National HIV/AIDS mortality, prevalence, and incidence rates are associated with the Human Development Index

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Key Words: Socioeconomic status, Global epidemic, Less-developed countries

Background: HIV/AIDS is a worldwide threat to human health with mortality, prevalence, and incidence rates varying widely. We evaluated the association between the global HIV/AIDS epidemic and national socioeconomic development.

Methods: We obtained global age-standardized HIV/AIDS mortality, prevalence, and incidence rates from the World Health Statistics Report of the World Health Organization. The human development indexes (HDIs) of 141 countries were obtained from a Human Development Report. Countries were divided into 4 groups according to the HDI distribution. We explored the association between HIV/AIDS epidemic and HDI information using Spearman correlation analysis, regression analysis, and the Kruskal-Wallis test.

Results: HIV/AIDS mortality, prevalence, and incidence rates were inversely correlated with national HDI ($r = -0.675$, $-0.519$, and $-0.398$, respectively; $P < .001$), as well as the 4 indicators of HDI (ie, life expectancy at birth, mean years of schooling, expected years of schooling, and gross national income per capita). Low HDI countries had higher HIV/AIDS mortality, prevalence, and incidence rates than that of medium, high, and very high HDI countries. Quantile regression results indicated that HDI had a greater negative effect on the HIV/AIDS epidemic in countries with more severe HIV/AIDS epidemic.

Conclusions: Less-developed countries are likely to have more severe HIV/AIDS epidemic. There is a need to pay more attention to HIV/AIDS control in less-developed countries, where lower socioeconomic status might have accelerated the HIV/AIDS epidemic more rapidly.

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The HIV/AIDS pandemic entered its third decade in 2011. In 1981 when it was first reported, no one expected the rampant spread of this universally fatal disease. The Joint United Nations Program on HIV/AIDS (UNAIDS) estimates that in 2011, a total of 34.2 million persons were living with HIV infection, 2.5 million persons were newly infected, and 1.7 million died. However, these global figures hide a wide diversity. The prevalence of HIV infection among adults in sub-Saharan Africa continues to be the highest, followed by Eastern Europe and the Caribbean. Considerable HIV/AIDS differences among nations might be due to poverty inequality, economic instability, migration, education, access to health services, drug use, and sexually transmitted diseases. Even within a country, the HIV/AIDS epidemic varies widely according to region and risk group.

There have been plenty of studies focusing on HIV/AIDS epidemiology. However, many of these articles are narrowed to a small region, a single country, or parts of a country. On the basis of the national reports reviewed, HIV/AIDS is suggested to impede development of African countries and hence reverse the social and economic gains that these countries are striving to attain. Nevertheless, the extent of this conclusion remains unknown. The purpose of our study was to review the global HIV/AIDS mortality, prevalence, and incidence rates, and to explore the association between HIV/AIDS epidemic and national socioeconomic development assessed according to the Human Development Index (HDI).

METHODS

Global HIV/AIDS epidemic

The global age-standardized HIV/AIDS mortality rates, prevalence rates, and incidence rates of different countries in 2011 were obtained from the World Health Statistics Report 2013 of the World Health Organization.

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L-XL and YC contributed equally to this work.

Conflicts of interest: None to report.
HDI

The HDI data of Union Nation members in 2011 were obtained from the United Nations Development Programme database (http://hdr.undp.org/), according to the 2011 Human Development Report.9 The HDI is a composite index measuring average achievement in 3 basic dimensions (4 indicators) of human development: long and healthy life (life expectancy at birth), education (mean and expected years of schooling), and decent standard of living (gross national income [GNI] per capita). The index ranges from 0–1, with higher scores reflecting a higher degree of human development. Based on quartiles of HDI distribution in the 2011 Human Development Report,9 countries were placed into 4 predefined socioeconomic groups as follows: very high (HDI ≥ 0.793), high (0.793 > HDI ≥ 0.698), medium (0.698 > HDI ≥ 0.522), and low (HDI < 0.522).

Statistical analysis

The medians (interquartile ranges) for the HIV/AIDS mortality, prevalence, and incidence rates across countries were calculated. National HIV/AIDS epidemiologic parameters were tested for normality using the Kolmogorov-Smirnov test.10 The relationships between HIV/AIDS epidemic and national HDI were evaluated by calculation of Spearman correlation coefficient after the hypotheses of normality were rejected by Kolmogorov-Smirnov test. We further performed linear regression analyses, which estimated the effect of the independent variable (ie, HDI) on dependent variable (ie, HIV/AIDS mortality, prevalence, and incidence rates); and quantile regression analyses, which estimated the effect of the independent variable at different quantiles of each dependent variable’s conditional distribution.11 The statistical significance of differences in HIV/AIDS mortality, prevalence, and incidence rates among 4 HDI countries was determined by Kruskal-Wallis test after the heterogeneity of variances were confirmed.12 HIV/AIDS mortality, prevalence, and incidence rates were compared in low HDI countries versus medium, high, and very high HDI countries using Mann-Whitney U test.12 All statistical analyses, except regression analyses, were performed using SPSS 20 (IBM-SPSS Inc, Armonk, NY), and results were plotted using GraphPad Prism 6 (GraphPad, San Diego, Calif). Regression analyses were performed using Stata 12 (Stata Corp, College Station, Tex). P values < .05 were considered significant.

RESULTS

HIV/AIDS epidemic and national HDI

Data on the global HIV/AIDS mortality, prevalence, and incidence rates were available for 137, 139, and 63 countries, respectively. HDI and its 4 indicators were available for 141 countries. The medians (interquartile ranges) and Kolmogorov-Smirnov test results of global HIV/AIDS epidemiologic parameters per 100,000 individuals are shown in Table 1. The Spearman correlation coefficients between Human Development Index (HDI), its 4 indicators, and HIV/AIDS epidemiologic parameters are shown in Table 2.

### Table 1

<table>
<thead>
<tr>
<th>Global HIV/AIDS epidemic</th>
<th>n</th>
<th>Median</th>
<th>Interquartile range</th>
<th>Kolmogorov-Smirnov test (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>137</td>
<td>14.5</td>
<td>1.25-49.5</td>
<td>.000</td>
</tr>
<tr>
<td>Prevalence</td>
<td>139</td>
<td>255</td>
<td>96-810</td>
<td>.000</td>
</tr>
<tr>
<td>Incidence</td>
<td>63</td>
<td>63</td>
<td>18-191</td>
<td>.000</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mortality</th>
<th>Prevalence</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDI</td>
<td>-0.675***</td>
<td>-0.519***</td>
<td>-0.398***</td>
</tr>
<tr>
<td>Life expectancy at birth, y</td>
<td>-0.662***</td>
<td>-0.529***</td>
<td>-0.463***</td>
</tr>
<tr>
<td>Mean years of schooling</td>
<td>-0.613***</td>
<td>-0.475***</td>
<td>-0.337***</td>
</tr>
<tr>
<td>Expected years of schooling</td>
<td>-0.634***</td>
<td>-0.484***</td>
<td>-0.310***</td>
</tr>
<tr>
<td>Gross national income per capita, $</td>
<td>-0.633***</td>
<td>-0.462***</td>
<td>-0.297***</td>
</tr>
</tbody>
</table>

*P < .05.
**P < .01.
***P < .001.
HIV/AIDS epidemiologic parameters are shown in Table 1. Kolmogorov-Smirnov test confirmed the nonnormal distributions of HIV/AIDS mortality, prevalence, and incidence rates ($P > .05$). Nonparametric Spearman correlation coefficients revealed that HIV/AIDS mortality, prevalence, and incidence rates were significantly inversely correlated with national HDI (Fig 1) and the 4 indicators of HDI (Table 2). Of the 3 HIV/AIDS epidemiologic parameters, mortality rates demonstrated the strongest association with national HDI and its indicators ($r = -0.613$ to $-0.675$; $P < .001$). Of the 4 HDI indicators, life expectancy at birth showed the strongest relationship with HIV/AIDS mortality, prevalence, and incidence rates ($r = -0.662$, $-0.529$, and $-0.464$, respectively; $P < .001$).

Quantile regressions were performed to examine if the effects of HDI differed across the quantiles in the conditional distributions of HIV/AIDS mortality, prevalence, and incidence rates. We estimated the model first by ordinary least squares and then at the 0.10, 0.25, 0.50, 0.75, and 0.90 quantiles (Table 3). Ordinary least squares regression results revealed that HDI had a significant average effect on HIV/AIDS mortality (regression coefficient $\beta = -223.461$; $P < .001$) and prevalence rates ($\beta = -454.320$; $P < .001$), but not HIV/AIDS incidence rates ($\beta = -333.760$; $P > .05$). HDI was significantly negatively associated with HIV/AIDS mortality and prevalence rates at different quantiles, except the 0.10 quantile. Although HDI had no average effect on HIV/AIDS incidence rates, significant relationships were observed at the 0.25 ($\beta = -74.792$; $P < .05$), and 0.75 ($\beta = -594.891$; $P < .05$) quantiles. The quantile regression curves (Fig 2) reveal that the absolute value of the estimated coefficient ($\beta < 0$) of HDI on HIV/AIDS mortality, prevalence, and incidence rates increased with increasing quantiles.

HIV/AIDS epidemic and socioeconomic development levels

The 141 countries were classified into 4 groups according to national HDI, including very high ($n = 39$), high ($n = 26$), medium ($n = 34$), and low ($n = 42$) HDI countries. Kruskal-Wallis tests indicated that HIV/AIDS mortality, prevalence, and incidence rates differed significantly among countries with different development levels. The results of Mann-Whitney U tests revealed that countries with lower HDI were likely to have higher HIV/AIDS mortality, prevalence, and incidence rates (Fig 3). Low HDI countries had a median (interquartile range) mortality rate (per 100,000 individuals) of 50 (22.75-145.8), which was significantly higher than that of medium HDI countries at 17 (5.2-68.5), high HDI countries at 9.4 (2.6-27), and very high HDI countries at 0.8 (0.45-1.7). HIV/AIDS prevalence rates (per 100,000 individuals) illustrated a similar pattern, with a median (interquartile range) of 820 (412-2,476) in low HDI countries versus 410 (153-1,176), 129 (69.5-410), and 113

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Ordinary least squares coefficient estimate</th>
<th>0.10</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>0.90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>$-223.461$***</td>
<td>$-7.516$</td>
<td>$-32.609$***</td>
<td>$-78.364$***</td>
<td>$-265.190$***</td>
<td>$-520.539$***</td>
</tr>
<tr>
<td>Prevalence</td>
<td>$-4454.320$***</td>
<td>$-155.709$</td>
<td>$-557.047$*</td>
<td>$-1263.158$***</td>
<td>$-3711.790$*</td>
<td>$-9457.484$*</td>
</tr>
<tr>
<td>Standard error</td>
<td>1193.044</td>
<td>141.448</td>
<td>229.003</td>
<td>256.584</td>
<td>1257.643</td>
<td>3860.490</td>
</tr>
<tr>
<td>Incidence</td>
<td>$-333.760$</td>
<td>$-22.507$</td>
<td>$-74.792$*</td>
<td>$-153.465$</td>
<td>$-594.891$*</td>
<td>$-873.737$*</td>
</tr>
<tr>
<td>Standard error</td>
<td>198.865</td>
<td>30.373</td>
<td>34.428</td>
<td>89.275</td>
<td>255.497</td>
<td>697.584</td>
</tr>
</tbody>
</table>

* $P < .05$.
** $P < .01$.
*** $P < .001$.

Fig 2. Variation in the regression coefficients of Human Development Index (HDI) on (A) HIV/AIDS mortality, (B) HIV/AIDS prevalence, and (C) HIV/AIDS incidence rates over the conditional quantiles. Confidence intervals extend to 1.96 standard errors. Horizontal lines represent ordinary least squares estimates with 95% confidence intervals.
In our study, we reviewed the global HIV/AIDS mortality, prevalence, and incidence rates according to the World Health Organization statistics report. There are huge disparities in global the HIV/AIDS epidemic. HIV/AIDS mortality, prevalence, and incidence rates were inversely correlated with national HDI and its 4 indicators (ie, life expectancy at birth, mean years of schooling, expected years of schooling, and GNI per capita), with higher rates in lower HDI countries compared with higher HDI countries. The downward sloping curves plotted using quantile regression analyses indicate that national HDI had a greater negative effect on HIV/AIDS epidemic in nations with more severe HIV/AIDS epidemic.

HIV/AIDS is directly affecting health and demographic indicators such as mortality rates and life expectancy. It is estimated that in the 7 most affected countries in Africa life expectancy declined by 12.1 years by 1995–2000 and is expected to decline by 29.4 years by 2010–2015. Analysis of global inequality of life expectancy showed that 6 years of the difference in life expectancy between Africa and North America, 2 extreme continents in terms of health and wealth, is due to AIDS.

The 2-way interaction between education and HIV/AIDS has been extensively discussed. In our study, we found that years of schooling were reversely related to HIV/AIDS epidemic. Education is essential for human development and needs to be enhanced especially in low- and medium-income countries. Unfortunately, HIV/AIDS is reversing the trend toward the achievement of universal primary education in most African countries. The death of AIDS parents eventually will result in economic status deterioration and increasing number of children out of school (especially girls), which leads to the de-education of the future generation. On the other hand, education can make significant contribution to the prevention of HIV transmission and has been considered as a vehicle to combat HIV/AIDS.

Many researchers have described AIDS as a disease of poverty. This causes a vicious circle with the loss of young wealth-producing adults and the high cost of caring for those with AIDS. More than 60% of people living with HIV inhabit the world’s poorest region: sub-Saharan Africa. Even with the help of global organizations such as UNAIDS, a nation with low economic growth can hardly pay the cost of highly active antiretroviral therapy and prevention programs. Hence, the cyclical relationship is clear: poverty makes people more vulnerable to AIDS and AIDS generates poverty. This was verified in our study by the negative correlation between GNI per capita and HIV/AIDS mortality, prevalence, and incidences rates.

AIDS has been long considered as a disease at the core of a vicious circle, whereby the downstream effects of AIDS on socioeconomic status and the upstream effects of socioeconomic status upon the risk of acquiring HIV. The upstream effects were verified in our study with negative regression coefficients of HDI on HIV/AIDS mortality, prevalence, and incidences rates, which may due to the effects of poor education and poverty on HIV/AIDS.

CONCLUSIONS

The results of our study, obtained by collating reliable data resources, revealed an inverse relationship between national HIV/AIDS epidemic and HDI—including life expectancy, years of schooling, and GNI per capita. Less developed countries, as measured by HDI, are likely to have more severe HIV/AIDS epidemic. National socioeconomic status tends to affect HIV/AIDS epidemic more negatively in nations with higher HIV/AIDS mortality, prevalence, and incidence rates. The findings from our study suggest a need to pay more attention to the HIV/AIDS control in less...
developed countries where lower socioeconomic status might have accelerated the HIV/AIDS epidemic more rapidly.

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