerged as a valuable

tool for HIV prevention; however, its effectiveness relies on the population it aims to protect having adequate knowledge.<sup>7</sup> SSA has the highest HIV/AIDS burden globally, with approximately 70% of the global HIV-positive population residing in this region.<sup>4</sup> Women are particularly more vulnerable, accounting for a significant proportion of new infections. Sociocultural, economic, and gender-related factors contribute to this vulnerability, highlighting the need for tailored interventions to protect women from acquiring HIV.<sup>6,8,9</sup>

As of 2020, 380,000 people (of all ages) were living with HIV in Côte d'Ivoire, and 2.1% of adults aged 15–49 years were infected with the virus. Of these, 77% were aware of their status.<sup>10</sup> Since 2010, there has been a 69% decrease in AIDS-related deaths due to increased access to antiretroviral therapy (ART). However, only 49% of the children aged 0–14 years received ART, and adult women were significantly more likely to receive ART (83%) than adult men (61%). Higher HIV prevalence has been estimated among key populations, including sex workers (4.8%), gay men and other men who have sex with men (7.7%) and drug injectors (3.4%).<sup>11</sup> Over the past decade, a combination of preventive measures has led to a 72% reduction in new infections.<sup>10</sup> While there is a high level of HIV awareness and testing among sex workers, there is a need to increase knowledge of prevention and treatment programmes for other vulnerable groups, such as women.<sup>11</sup> Although Côte d'Ivoire has made significant progress in its HIV response, addressing the poor knowledge of prevention strategies is still necessary to achieve national and international HIV targets.

Education plays a crucial role in shaping individuals' knowledge and behaviors related to health,<sup>12,13</sup> particularly in the context of HIV prevention. In Cote d'Ivoire, it is essential to address inequalities in access to information about HIV prevention methods to reduce the transmission of the virus. One such method is PrEP, a medication that has proven effective in preventing HIV transmission.<sup>14</sup> However, there are disparities in PrEP knowledge among women in Cote d'Ivoire based on their educational background, which is a significant public health concern. PrEP is a biomedical prevention strategy that involves taking antiretroviral medications before potential exposure to HIV. The consistent use of PrEP has been shown to reduce the risk of HIV infection by up to 93%.<sup>15</sup> It is an important addition to other HIV prevention methods such as condom use and voluntary medical male circumcision. However, despite its effectiveness, PrEP knowledge and uptake remain relatively low in many SSA countries including Cote d'Ivoire. Education, or the lack thereof, often plays a significant role in determining an individual's awareness of and access to healthcare services and information.

Like many low- and middle-income countries, Cote d' Ivoire faces disparities in educational attainment among women. Access to quality education is often influenced by several factors such as socioeconomic status, geographic location, and gender. Although efforts have been made in recent years to improve educational access in the country, inequalities persist. In 2021, the primary school completion rate was 84%, higher than the regional average (73%) but lower than the average for the income group (89%).<sup>16</sup> The secondary school gross enrollment rate was 57%, higher than the regional average (49%), but lower than the average for the income group (70%).<sup>16</sup> Thus, the role of education in shaping health knowledge cannot be overstated. Education equips individuals with the necessary skills to access and understand health information and to make informed decisions about their own health. In the context of HIV prevention, education can impact not only awareness, but also the ability to navigate healthcare systems and access PrEP services.

Women and adolescent girls have been reported to account for approximately 63% of all new cases of HIV infections.<sup>17</sup> Despite the disproportionate HIV incidence among women, when compared with the male counterparts, the use of HIV prevention and testing practices remain suboptimal.<sup>18</sup> Hence, we focused on women population in this study to unravel PrEP knowledge among the more vulnerable population. Addressing educational inequalities in PrEP knowledge is a crucial step towards reducing HIV transmission. This study aims to provide a comprehensive understanding of the factors contributing to these disparities, enabling policymakers and healthcare providers to develop targeted interventions that can bridge the gap in PrEP knowledge and utilization. By decomposing these inequalities, we can work towards a more equitable distribution of knowledge about HIV prevention and ultimately contribute to the reduction of new HIV infections. Thus, this study aimed to analyze the educational disparities in PrEP knowledge among women in Cote d'Ivoire to inform targeted interventions and improve HIV prevention efforts in the country.

## Methods

### Sample and Procedure

Data from a women's survey questionnaire from the 2021 Cote d'Ivoire Demographic and Health Survey (CDHS) were analyzed. A total of 12,934 women of reproductive age (15–49 years) were included in this study. The 1994, 1998–99, 2005 and 2011–12 surveys were followed by the 2021 CDHS, which was the fifth round. The survey was conducted from September to December, 2021. Using systematic sampling with a probability proportional to size, a two-stage stratified sample was used. Only the sample of women who answered the question about their knowledge of PrEP was used for analysis. This study is based on the analysis of secondary data that were completely de-identified. We received approval from the Opinion Research Corporation (ORC) Macro Inc. to use the data. Public access is available to the data. The National Ethics Committee of Côte d'Ivoire and the Internal Review Board (IRB) of the Centers for Disease Control (CDC) in Atlanta approved the survey method and tools used.<sup>19</sup>

### Measures

#### Outcome Variable

The outcome variable for this study is the knowledge of PrEP among women of reproductive age in Cote d'Ivoire. This was computed from the variable - V859 "Knowledge and attitude to PrEP to prevent getting HIV". Women responded: "0 - have not heard", "1 - Heard and approve of taking it every day", "2 - Heard, but do not approve of taking it every day", "3 - Heard, but not sure about approving its use". This variable was recoded dichotomously as "0" if have not heard and "1" if a woman has heard irrespective of her attitude towards it.

#### Explanatory Variables

Formal education (none/primary/secondary+) is the most important factor in the study of socioeconomic inequalities.<sup>20</sup> Furthermore, the questionnaire included socio-demographic and health variables such as age (15–19/20–24/25–29/30–34/35–39/40–44/45–49), region (Abidjan/Yamoussoukro/Bas Sassandra/Comoe/Denguele/Goh-Djiboua/Lacs/Lagunes/Montagnes/Sassandra-Marahoue/Savanes/Vallee du bandama/Woroba/Zanzan), type of place of residence (urban/rural), religion (Muslim/Christian/other religion), sex of household head (male/female), exposure to newspaper or magazine (not at all/less than once a week/at least once a week), exposure to radio (not at all/less than once a week/at least once a week), exposure to television (not at all/less than once a week/at least once a week), exposure to internet (not at all/less than once a week/at least once a week/almost every day), health insurance (not covered/covered), marital status (single/living in union/separated or widowed), age at first sex (never had sex/<18/18+), ever been tested for HIV (no/yes) and wealth status (poorest/poorer/middle/richer/richest), a composite index based on the household's ownership of consumer items such as television, car, drinking water, toilet facilities, etc.

#### Concentration Curves and Indices

The analysis of health inequalities frequently employs the concentration index. The existence of health inequalities was examined by using indices and curves. The Erreygers normalized concentration indices<sup>21</sup> were used in this study to assess the degree of education-based inequalities in PrEP knowledge for HIV prevention. The Erreygers was chosen over the other possible indices because of its decomposability and simplicity. The "convenient covariance" can be used to compute the concentration index, as shown below:

$$CI = \frac{2}{\hat{y}} COV(y_i, R_i) \quad (1)$$

Where:  $y_i$  is the health variable

$\hat{y}$  is the mean of  $y_i$

$R_i$  is the fractional rank of the  $i$ th individual

COV symbolizes the covariance

By dividing by two distances between the concentration curve and the line of equality (the 45-degree line), the concentration indices were calculated as.<sup>17</sup> If the concentration curve is on the 45° line, then there is no health

disparity. The magnitude of the health disparity is indicated by the concentration curve's angle from the line of equality (45° line). The degree of health inequality increases with the width of the gap between the concentration curve and line of equality. This study chose to use normalized formulae because it has been suggested that doing so ensures that the boundary problem for a binary Cardinal Health variable is resolved. The Erreygers normalized index ( $E_c$ ) is denoted as:

$$E_c = \frac{4\hat{y}}{y^{\max} - y^{\min}} CI \quad (2)$$

In the case of binary variables,  $y^{\max} - y^{\min}$  represents the range of the health variable, which is “one”. The current study focused on the Erreygers normalized index because it is the corrected concentration index that is most commonly used in the health literature.

### Decomposing Erreygers Normalized Concentration Index

To determine the contributions of women's health indicator determinants, the Erreygers normalized concentration index can be decomposed.<sup>22,23</sup> Each explanatory factor's contribution to health inequalities was broken down into its component parts by health elasticity. Given a linear relationship between individual health ( $y_i$ ) and a collection of  $k$  explanatory variables,  $y_i$  is calculated as follows:

$$y_i = a + \sum_k \beta_k X_{ki} + \varepsilon_i \quad (3)$$

Wagstaff et al<sup>23</sup> shows the concentration index for any health measure that has a linear relationship with a set of  $k$  explanatory variables, which may be divided as follows:

$$CI = \sum_k \left( \frac{\beta_k \dot{X}_k}{\hat{y}} \right) CI_k + \frac{GCI_\varepsilon}{\hat{y}} \quad (4)$$

Where:  $\beta_k$  is the partial

$\hat{y}$  is the mean of the health variable

$\dot{x}_k$  is the mean of  $\dot{x}_k$

$CI_k$  denotes the concentration index of  $x_k$  against education

$GC_\varepsilon$  is the generalised concentration for the error term

To decompose the Erreygers concentration index, we modified Equation (4) as shown below:<sup>24</sup>

$$E_c = 4 \left[ \sum_k (\beta_k \dot{X}_k) CI_k + GCI_\varepsilon \right] \quad (5)$$

### Analytical Approach

Data analysis was conducted using Stata software version 14.0 (Stata Corporation, College Station, Texas, USA). Utilizing the survey module's (“svy”) command to account for the sampling design, the analysis in Stata took into account the multi-stage stratified cluster sample design. In the univariate analysis, the percentage was used. For PrEP knowledge, concentration indices and Lorenz curves were used to investigate education-based inequalities. When PrEP knowledge was higher among educated women, the concentration index value was positive. In contrast, a negative concentration index value indicates the opposite.<sup>25,26</sup> The level of statistical significance was set at  $p < 0.05$ .

### Ethical Consideration

For this research, the secondary dataset that was available to the general public had identifiers removed. Following a recognized ethical procedure, the CDHS obtained informed consent from respondents. No additional participant consent was needed because the authors were given permission to use this data, which was collected following ethical standards. Here is where you can find details on DHS guidelines: <http://goo.gl/ny8T6X>.

## Results

A weighted sample size of 12,934 women of childbearing age was used for this analysis. A weighted prevalence of 14.5% (95% CI: 12.5–16.3%) was estimated for knowledge of PrEP among women of reproductive age in Cote d'Ivoire (Table 1). This shows that approximately 85% of reproductive-aged women in Cote d'Ivoire do not have any knowledge of PrEP. Table 1 shows that the knowledge of PrEP was higher among women in Vallee du Bandama (19.9%), Abidjan (19.3%), Yamoussoukro (18.4%), and Savanes (17.1%). Among urban dwellers, Christians read newspapers or

**Table 1** Distribution of PrEP Knowledge Among Women of Reproductive Age and by Education Gradient

Variable	n (%)	Prevalence of PrEP Knowledge for HIV Prevention			Pooled Prevalence of PrEP Knowledge for HIV Prevention (95% CI)
		No Education (%)	Primary (%)	Secondary+ (%)	
Age (in years)					0.004*
15–19	2573 (19.9)	4.1	6.9	13.4	11.0 (9.0, 13.4)
20–24	2290 (17.7)	6.4	13.3	18.1	14.1 (11.6, 16.9)
25–29	2038 (15.8)	10.1	10.5	28.2	15.5 (13.1, 18.2)
30–34	2028 (15.7)	9.6	16.1	32.6	17.3 (14.5, 20.4)
35–39	1752 (13.6)	8.0	15.6	28.5	15.7 (12.6, 19.4)
40–44	1356 (10.5)	8.1	14.9	35.9	15.0 (12.5, 18.0)
45–49	897 (6.9)	6.7	19.6	29.8	14.9 (11.6, 18.9)
Region					<0.001*
Abidjan	1335 (10.3)	15.3	13.6	25.6	19.3 (14.8, 24.8)
Yamoussoukro	841 (6.5)	8.5	18.5	25.4	18.4 (15.3, 21.9)
Bas Sassandra	1055 (8.2)	9.0	14.6	20.0	13.2 (9.6, 17.9)
Comoe	748 (5.8)	7.1	17.6	18.9	13.9 (11.0, 17.3)
Denguele	820 (6.3)	4.5	8.9	15.5	7.2 (5.0, 10.4)
Goh-Djiboua	859 (6.6)	6.9	10.3	21.6	13.1 (8.6, 19.3)
Lacs	895 (6.9)	8.0	11.2	11.3	9.5 (7.3, 12.2)
Lagunes	939 (7.3)	8.8	14.0	15.7	12.3 (9.2, 16.2)
Montagnes	1019 (7.9)	7.4	7.8	19.4	10.8 (8.0, 14.6)
Sassandra-Marahoue	1243 (9.6)	6.0	10.2	13.7	9.0 (7.0, 11.5)
Savanes	763 (5.9)	10.7	21.1	30.1	17.1 (13.1, 22.1)
Vallee du bandama	813 (6.3)	12.4	18.5	27.8	19.9 (15.5, 25.0)
Woroba	897 (6.9)	3.7	2.1	21.0	5.9 (4.1, 8.5)
Zanzan	707 (5.5)	8.5	16.9	18.1	11.9 (8.6, 16.2)
Type of place of residence					<0.001*
Urban	6807 (52.6)	10.4	14.5	22.5	17.7 (15.3, 20.4)
Rural	6127 (47.4)	6.3	12.0	15.9	9.0 (7.9, 10.3)
Religion					<0.001*
Muslim	5695 (44.0)	6.5	9.0	18.4	10.8 (9.3, 12.6)
Christian	6432 (49.7)	10.6	15.0	22.0	17.8 (15.7, 20.2)
Other religion	807 (6.2)	7.4	13.5	17.8	11.3 (8.4, 15.1)
Sex of household head					0.006*
Male	9909 (76.6)	7.7	12.3	20.0	13.8 (12.1, 15.6)
Female	3025 (23.4)	9.6	16.0	22.2	16.9 (14.5, 19.6)
Exposure to newspaper or magazine					<0.001*
Not at all	11,546 (89.3)	7.9	12.4	18.4	12.7 (11.4, 14.1)
Less than once a week	874 (6.8)	13.0	21.7	23.6	23.1 (18.0, 29.2)
At least once a week	514 (4.0)	50.0	22.7	31.0	29.4 (22.1, 38.0)

(Continued)

Table I (Continued).

Variable	n (%)	Prevalence of PrEP Knowledge for HIV Prevention			Pooled Prevalence of PrEP Knowledge for HIV Prevention (95% CI)
		No Education (%)	Primary (%)	Secondary+ (%)	
Exposure to radio					0.001*
Not at all	8134 (62.9)	7.5	13.2	19.6	13.0 (11.5, 14.6)
Less than once a week	2725 (21.1)	7.8	12.2	20.3	15.2 (12.2, 18.8)
At least once a week	2075 (16.0)	11.0	15.0	24.3	19.2 (15.9, 23.0)
Exposure to television					<0.001*
Not at all	4266 (33.0)	6.5	10.8	15.0	8.7 (7.4, 10.1)
Less than once a week	2077 (16.1)	8.0	14.1	17.5	14.0 (11.5, 17.0)
At least once a week	6591 (51.0)	9.8	14.4	22.6	17.5 (15.3, 20.1)
Exposure to internet					<0.001*
Not at all	9527 (73.7)	7.2	11.8	14.0	10.1 (8.9, 11.5)
Less than once a week	388 (3.0)	13.5	13.6	16.6	15.7 (11.3, 21.5)
At least once a week	1160 (9.0)	12.9	15.4	20.2	17.5 (14.4, 21.1)
Almost every day	1859 (14.4)	17.7	21.7	30.8	28.4 (24.1, 33.0)
Wealth index for urban/rural					<0.001*
Poorest	2552 (19.7)	6.9	11.5	14.5	9.1 (7.5, 11.0)
Poorer	2736 (21.2)	7.2	11.3	15.7	10.9 (9.1, 12.9)
Middle	2395 (18.5)	8.2	11.0	16.5	11.4 (9.3, 13.9)
Richer	2459 (19.0)	9.8	14.6	19.5	17.0 (13.5, 21.2)
Richest	2792 (21.6)	8.9	16.9	28.2	21.6 (18.3, 25.3)
Covered by health insurance					<0.001*
No	12,144 (93.9)	7.8	12.8	18.6	13.1 (11.7, 14.7)
Yes	790 (6.1)	16.2	23.4	34.6	31.4 (25.2, 38.4)
Marital status					0.027*
Never in union	3984 (30.8)	8.9	12.3	17.1	15.9 (13.7, 18.4)
Currently in union/living with a man	8258 (63.9)	7.6	13.2	26.5	13.5 (11.9, 15.3)
Formerly in union	692 (5.4)	11.9	17.1	30.3	16.8 (13.1, 21.3)
Age at first sex					<0.001*
Not had sex	1330 (10.3)	3.5	5.5	11.6	9.2 (7.1, 11.9)
<18 years	8882 (68.7)	8.0	14.1	22.5	14.3 (12.8, 16.1)
18+ years	2722 (21.1)	8.5	13.3	26.0	17.7 (14.9, 20.9)
Ever been tested for HIV					<0.001*
No	6438 (49.8)	5.4	8.9	13.8	9.6 (8.2, 11.2)
Yes	6496 (50.2)	11.0	16.3	27.1	19.1 (16.7, 21.6)
Education					<0.001*
None	6421 (49.6)	-	-	-	9.5 (8.0, 11.3)
Primary	2544 (19.7)	-	-	-	13.0 (11.0, 15.3)
Secondary+	3969 (30.7)	-	-	-	21.9 (19.1, 25.0)
Total estimate	12,934 (100.0)	8.0	13.3	20.7	14.5 (12.5, 16.3)

Note: \*Significant at  $p < 0.05$ .

magazines, listen to radio, watch TV at least once a week, and use the Internet last month almost every day; the knowledge of PrEP was 17.7%, 17.8%, 29.4%, 19.2%, 17.5%, and 28.4%, respectively. Furthermore, women from richest households, covered by health insurance, formerly in union, aged 18+ at sexual debut and ever been tested for HIV had 21.6%, 31.4%, 16.8%, 17.7% and 19.1% PrEP knowledge respectively. The analysis revealed a clear pattern of higher PrEP knowledge among women with higher education levels, with prevalence rates of 9.5%, 13.3%, and 21.9% among women with no education, primary education, and secondary education or higher, respectively. The highest

prevalence of PrEP knowledge was observed among women aged 40–44 (35.9% among those with secondary education or higher), highlighting the significant age-related disparities.

Table 2 shows the results of education-based inequalities in PrEP knowledge regarding HIV prevention among women of reproductive age in Cote d'Ivoire. Overall, pro-education regarding PrEP knowledge for HIV prevention (Conc. Index= 0.225; SE= 0.012;  $p < 0.001$ ) indicating that PrEP awareness is significantly concentrated among more educated women. The analysis also revealed significant disparities in PrEP knowledge across various demographic and socioeconomic variables. The highest concentration index was observed in the age group 45–49 years (0.326\*, SE = 0.041), indicating the most pronounced inequality in PrEP knowledge favoring educated women within this age bracket. Regionally, significant differences in the concentration indices ( $p = 0.009$ ) indicate geographic disparities in PrEP knowledge, with the highest inequality observed in

**Table 2** Education-Based Inequalities in PrEP Knowledge for HIV Prevention Among Women

Variable	Concentration Index	Standard Error	P
Age (in years)			0.110
15–19	0.193*	0.029	
20–24	0.228*	0.029	
25–29	0.234*	0.027	
30–34	0.269*	0.026	
35–39	0.267*	0.030	
40–44	0.291*	0.033	
45–49	0.326*	0.041	
Region			0.009*
Abidjan	0.133*	0.029	
Yamoussoukro	0.221*	0.039	
Bas Sassandra	0.188*	0.041	
Comoe	0.206*	0.049	
Denguele	0.272*	0.058	
Goh-Djiboua	0.268*	0.048	
Lacs	0.079	0.054	
Lagunes	0.129*	0.047	
Montagnes	0.213*	0.048	
Sassandra-Marahoue	0.192*	0.047	
Savanes	0.247*	0.039	
Vallee du bandama	0.192*	0.038	
Woroba	0.365*	0.056	
Zanzan	0.184*	0.051	
Type of place of residence			0.205
Urban	0.178*	0.015	
Rural	0.209*	0.020	
Religion			0.024*
Muslim	0.232*	0.020	
Christian	0.164*	0.015	
Other religion	0.195*	0.051	
Sex of household head			0.121
Male	0.225*	0.014	
Female	0.182*	0.022	
Exposure to newspaper or magazine			0.003*
Not at all	0.195*	0.013	
Less than once a week	0.024	0.025	
At least once a week	0.023	0.023	

(Continued)

**Table 2** (Continued).

Variable	Concentration Index	Standard Error	P
Exposure to radio			0.470
Not at all	0.227*	0.016	
Less than once a week	0.222*	0.026	
At least once a week	0.186*	0.026	
Exposure to television			0.781
Not at all	0.170*	0.024	
Less than once a week	0.185*	0.031	
At least once a week	0.189*	0.015	
Exposure to internet			0.108
Not at all	0.154*	0.016	
Less than once a week	0.052	0.065	
At least once a week	0.098*	0.034	
Almost every day	0.083*	0.017	
Wealth index for urban/rural			0.320
Poorest	0.164*	0.030	
Poorer	0.180*	0.029	
Middle	0.162*	0.030	
Richer	0.162*	0.026	
Richest	0.228*	0.020	
Covered by health insurance			0.127
No	0.205*	0.013	
Yes	0.120*	0.026	
Marital status			<0.001*
Never in union	0.113*	0.019	
Currently in union/living with a man	0.264*	0.015	
Formerly in union	0.197*	0.044	
Age at first sex			0.102
Not had sex	0.165*	0.040	
<18 years	0.238*	0.014	
18+ years	0.265*	0.025	
Ever been tested for HIV			0.681
No	0.221*	0.021	
Yes	0.211*	0.014	
Total estimate	0.225	0.012	<0.001*

**Notes:** \*Significant at  $p < 0.05$ ; P= comparing concentration indices across the levels of a variable.

Woroba (0.365\*, SE = 0.056). Religious affiliations also demonstrated disparities in PrEP knowledge ( $p = 0.024$ ), with Muslim women showing a higher concentration index (0.232\*, SE = 0.020) than their Christian counterparts. The frequency of reading newspapers or magazines significantly affected PrEP knowledge ( $p = 0.003$ ), indicating that regular engagement with written media is associated with higher awareness. Marital status presented the most substantial differences in PrEP knowledge ( $p < 0.001$ ), with women currently in union/living with a man showing a higher concentration index (0.264\*, SE = 0.015). This finding could imply that marital status, and potentially the associated social and economic stability, influence access to and interest in HIV prevention methods.

Figure 1 shows the Lorenz curve for the knowledge of PrEP by education gradient. It was used as a graphical representation of the distribution or degree of education-based inequalities in PrEP knowledge within women population in Cote d'Ivoire. The extent to which the curve deviates from the line of equality indicates whether there are inequalities in PrEP knowledge, and to what extent. Figure 1 demonstrates that the most educated women had higher knowledge of PrEP, as the line of equality sags below the diagonal line.



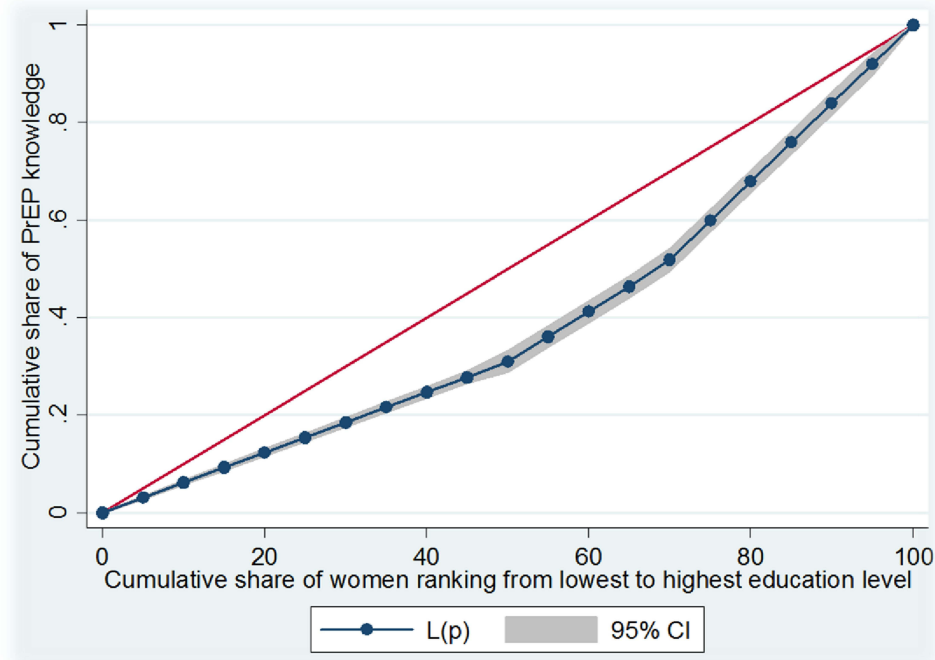


Figure 1 Lorenz curve for the knowledge of PrEP by education gradient.

Table 3 shows Erreygers concentration ( $E_c$ ) indices decomposed to determine the contribution (Contri) of PrEP knowledge for HIV prevention among women of reproductive age in Cote d'Ivoire. Education (Contri: 40.7327%,  $E_c$ : 0.5390), exposure to the Internet (Contri: 20.1039%,  $E_c$ : 0.3484), place of residence (Contri: 12.9801%,  $E_c$ : -0.0537), household wealth (Contri: 10.0062%,  $E_c$ : 0.0642), and religion (Contri: 5.7509%,  $E_c$ : 0.0354) were positive contributors to PrEP knowledge regarding HIV prevention among women. However, age (Contri: -8.8298%,  $E_c$ : -0.0950) and region (Contri: -3.5942,  $E_c$ : -0.0768) were negative contributors to PrEP knowledge regarding HIV prevention among women of reproductive age in Cote d'Ivoire.

Table 3 Decomposition of PrEP Knowledge for HIV Prevention

Variable	Elasticity	Concentration Index	Absolute Contribution	% Contribution
Age (in years)	0.0271	-0.0950	-0.0103	-8.8298
Region	0.0136	-0.0768	-0.0042	-3.5942
Type of place of residence	-0.0704	-0.0537	0.0151	12.9801
Religion	0.0473	0.0354	0.0067	5.7509
Education	0.0220	0.5390	0.0474	40.7327
Sex of household head	0.0047	0.0254	0.0005	0.4088
Exposure to newspaper or magazine	0.0025	0.5497	0.0056	4.8119
Exposure to radio	-0.0011	0.1030	-0.0005	-0.3911
Exposure to television	0.0088	0.1154	0.0004	0.3178
Exposure to internet	0.0168	0.3484	0.0234	20.1039
Wealth index for urban/rural	0.0453	0.0642	0.0117	10.0062
Covered by health insurance	0.0027	0.3924	0.0043	3.6568
Marital status	-0.0037	-0.1637	0.0025	2.1070
Age at first sex	0.0161	-0.0309	-0.0020	-1.7033
Ever been tested for HIV	0.0274	0.0394	0.0043	3.7125

## Discussion

The findings from this study underscore a pivotal concern for public health policies and intervention strategies. The knowledge of PrEP among women of reproductive age in Cote d'Ivoire was low (14.5%), implying that the majority of the population does not have knowledge of PrEP as a preventive method for HIV. This aligns with previous research. For instance, a study of African American participants revealed that over 80% were unaware of the availability of PrEP.<sup>27</sup> It has been recognized that PrEP has the potential to be a crucial HIV prevention strategy for women.<sup>28</sup> However, a significant proportion of the population who could benefit from it is unaware of this important strategy.<sup>29</sup> Another study reported limited PrEP knowledge among women, with participants expressing frustration with not having heard of PrEP prior to a study conducted in a developed country.<sup>30</sup> The level of PrEP knowledge among women identified in this study is similar to the findings from research conducted among women living in low-income settings, where only 16% were aware that PrEP is used for HIV prevention.<sup>31</sup> These findings confirm previous reports indicating that the majority of women in developed and resource-constrained settings lack knowledge of PrEP. This should be a matter of concern for all public health stakeholders, particularly the government of Cote d'Ivoire.

In a study conducted in North Carolina from February to April 2018, approximately half of participants said they had heard about PrEP,<sup>32</sup> higher than the findings from this study. The respondents reported that non-social media advertising (15%) and campus health services (24%) were the most popular sources of information about PrEP.<sup>32</sup> Since only roughly one-third of women in Cote d'Ivoire had completed secondary education, the higher level of knowledge of PrEP in the study conducted in the United States may have resulted from better levels of education and health literacy among respondents. Another study done in the United States found that while 19.8% of high-risk respondents knew about PrEP, only 14.5% of all respondents were aware of it,<sup>33</sup> which is consistent with the findings from our study. In order to prevent HIV transmission and promote general sexual wellbeing, it is imperative that education programmes be designed and sustained in countries with low PrEP knowledge. In Cote d'Ivoire, women face a wide range of barriers and facilitators to PrEP knowledge. In order to improve access to this biomedical intervention, it is imperative to fully understand these barriers and take advantage of the identified facilitators.

This study highlights a strong association between formal education and knowledge of PrEP for HIV prevention. Several studies conducted in diverse settings have consistently shown that individuals with higher levels of education are more likely to have knowledge of healthcare programs and interventions, such as PrEP, understand its purpose, and know how to access it.<sup>12,34–37</sup> The evident pro-education gradient in PrEP knowledge, especially highlighted by the variation in concentration indices across different age groups, reveals a critical insight: older women possess greater knowledge about PrEP, likely because of enhanced health awareness and improved access to information over time. This pattern not only underscores the importance of educational attainment in health literacy, but also suggests that aging may confer an advantage in accumulating health knowledge, possibly through sustained exposure to health information and services.<sup>38</sup> The research findings emphasizing the relationship between the education gradient and knowledge of PrEP underscore the significance of addressing knowledge gaps in HIV prevention strategies. To maximize the impact of PrEP as a preventive tool, public health interventions must be tailored to individuals with diverse educational backgrounds. This should involve a focus on reducing stigma, increasing access, and providing more accurate information. Ultimately, a comprehensive approach that combines education, access, and community engagement is essential to making significant strides in the ongoing fight against HIV.

Several factors contribute to the relationship between education and knowledge of PrEP in HIV prevention. Higher education often equips individuals with skills to access and critically evaluate information.<sup>34</sup> Those with more education may be more adept at seeking healthcare information, which includes knowledge about PrEP.<sup>36</sup> Women with higher educational levels tended to have better health literacy. They are more comfortable navigating healthcare systems, engaging with healthcare providers, and understanding complex medical information, including PrEP.<sup>35</sup> Education could encourage individuals to engage more actively with healthcare services, leading to opportunities for healthcare providers to educate them about PrEP during routine checkups. Women with higher education levels may be part of social networks where discussions about sexual health and HIV prevention are more prevalent, leading to increased awareness of PrEP.<sup>37</sup> Education empowers women to take control of their health. Those with higher education levels may be more proactive in

seeking information and advocating for their healthcare needs, including PrEP.<sup>12</sup> Besides education, exposure to the Internet, place of residence, household wealth, and religion were positive contributors to knowledge of PrEP for HIV prevention among women. However, age and region were negative contributors to knowledge of PrEP for HIV prevention among women of reproductive age in Cote d'Ivoire.

Furthermore, the significant role of regional factors in influencing PrEP awareness points to the unequal distribution of health education and services across different areas, indicating that interventions need to be geographically tailored to effectively address these disparities effectively.<sup>39</sup> The nuanced impact of media exposure on PrEP knowledge, with minimal significance observed for those engaging with media less than once a week, calls for a deeper examination of the content and quality of health information disseminated through these channels. This observation suggests that simply increasing media exposure may not suffice; rather, enhancing the relevance, accuracy, and comprehensibility of health information could be the key to improving PrEP awareness.<sup>38,40</sup> These findings highlight a multifaceted challenge in bridging the knowledge gap regarding PrEP for HIV prevention, emphasizing the need for targeted, culturally sensitive, and educationally appropriate public health interventions to ensure that women across all demographics have equitable access to crucial HIV prevention strategies.

## Strength and Limitation

This study examined the knowledge of PrEP for HIV prevention using a large, nationally representative dataset that included women of reproductive age. Thus, these findings are suitable for making valid comparisons. It is worth noting that this study is the first of its kind in the context of Cote d'Ivoire. The survey was conducted in 2021, so the current state of knowledge regarding PrEP for HIV prevention in the country is reflected. However, our study has a few limitations. As we relied on secondary data, we had no control over the selection of variables, data quality, or indicator measurement. Furthermore, since we analyzed data from a cross-sectional study, we could only establish associations, not causality.

## Conclusion

This study underscores a critical gap in the awareness and understanding of PrEP for HIV prevention among women of reproductive age in Côte d'Ivoire, highlighting the disparity linked to educational levels. Such insights are invaluable for shaping future public health strategies aimed at enhancing PrEP awareness as a viable option for HIV prevention. To effectively address these knowledge gaps, public health initiatives must prioritize targeted educational campaigns designed to engage populations with lower educational attainment. These interventions should leverage culturally sensitive materials and messaging frameworks to ensure their relevance and resonance within diverse communities. Engaging communities in open discussions about PrEP is also essential. Community leaders and organizations can play a pivotal role in disseminating information and reducing the stigma surrounding HIV prevention methods. Efforts to improve access to PrEP should be accompanied by educational initiatives, as individuals who are knowledgeable about the benefits and availability of PrEP are more likely to seek it.

## Data Sharing Statement

Data for this study were sourced from Demographic and Health surveys (DHS) and available here: <http://dhsprogram.com/data/available-datasets.cfm>.

## Ethical Approval and Consent to Participate

This study is a secondary data analysis, which is publicly available; approval was sought from MEASURE DHS/ICF International and permission was granted for this use. The original DHS data were collected in conformity with international and national ethical guidelines. Written consent was obtained from the mothers/caregivers, and data were recorded anonymously at the time of data collection during the data collection. More details regarding DHS data and ethical standards are available at: <http://dhsprogram.com/data/availabledatasets.cfm>.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## References

- UNAIDS Global AIDS Monitoring, 2023; UNAIDS epidemiological estimates, 2023; 2024. Available from: <https://www.unaids.org/en/resources/fact-sheet>. Accessed June 12, 2024.
- Baeten JM, Haberer JE, Liu AY, Sista N. Pre-exposure prophylaxis for HIV prevention: where have we been and where are we going? *J Acquir Immune Defic Syndr*. 2013;63(2):S122–S129. doi:10.1097/QAI.0b013e3182986f69
- UNAIDS Global AIDS Update 2022. Geneva: joint United Nations Programme on HIV/AIDS; 2022; 2024. Available from: <https://www.unaids.org/en/resources/documents/2022/in-danger-global-aids-update>. Accessed June 12, 2024.
- Kharsany ABM, Karim QA. HIV Infection and AIDS in Sub-Saharan Africa: current Status, Challenges and Opportunities. *Open AIDS J*. 2016;10:34–48. doi:10.2174/1874613601610010034
- Ramjee G, Daniels B. Women and HIV in Sub-Saharan Africa. *AIDS Res Ther*. 2013;10(1):30. doi:10.1186/1742-6405-10-30
- Ekholueta M, Owunari Benebo F, Barrow A, Francis Idebolo A, Igwegbe Nzopotam C. Seroprevalence and determinants of human immunodeficiency virus infection among women of reproductive age in Mozambique: a multilevel analysis. *Infect Dis Ther*. 2020;9(4):881–900. doi:10.1007/s40121-020-00336-z
- McMahon JM, Myers JE, Kurth AE, et al. Oral Pre-Exposure Prophylaxis (PrEP) for Prevention of HIV in Serodiscordant Heterosexual Couples in the United States: opportunities and Challenges. *AIDS Patient Care STDs*. 2014;28(9):462–474. doi:10.1089/apc.2013.0302
- Ekholueta M, Nzopotam CI, Okonji OC. Association between socio-economic factors and HIV self-testing knowledge amongst South African women. *South Afr J HIV Med*. 2022;23(1):10. doi:10.4102/sajhivmed.v23i1.1347
- Ekholueta M, Onuoha H, Ekholueta CE, Barrow A, Nzopotam CI. Socioeconomic Inequalities in Human Immunodeficiency Virus (HIV) Sero-Prevalence among Women in Namibia: further Analysis of Population-Based Data. *Int J Environ Res Public Health*. 2021;18(17):9397. doi:10.3390/ijerph18179397
- UNAIDS 2021 Epidemiological estimates. AIDSINFO Country factsheets; 2021. Available from: <https://aidsinfo.unaids.org/>. Accessed June 12, 2024.
- UNAIDS and World Food Programme. Côte d'Ivoire: providing cash transfers for vulnerable people living with HIV and key populations; 2022. Available from: <https://www.wfp.org/publications/cote-divoire-providing-cash-transfers-vulnerable-people-living-hiv-and-key-populations>. Accessed June 12, 2024.
- Neves PAR, Barros AJD, Gatica-Dominguez G, Vaz JS, Baker P, Lutter CK. Maternal education and equity in breastfeeding: trends and patterns in 81 low- and middle-income countries between 2000 and 2019. *Int J Equity Health*. 2021;20(1):20. doi:10.1186/s12939-020-01357-3
- Ekholueta M, Nzopotam CI, Barrow A, Onikan A. Women's enlightenment and early antenatal care initiation are determining factors for the use of eight or more antenatal visits in Benin: further analysis of the Demographic and Health Survey. *J Egypt Public Health Assoc*. 2020;95(1):13. doi:10.1186/s42506-020-00041-2
- Grant RM, Lama JR, Anderson PL, et al. Preexposure Chemoprophylaxis for HIV prevention in men who have sex with men. *N Engl J Med*. 2010;363(27):2587–2599. doi:10.1056/NEJMoa1011205
- Jourdain H, Gage SB, Desplas D, Dray-Spira R. Real-world effectiveness of pre-exposure prophylaxis in men at high risk of HIV infection in France: a nested case-control study. *Lancet Public Health*. 2022;7(6):e529–e536. doi:10.1016/S2468-2667(22)00106-2
- Human Capital Country Brief. Cote d'Ivoire. 2022; 2023. Available from: <https://thedocs.worldbank.org/en/doc/7c9b64c34a8833378194a026e4e247-0140022022/related/HCI-AM22-CIV.pdf>. Accessed June 12, 2024.
- UNAIDS. Fact sheet - Latest global and regional statistics on the status of the AIDS epidemic; 2021. Available from: [https://www.unaids.org/sites/default/files/media\\_asset/UNAIDS\\_FactSheet\\_en.pdf](https://www.unaids.org/sites/default/files/media_asset/UNAIDS_FactSheet_en.pdf). Accessed June 12, 2024.
- Duby Z, Jonas K, Appollis TM, et al. “There is no fear in me ... well, that little fear is there”: dualistic views towards HIV testing among South African adolescent girls and young women. *Afr J AIDS Res*. 2020;19(3):214–221. doi:10.2989/16085906.2020.1799232
- Institut National de la Statistique-INS et ICF 2023. Enquête Démographique et de Santé de Côte d'Ivoire, 2021. Rockville, Maryland, USA: INS/ Côte d'Ivoire et ICF; 2023. Available from: <https://dhsprogram.com/pubs/pdf/FR385/FR385.pdf>. Accessed June 12, 2024.
- Emamian MH, Fateh M, Gorgani N, Fotouhi A. Mother's education is the most important factor in socio-economic inequality of child stunting in Iran. *Public Health Nutr*. 2014;17(9):2010–2015. doi:10.1017/S1368980013002280

21. Erreygers G. Correcting the Concentration Index. *J Health Econ.* 2009;28(2):504–515. doi:10.1016/j.jhealeco.2008.02.003
22. Alaba O, Chola L. Socioeconomic inequalities in adult obesity prevalence in South Africa: a decomposition analysis. *Int J Environ Res Public Health.* 2014;11(3):3387–3406. doi:10.3390/ijerph110303387
23. Wagstaff A, Doorslaer E, Van Watanabe N. On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in Vietnam. *J Econom.* 2003;112(1):207–223. doi:10.1016/S0304-4076(02)00161-6
24. Poel E, Doorslaer E, O'Donnell O. Measurement of inequity in health care with heterogeneous response of use to need. *J Health Econ.* 2012;31(4):676–689. doi:10.1016/j.jhealeco.2012.05.005
25. Uthman OA. Using extended concentration and achievement indices to study socioeconomic inequality in chronic childhood malnutrition: the case of Nigeria. *Int J Equity Health.* 2009;8(1):22. doi:10.1186/1475-9276-8-22
26. Ekholuenetale M, Tudeme G, Onikan A, Ekholuenetale CE. Socioeconomic inequalities in hidden hunger, undernutrition, and overweight among under-five children in 35 sub-Saharan Africa countries. *J Egypt Public Health Assoc.* 2020;95(1):9. doi:10.1186/s42506-019-0034-5
27. Johnson AK, Fletcher FE, Ott E, et al. Awareness and Intent to Use Pre-exposure Prophylaxis (PrEP) Among African American Women in a Family Planning Clinic. *J Racial Ethn Health Disparities.* 2020;7(3):550–554. doi:10.1007/s40615-019-00683-9
28. Auerbach JD, Hoppe TA. Beyond “getting drugs into bodies”: social science perspectives on pre-exposure prophylaxis for HIV. *J Int AIDS Soc.* 2015;18(4 Suppl 3):19983. doi:10.7448/IAS.18.4.19983
29. Pasipanodya EC, Stockman J, Phuntsog T, et al. “PrEP”ing for a PrEP demonstration project: understanding PrEP knowledge and attitudes among cisgender women. *BMC Women's Health.* 2021;21(1):220. doi:10.1186/s12905-021-01348-8
30. Auerbach JD, Kinsky S, Brown G, Charles V. Knowledge, Attitudes, and Likelihood of Pre-Exposure Prophylaxis (PrEP) Use Among US Women at Risk of Acquiring HIV. *AIDS Patient Care STDs.* 2015;29(2):102–110. doi:10.1089/apc.2014.0142
31. Hill LM, Lightfoot AF, Riggins L, Golin CE. Awareness of and attitudes toward pre-exposure prophylaxis among African American women living in low-income neighborhoods in a Southeastern city. *AIDS Care.* 2021;33(2):239–243. doi:10.1080/09540121.2020.1769834
32. Okeke NL, McLaurin T, Gilliam-Phillips R, et al. Awareness and acceptability of HIV pre-exposure prophylaxis (PrEP) among students at two historically Black universities (HBCU): a cross-sectional survey. *BMC Public Health.* 2021;21(1):943. doi:10.1186/s12889-021-10996-2
33. Ojikutu BO, Bogart LM, Higgins-Biddle M, et al. Facilitators and Barriers to Pre-Exposure Prophylaxis (PrEP) Use Among Black Individuals in the United States: results from the National Survey on HIV in the Black Community (NSHBC). *AIDS Behav.* 2018;22(11):3576–3587. doi:10.1007/s10461-018-2067-8
34. Acharya P, Khanal V. The effect of mother’s educational status on early initiation of breastfeeding: further analysis of three consecutive Nepal Demographic and Health Surveys. *BMC Public Health.* 2015;15(1):1069. doi:10.1186/s12889-015-2405-y
35. Atteraya MS, Kimm H, Song IH. Women’s Autonomy in Negotiating Safer Sex to Prevent HIV: findings From the 2011 Nepal Demographic and Health Survey. *AIDS Educ Prev.* 2014;26(1):1–12. doi:10.1521/aeap.2014.26.1.1
36. Sanchez-Espino LF, Zuniga-Villanueva G, Ramirez-GarciaLuna JL. An educational intervention to implement skin-to-skin contact and early breastfeeding in a rural hospital in Mexico. *Int Breastfeed J.* 2019;14(1):8. doi:10.1186/s13006-019-0202-4
37. Oluwasanu MM, John-Akinola YO, Desmennu AT, Oladunni O, Adebowale AS. Access to information on family planning and use of modern contraceptives among married igbo women in southeast, Nigeria. *Int Q Community Health Educ.* 2019;3:0272684X18821300.
38. Smith LC, Haddad L. Reducing child undernutrition: past drivers and priorities for the post-MDG Era. *World Dev.* 2015;68:180–204. doi:10.1016/j.worlddev.2014.11.014
39. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med.* 2011;155(2):97. doi:10.7326/0003-4819-155-2-201107190-00005
40. Kurth AE, Celum C, Baeten JM, Vermund SH, Wasserheit JN. Combination HIV Prevention: significance, Challenges, and Opportunities. *Curr HIV/AIDS Rep.* 2011;8(1):62–72. doi:10.1007/s11904-010-0063-3