Impact of Socioeconomic Inequality on Access, Adherence, and Outcomes of Antiretroviral Treatment Services for People Living with HIV/AIDS in Vietnam

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Abstract

Background

Ensuring an equal benefit across different patient groups is necessary while scaling up free-of-charge antiretroviral treatment (ART) services. This study aimed to measure the disparity in access, adherence, and outcomes of ART in Vietnam and the effects of socioeconomic status (SES) characteristics on the levels of inequality.

Methods

A cross-sectional study was conducted in 1133 PLWH in Vietnam. ART access, adherence, and treatment outcomes were self-reported using a structured questionnaire. Wealth-related inequality was calculated using a concentration index, and a decomposition analysis was used to determine the contribution of each SES variable to inequality in access, adherence, and outcomes of ART.

Results

Based on SES, minor inequality was found in ART access and adherence while there was considerable inequality in ART outcomes. Poor people were more likely to start treatment early, while rich people had better adherence and overall treatment outcomes. Decomposition revealed that occupation and education played important roles in inequality in ART access, adherence, and treatment outcomes.
Conclusion

The findings suggested that health services should be integrated into the ART regimen. Furthermore, occupational orientation and training courses should be provided to reduce inequality in ART access, adherence, and treatment outcomes.

Introduction

Globally, a rapid scale-up of antiretroviral therapy (ART) service has sustainably contributed to diminishing the burden of HIV epidemic in both individual and social perspectives [1–3]. By the end of 2015, over 17 million people living with HIV (PLWHs) worldwide were on ART, two million of whom initiated their treatment the same year [4]. ART helps PWLH to prolong virologic suppression, bolster their immune systems, decrease opportunistic infections, and therefore, lengthen their lifespan and improve their quality of life [5–9]. The patients have to strictly adhere to their regimes in order for the treatment to be successful and to prevent drug resistance [10]. The World Health Organization (WHO) recommends that PLWHs should start ART irrespective of their CD4 cell count [6].

In spite of the critical role of ART, there are widespread inequalities in accessing and utilizing this service [11–14]. International research suggests that lower socioeconomic status (SES) was closely related to delayed ART initiation, lower treatment adherence, and poorer outcomes [11–14]. For example, previous studies showed the positive association between education and early HIV diagnosis and ART initiation [11,15,16]. Furthermore, WHO emphasized in “Treatment 2.0” guideline that wealthier PLWH were more likely to have access to better HIV/AIDS care services [17]. Another study suggests that unemployed people were more likely to withdraw from treatment [10]. Since socioeconomically disadvantaged groups have been extremely vulnerable to the HIV epidemic, the impacts of SES on access, adherence and outcomes of antiretroviral treatment services among PLWH should be carefully elucidated.

In Vietnam, in the first half of 2016, there were about 227,225 people reported HIV/AIDS positive, a large portion belonging to some of the most at-risk populations such as people injecting drugs, men who have sex with men, and female sex workers [18]. Thanks to funding from international donors, there are currently more than four hundred outpatient clinics providing ART and other HIV-related services free-of-charge [19,20]. However, only 48% of PLWH have access to ART [18]. Furthermore, delayed ART access and utilization are still common in Vietnam. Several reports suggest that more than 50% of patients started treatment when their CD4 cell count was less than 100 cell/m$^3$ [21,22]. Lower educational attainment, lower income, high out-of-pocket payments, and social stigma against PLWH are considered to be major contributors to the delayed use of ART in Vietnam [23]. The Vietnamese government has shown a strong commitment to addressing these issues by implementing national HIV/AIDS control strategies that 80% of PLWH will receive ART-related services by 2020 [24].

Despite an increasing concern in health-care inequalities topic in Vietnam [25], limited empirical studies show the relationship between SES and primary aspects of ARV treatment. A few studies showed that SES inequalities could be directly and indirectly associated with the risk of HIV infection [26] and the level of stigma against PLWH [27]. However, none of them mentions whether PLWH could have timely access to ART services, adhere to the regimen, and achieve successful treatment outcomes without depending on SES. Moreover, in the literature, most treatment outcomes are only measured in biological indicators, such as CD4 count.
or HIV viral load. These measures alone cannot take into account larger socioeconomic factors, which affect the overall success of and access to ART in different populations over an extended period of time. Therefore, it is necessary to develop a specific indicator that can display the long-term effects of ART. This study aimed to measure the socioeconomic inequalities in access, adherence, and outcomes of ART services for Vietnamese PLWH; and identify contributors to those disparities.

Materials and Methods

Study settings and subjects
A cross-sectional study was performed from January to September 2013 in two leading HIV epicenters in northern Vietnam, the Hanoi capital and Nam Dinh province, with 20,762 and 3,781 PLWH, respectively [28]. Eight ART clinics, five in Hanoi and three in Nam Dinh, were included in this study. Those clinics were selected based on following criteria: 1) including clinics in central-, provincial- and district-levels; 2) having an adequate number of PLWH currently on ART.

The participants must meet following criteria: 1) age ≥ 18 years old; 2) currently being on ART; 3) agreeing to participate in the study and providing written informed consent; 4) having the physical and psychological capacity to answer questionnaire within 25–30 minutes. A convenience sampling technique was used to recruit patients. People who were visiting the clinics during the study period were invited to enroll in the study. A total of 1133 HIV/AIDS patients participated in this study.

Data collection
The collection team included well-trained master students in public health and HIV/AIDS experts. A structure questionnaire was used, which included information about socio-demographic and clinical characteristics (i.e. HIV stage, history of drug use, initiated and current CD4 cell count, ART adherence and duration) as well as health outcomes (health-related quality of life—HRQOL).

Variables

Socio-economic characteristics. We investigated some variables namely age, gender, religion, marriage status, educational attainment, occupations and self-reported household income in the last 12 months. In general practice, income, education, and occupation are frequently used to assess socioeconomic status (SES), each with their own advantages and disadvantages [29]. In this case, income was used to assess SES and classified the socio-economic status into five quintiles, with the 1st quintile representing the poorest and the 5th quintile representing the richest.

ART access and adherence. Initiated CD4 cell count was retrieved from medical records to measure ART service access. Based on this indicator, we assessed whether people received late ART treatment or not. At the time when the study was conducted, the guidelines of the WHO recommended that PLWH should be treated when CD4 cell count reaches 350 [5]. This threshold was utilized to assess late ART access.

The ART adherence within 30 days of respondents was measured by using a 100-point visual analogue scale (VAS), with the value of 0 meaning complete non-adherence and the value of 100 suggesting complete adherence. [30]. The threshold of ≥ 95% was selected for optimal adherence [31].
ART outcome of treatment. Self-reports about the latest CD4 cell count and health-related quality of life were collected from patients. HRQOL was measured by using EQ-5D-5L instrument in the Vietnamese version, which was validated elsewhere [32]. This tool measures five dimensions including mobility, self-care, usual activities, pain/discomfort and anxiety/depression with five response levels: no problems, slight problems, moderate problems, severe problems, and extreme problems [33]. The combination of responses gives 3125 health states with weighting to have aggregate single index [32]. Furthermore, the EQ-VAS (visual analogue scale) measures the self-rated health on a 20-cm vertical scale, with the endpoint ranges from 0 to 100 point, labeled “the worst health you can imagine” and “the best health you can imagine” [33]. A prior study suggested that the VAS score of 80 was equal to the average score of normal Vietnamese population [9]. Therefore, this threshold was chosen for optimal HRQOL.

Concentration Index (CI) and decomposition of the CI. Concentration Index (CI) was applied to assess the income-related inequality in health outcomes and health care services. The CI is a popular tool to measure health and health care inequality in the field of health policy and health economics research [34]. It is obtained by quantifying the area between the concentration curve (which individuals, ranked by socioeconomic status, are plotted against the cumulative share of health outcome or health care service variable) and the line of equity (45-degree line, obtained from concentration curve).

In general, the CI ranges between -1 and +1, and CI is zero when there is no difference in sharing of health or health care outcome among different SES ranking groups. Positive CI value indicates that the outcome is concentrated in higher SES groups, which can be called “pro-rich”; and the opposite is true for negative values.

Decomposition of the CI method was applied to identify major contributors to the observed income-related inequality. The basic idea of decomposing the CI is quantifying each contributor to the observed CI, as the overall CI is a sum of the contribution from each factor and residual.

Statistical analysis

Data was analyzed using STATA version 12 (Stata Corp. LP, College Station, United States of America). Descriptive analysis was used for demographic characteristics of respondents as well as HRQOL, adherence to treatment and changes in CD4 level. The disparity in access, adherence, and outcome of treatment between people with different income per capita regarding quintiles was determined using CI.

Ethics approval

The protocol of this study was reviewed and approved by the Vietnam Authority of HIV/AIDS Control’s Scientific Research Committee. Written informed consent was obtained from all participants. Patients could withdraw at any time without it influencing their current treatment.

Results

Table 1 describes the demographic characteristics of respondents. A total of 1133 patients enrolled in this survey (90% response rate). Most of them were male (58.7%) between 30 and 45 years old (75.3%), living with their spouses or partners (61.2%) and having at least high-school education (41.2%). The majority of respondents were self-employed (41.4%) and workers/farmers (24.9%).

The ART access, adherence, and outcomes of respondents are depicted in Table 2. The majority of them received treatment for more than two years (94.7%). Approximately half of the patients were at asymptomatic (41.6%), while 16% reported symptoms and 10.8% reported to be at the disease stage of AIDS. However, over one-third of the patients did not know their
HIV disease stages. Most of the respondents had low CD4 cell counts (<200 cells) at ART initiation (65.6%). However, the percentage of people with low CD4 cell counts was remarkably higher in the poor group than the rich group ($p<0.05$). About half of the patients had current CD4 cell counts at 350 cells or higher (47.1%) and only 25.7% of patients reported to have optimally adhered to ARV treatment during the last 30 days (VAS $\geq 95\%$).

The results of Table 3 suggest that participants with greater wealth had better HRQOL. The proportion of people who had problems in all of five of the characteristics of mobility, self-care, usual activities, pain/discomfort and anxiety/depression decreased from poor to rich quintiles ($p<0.05$). The overall EQ-5D score and EQ-VAS were also significantly higher in the rich group than the poor group ($p<0.05$). The proportion of optimal HRQOL people in the rich group was double those in the poor group ($p<0.05$).

Table 1. Demographic characteristics of respondents.

| Characteristics | Poverty status | Wealth status | Total | p-value |
|-----------------|----------------|---------------|-------|---------|
|                 | ≤ Poor | Middle | ≥ Rich | Total |       |
| Level of clinic | n     | %     | n     | %     | n     | %     |       |
| Central         |   86  | 18.4  |   66  | 26.5  | 125   | 30.1  | 277   | 24.5  | <0.01  |
| Province        |   51  | 10.9  |   24  |  9.6  |   24  |  5.8  |   99  |  8.7   |       |
| District        |  331  | 70.7  |  159  | 63.9  |  267  | 64.2  |  757  | 66.8   |       |
| Gender          |      |       |      |       |      |       |      |       |       |
| Female          |  187  | 40.0  |  108  | 43.4  |  173  | 41.6  |  468  | 41.3   | 0.67   |
| Age             |      |       |      |       |      |       |      |       |       |
| 18-25           |   9   | 1.92  |   4   | 1.61  |   10  | 2.4   |   23  | 2.0    | 0.04   |
| 25-30           |  52   | 11.1  |  32   | 12.85 |   65  | 15.6  |  149  | 13.2   |       |
| 30-35           |  170  | 36.32 |  83   | 33.33 |  160  | 38.5  |  413  | 36.5   |       |
| 35-40           |  121  | 25.85 |  68   | 27.31 |  119  | 28.6  |  308  | 27.2   |       |
| 40-45           |   66  | 14.1  |  31   | 12.45 |   35  |  8.4  |  132  | 11.7   |       |
| ≥ 45            |   50  | 10.68 |  31   | 12.45 |   27  |  6.5  |  108  |  9.5   |       |
| Marital status  |      |       |      |       |      |       |      |       |       |
| Single          |   65  | 13.9  |   30  | 12.1  |   74  | 17.8  |  169  | 14.9   | 0.20   |
| Live with spouse/partner | 285 | 60.9 | 164 | 65.9 | 244 | 58.7 | 693 | 61.2   |       |
| Divorced/ Widow |  118  | 25.2  |  55   | 22.1  |  98   | 23.6  |  271  | 23.9   |       |
| Educational attainment |      |       |      |       |      |       |      |       |       |
| ≤ Second        | 340   | 72.8  | 139   | 55.8  | 170   | 40.9  | 649   | 57.3   | <0.01  |
| High            |  114  | 24.4  |   87  | 34.9  |  161  | 38.7  |  362  | 32.0   |       |
| Vocational training |  5   | 1.1   |  12   |  4.8  |   37  |  8.9  |   54  |  4.8   |       |
| University      |   8   | 1.7   |   11  |  4.4  |   48  | 11.5  |   67  |  5.9   |       |
| Employment      |      |       |      |       |      |       |      |       |       |
| Unemployed      | 132   | 28.2  |   51  | 20.5  |   49  | 11.8  |  232  | 20.5   | <0.01  |
| Self-employed   | 131   | 28.0  |  123  | 49.4  |  215  | 51.7  |  469  | 41.4   |       |
| Officers        |   8   | 1.7   |   15  |  6.0  |   57  | 13.7  |   80  |  7.1   |       |
| Workers, Farmers| 176   | 37.6  |   47  | 18.9  |   59  | 14.2  |  282  | 24.9   |       |
| Other jobs      |  21   | 4.5   |   13  |  5.2  |   36  |  8.7  |   70  |  6.2   |       |
| Religion        |      |       |      |       |      |       |      |       |       |
| Cult of ancestors | 404 | 86.3 | 222 | 89.2 | 375 | 90.1 | 1001 | 88.4  | 0.19   |
| Others          |   64  | 13.7  |   27  | 10.8  |   41  |  9.9  |  132  | 11.7   |       |
| History of drug use |      |       |      |       |      |       |      |       |       |
| Yes             | 178   | 38.03 |   86  | 34.54 |  138  | 33.17 |  402  | 35.48  | 0.30   |

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The severity of inequality was shown in Fig 1. A slight inequality in timely access to ART was found with CI = -0.027, showing that timely ART access was concentrated among poor people. In contrast, the CI for treatment had a positive value (CI = 0.021), indicating poor people experienced greater difficulty in ART adherence. In term of treatment outcomes such as HRQOL and current CD4 cell count, the CI was also a positive value (CI = 0.196 and 0.051, respectively), revealing an inequality in outcomes that favored the rich.

The results of a decomposition analysis are shown in Table 4. Education and age were two main factors contributing to inequality in access to ART (23% and 18%, respectively). These two factors were also the main contributors to the disparity in treatment outcomes based on CD4 count measurements, where occupation contributed 24%, and age contributed 15% to the CI. Meanwhile, the inequality in treatment adherence was mainly attributed to education and occupation (47% and 16%, respectively). The negative value of the contribution of occupation to adherence inequality showed that while the overall inequality is pro-rich, occupation had a reverse effect, lessening the disparity. Education and occupation were also the main contributors to the inequality in treatment outcomes when the quality of life is measured. Notably, a large part of all four indexes is explained by the error term of the regression.

**Discussion**

This study used a concentration index (CI) to investigate the presence of inequality in ART access, adherence and treatment outcomes among PLWH in Vietnam. We also decomposed the CI to identify the contributors of some SES variables to the inequalities. Our analysis

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**Table 2. ART access, adherence and outcome of respondents regarding to income quintiles.**

| Characteristics                      | ≤ Poor | Middle | ≥ Rich | p-value |
|--------------------------------------|--------|--------|--------|---------|
|                                      | n      | %      | n      | %       | n      | %       |
| **Duration of ART**                  |        |        |        |         |
| < 2 years                            | 21     | 4.5    | 7      | 2.8     | 22     | 5.3     | 0.07    |
| 2–< 4 years                          | 140    | 29.9   | 72     | 28.9    | 154    | 37.0    |         |
| 4–< 7 years                          | 196    | 41.9   | 104    | 41.8    | 140    | 33.7    |         |
| ≥ 7 years                            | 111    | 23.7   | 66     | 26.5    | 100    | 24.0    |         |
| **HIV stage**                        |        |        |        |         |
| Asymptomatic                         | 182    | 38.9   | 101    | 40.6    | 173    | 41.6    | 0.36    |
| Symptomatic                          | 78     | 16.7   | 48     | 19.3    | 67     | 16.1    |         |
| AIDS                                 | 35     | 7.5    | 21     | 8.4     | 45     | 10.8    |         |
| Unknown                              | 173    | 37.0   | 79     | 31.7    | 131    | 31.5    |         |
| **Initiated CD4 cell count**         |        |        |        |         |
| <100                                 | 274    | 58.6   | 147    | 59.0    | 199    | 47.8    | 0.02    |
| 100- < 200                           | 75     | 16.0   | 37     | 14.9    | 70     | 16.8    |         |
| 200- < 350                           | 83     | 17.7   | 43     | 17.3    | 99     | 23.8    |         |
| ≥ 350                                | 36     | 7.7    | 22     | 8.8     | 48     | 11.5    |         |
| **Current CD4 cell counts**          |        |        |        |         |
| <100                                 | 108    | 23.1   | 53     | 21.3    | 70     | 16.8    | 0.25    |
| 100–200                              | 51     | 10.9   | 21     | 8.4     | 43     | 10.3    |         |
| 200–350                              | 120    | 25.6   | 62     | 24.9    | 107    | 25.7    |         |
| ≥ 350                                | 189    | 40.4   | 113    | 45.4    | 196    | 47.1    |         |
| **ART adherence (VAS ≥ 95%)**        |        |        |        |         |
| Yes                                  | 146    | 31.2   | 60     | 24.1    | 107    | 25.7    | 0.07    |
| No                                   | 322    | 68.8   | 189    | 75.9    | 309    | 74.3    |         |

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Timely access to ART service plays a crucial role in HIV treatment, as delaying ART treatment can lead to an increased risk of HIV-related opportunistic infections and mortality, poor responses to treatment, and reduced life expectancy [35–37]. This study showed that the majority of respondents had late ART initiation, which was consistent with previous reports in Vietnam and other developing countries [21,23,38]. Nonetheless, we found a small pro-poor pattern in ART initiation regarding different SES groups (CI = -0.027). This value of CI is considerably small compared to the inequality in accessing general health care service in Vietnam (CI = 0.10–0.26) [39]. A possible explanation is that since ART has been provided freely in Vietnam, people can access treatment regardless of socioeconomic disadvantages. However, as foreign funding will decrease rapidly in the upcoming years, PLWH will have to pay for their own medications. This suggests that the income-related inequality will be worse if subsidies are unavailable for poor PLWH, who cannot afford ART treatment [40].

Compliance to ART treatment is a strict requirement for high effectiveness in HIV treatment [5,41]. Overall, the results suggest that most of the patients had good adherence to ART treatment. The results also indicated that the relationship between SES and inequality in ART adherence was relatively small among PLWH. This finding is similar to other prior studies, which indicated that socioeconomic factors might not have a significant impact on adherence among patients [42,43].

The disparities in treatment outcome varied based on CD4 cell counts and quality of life measurements. The positive value of CI represented a pro-rich tendency in the treatment outcomes. However, low concentration indexes when using CD4 cell counts indicated that the

Table 3. HRQOL of respondents by household’s economic status.

| Characteristics         | ≤ Poor | Middle | > Rich | p-value |
|-------------------------|--------|--------|--------|---------|
|                         | n      | %      | n      | %      | n      | %      |        |
| Mobility                |        |        |        |        |
| Have problems           | 124    | 26.5   | 53     | 21.3   | 55     | 13.2   | <0.01  |
| No problems             | 344    | 73.5   | 196    | 78.7   | 361    | 86.8   |        |
| Self-care               |        |        |        |        |
| Have problems           | 64     | 13.7   | 20     | 8.0    | 26     | 6.3    | <0.01  |
| No problems             | 404    | 86.3   | 229    | 92.0   | 390    | 93.8   |        |
| Usual activities        |        |        |        |        |
| Have problems           | 103    | 22.0   | 41     | 16.5   | 44     | 10.6   | <0.01  |
| No problems             | 365    | 78.0   | 208    | 83.5   | 372    | 89.4   |        |
| Pain/discomfort         |        |        |        |        |
| Have problems           | 203    | 43.4   | 100    | 40.2   | 124    | 29.8   | <0.01  |
| No problems             | 265    | 56.6   | 149    | 59.8   | 292    | 70.2   |        |
| Anxiety/depression      |        |        |        |        |
| Have problems           | 250    | 53.4   | 121    | 48.6   | 138    | 33.2   | <0.01  |
| No problems             | 218    | 46.6   | 128    | 51.4   | 278    | 66.8   |        |
| Optimal HRQOL           |        |        |        |        |
| ≥ 80 VAS score          | 117    | 25.0   | 99     | 39.8   | 210    | 50.5   | <0.01  |
| < 80 VAS Score          | 351    | 75.0   | 150    | 60.2   | 206    | 49.5   |        |
| Mean                    | 0.74   | 0.26   | 0.78   | 0.22   | 0.84   | 0.21   | <0.01  |
| SD                      | 0.42   | 0.28   | 0.39   | 0.16   | 0.08   | 0.07   |        |
| EQ-5D index             |        |        |        |        |
| Have problems           | 684    | 17.42  | 68.36  | 17.31  | 74.09  | 15.40  | <0.01  |
| No problems             | 247    | 82.58  | 31.64  | 82.69  | 22.91  | 84.60  |        |

indicated that the poor tended to have more timely access ARV treatment but had lower HRQOL, as compared to the rich. Furthermore, decomposition results suggested the minor contributions of socioeconomic factors to these inequalities.
Table 4. Decomposition of SES inequalities in ART access, adherence and outcome treatments.

| Characteristics     | Late access to ART | ART adherence | HRQOL | Current CD4 cell count |
|---------------------|--------------------|---------------|-------|------------------------|
|                     | Marginal effect    | Contribution (%) | Marginal effect    | Contribution (%) | Marginal effect    | Contribution (%) |
| Gender              | 0.000              | 0%             | 0.000              | 0%              | 0.000              | 0%              |
| Age                 | -0.005             | 18%            | 0.000              | 0%              | 0.012              | 6%              |
|                     | 0.004              | 15%            |                    |                 | 0.004              | 15%             |
| Marital status      | 0.000              | 2%             | 0.001              | 4%              | -0.001             | 0%              |
|                     | 0.000              | 2%             | 0.016              | 8%              | 0.001              | 4%              |
| Education           | -0.006             | 23%            | 0.010              | 47%             | 0.016              | 8%              |
| Occupation          | -0.001             | 2%             | -0.003             | -16%            | 0.032              | 16%             |
| Religion            | 0.001              | 2%             | -0.001             | 4%              | 0.001              | 0%              |
|                     | 0.011              | 5%             | 0.000              | 1%              |
| Level of clinic     | -0.001             | 2%             | 0.000              | 1%              | 0.011              | 5%              |
| Drug use            | -0.004             | 4%             | 0.001              | 4%              | 0.000              | 0%              |
| HIV stage           | 0.001              | -5%            | 0.000              | 0%              | -0.003             | -2%             |
|                     | -0.002             | -6%            | 0.000              | 0%              |
| Duration of ART     | -0.001             | 5%             | 0.000              | 0%              | -0.001             | -1%             |
| Residual            | -0.014             | 51%            | 0.013              | 62%             | 0.131              | 67%             |
| Inequality (total)  | -0.027             | 51%            | 0.021              | 62%             | 0.196              | 67%             |

Fig 1. Concentration curves for the severity of inequality on access, adherence, and outcomes of ART services. (A) Late ART access (B) ART adherence treatment (C) HRQOL (D) Current CD4 cell count.

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poor and the rich experienced somewhat similar clinical effectiveness of ART. This result was consistent with a previous longitudinal study, which found that SES did not have a significant influence on the change in CD4 cell count [44]. When quality of life measurement was utilized, the result showed a greater level of inequality; in particular, people with better SES tended to have better HRQOL. This can be attributed to the fact that people with high SES have a higher chance to access better living conditions and good health care services than poor people. This finding was consistent with prior studies in Vietnam that lower income, unemployment, and lower education attainment were related to lower HRQOL [32,45].

In addition, the difference can be explained by the distinct nature of each indicator. CD4 cell count is purely a clinical indicator, which is mainly affected by treatment regimen, drug quality, and the patient’s adherence to treatment. In the context of Vietnam, ART was received free of charge with comparable quality in the whole country, and with a similar level of adherence, the CD4 cell count does not significantly vary. Meanwhile, EQ-5D-5L scores and VAS scores reflected the psychological aspect of health, as well as the patients’ outlook towards living with HIV, which is mainly affected by individual socioeconomic status. A prior study about the psychometrics of the EQ-5D-5L instrument suggested that this tool has the potential to contribute to HIV treatment monitoring, along with clinical indicators such as CD4 cells and viral load [32]. Notably, in this study, VAS score for HRQOL was used to identify the optimal threshold instead of EQ-5D-5L index. According to a recent meta-analysis, VAS demonstrated good reliability and better discriminate validity than EQ-5D-5L in HIV treatment monitoring [8,32]. Additionally, EQ-5D-5L, as well as other generic instruments such as EQ-5D-3L, can have a high ceiling effect, which can influence the responsiveness of patients [8].

Decomposition revealed the contribution of various SES characteristics to the level of inequality, which is mostly affected by education and occupation. The results also showed that inequality in access, adherence, and outcomes of ARV treatment had patterns similar to the contributions of SES characteristics in comparison to those of other chronic diseases [46–48]. Meanwhile, high residual errors meant that a large proportion of contributions to inequalities were unexplained factors. For example, a study indicated that people experiencing discrimination and culture barriers were more likely to withdraw from treatment [49]. In addition, low quality of ART services was a factor that reduced the HRQOL of ART patients [45]. Further studies are needed to elucidate the impacts of a range of factors such on the levels of the individual (e.g. stigma), community (e.g. culture) and facility (e.g. quality of services, distance to access, etc.).

Although PLWH could access to ART without income barriers, the proportion of people receiving late ARV treatment was high. It suggested that HIV-related services should be effectively and efficiently scaled-up, as well as integrated into other health care facilities to improve their accessibility [23]. Integrating ART into other health care services will narrow the distance gap to access to this service, as well as reduce the operational cost of ART clinics, and promote community engagement to support the treatment [17,50]. A review of Suthar et al. (2014) suggests that integrating ART services with other services such as maternal care, tuberculosis, and drug addiction treatment enhanced ART coverage significantly [51].

Given the the dramatic contribution of occupational factors to the inequalities, vocational training and job referrals should be considered as potential interventions along with providing ART services. These have been shown to be effecting in improving HRQOL in Vietnam [9]. Moreover, financial mechanisms such as national subsidies or health insurance schemes should be provided, as they are potentially beneficial for PLWH in reducing income-related inequalities in the access and utilization of ART services.

Third, in addition to the clinical measurements of outcomes such as CD4 cell count and viral load, HRQOL, as well as the capacity for daily living should be used as regular monitoring tools in HIV treatments, especially among poor people. For clinical practice, a meta-analysis of
Bach et al. (year) suggested that during the course of ART treatment, HRQOL measurements were sensitive and responsive to the long-term changes of clinical experience among PLWH, which can help physicians to provide timely support to the patients [8]. For research purposes, longitudinal information from those measurements could serve as a vital indicator for economic and clinical evaluation in the field of HIV/AIDS [8].

To our knowledge, this is the first study that evaluated the socio-economic disparities in ART access, adherence, and outcomes of treatment among PLWH in the context of the concentrated epidemic of HIV in Vietnam. However, several limitations should be taken into consideration. First, the information collected was mainly based on patient self-reporting, which can lead to recall bias or over-/under-estimate the true value of income or HRQOL. To minimize this bias, we used different questions to recheck the information to ensure the reliability of the answers. Second, although viral load is generally more accurate than CD4 cell counts in measuring the effects of ART, it was not utilized in this study. Third, the convenient sampling technique limits the accuracy of the generalization of the entire population. Furthermore, the study utilized cross-sectional design, which does not allow for conclusions regarding the causal relationships among factors. A longitudinal study should be conducted to monitor and measure ART access, adherence, and outcomes of treatment regarding inequity in order to provide more reliable evidence for policy-making. In addition, the SES was measured by income per-capital alone, which lacks a more comprehensive view of the respondents’ SES.

Conclusions
In conclusion, this study revealed the slightly pro-poor inequality in timely ART access, but pro-rich disparities in ARV treatment outcomes, especially in terms of HRQOL measurements. The findings also showed the minor contributions of socio-economic factors to inequality in ART access, adherence, and treatment outcomes among PLWH. These results can contribute to the development of policies geared toward greater equity in HIV care in Vietnam.

Author Contributions

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References

1. Jain MK (2009) Mortality in Patients Coinfected with Hepatitis B Virus and HIV: Could Antiretroviral Therapy Make a Difference? Clinical Infectious Diseases 48: 1772–1774. doi: 10.1086/599111 PMID: 19435435

2. Castelnuovo B, Manabe YC, Kiragga A, Kamya M, Easterbrook P, Kambugu A (2009) Cause-specific mortality and the contribution of immune reconstitution inflammatory syndrome in the first 3 years after antiretroviral therapy initiation in an urban African cohort. Clin Infect Dis 49: 965–972. doi: 10.1086/605500 PMID: 19673615

3. Zwahlen M, Harris R, May M, Hogg R, Costagliola D, de Wolf F, et al. (2009) Mortality of HIV-infected patients starting potent antiretroviral therapy: comparison with the general population in nine industrialized countries. Int J Epidemiol 38: 1624–1633. doi: 10.1093/ije/dyp306 PMID: 19820106

4. UNAIDS (2016) Global AIDS Update 2016. Geneva, Switzerland.

5. Organization WH (2013) Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection: Recommendations for a public health approach. Geneva, Switzerland: World Health Organization.

6. Organization WH (2015) Guideline on when to start antiretroviral therapy and on pre-exposure prophylaxis for HIV. Geneva, Switzerland.

7. Saez-Cirion A, Bacchus C, Hocqueloux L, Avettand-Fenoel V, Girault I, Lecuroux C, et al. (2013) Post-treatment HIV-1 controllers with a long-term virological remission after the interruption of early initiated antiretroviral therapy ANRS VISCONTI Study. PLoS Pathog 9: e1003211. doi: 10.1371/journal.ppat.1003211 PMID: 23516360

8. Tran BX, Nguyen LH, Ohinmaa A, Maher RM, Nong VM, Latkin CA (2015) Longitudinal and cross-sectional assessments of health utility in adults with HIV/AIDS: a systematic review and meta-analysis. BMC Health Serv Res 15: 7. doi: 10.1186/s12913-014-0640-z PMID: 25609449

9. Tran BX, Ohinmaa A, Nguyen LT, Nguyen TA, Nguyen TH (2011) Determinants of health-related quality of life in adults living with HIV in Vietnam. AIDS Care 23: 1236–1245. doi: 10.1080/09540121.2011.555749 PMID: 21713611

10. Tran BX, Nguyen LT, Nguyen NH, Hoang QV, Hwang J (2013) Determinants of antiretroviral treatment adherence among HIV/AIDS patients: a multisite study. Glob Health Action 6.

11. Lodi S, Dray-Spira R, Touloumi G, Braun D, Teira R, D’Arminio Monforte A, et al. (2014) Delayed HIV diagnosis and initiation of antiretroviral therapy: inequalities by educational level, COHERE in EuroCoord. AIDS 28: 2297–2306. doi: 10.1097/QAD.0000000000000410 PMID: 25313585

12. Dray-Spira R, Lert F (2003) Social health inequalities during the course of chronic HIV disease in the era of highly active antiretroviral therapy. AIDS 17: 283–290. doi: 10.1097/01.aids.000002941.55529.da PMID: 12556681

13. Olaleye A, Ogwumike F, Olaniyan O (2013) Inequalities in access to healthcare services among people living with HIV/AIDS in Nigeria. Afr J AIDS Res 12: 85–94. doi: 10.2989/16085906.2013.851718 PMID: 25871378

14. Scott VE, Chopra M, Conrad L, Ntuli A (2005) How equitable is the scaling up of HIV service provision in South Africa? S Afr Med J 95: 109–113. PMID: 15751205

15. Sobrino-Vegaz P, Rodriguez-Urrego J, Berenguer J, Caro-Murillo AM, Blanco JRC, Viciana P, et al. (2012) Educational gradient in HIV diagnosis delay, mortality, antiretroviral treatment initiation and response in a country with universal health care. Antivir Ther 17: 1–8. doi: 10.3851/IMP1939 PMID: 22267463

16. Girardi E, Aloisi MS, Arici C, Pezzotti P, Serraino D, Balzano R, et al. (2004) Delayed presentation and late testing for HIV: demographic and behavioral risk factors in a multicenter study in Italy. J Acquir Immune Defic Syndr 36: 951–959. PMID: 15220702

17. Organization WH (2011) Treatment 2.0: Catalyzing Next Phase of Scale-up, Decentralized, Integrated and Community-Centered Service Delivery. Geneva, Switzerland.

18. Control VAoHA (2016) The annual review of HIV/AIDS control and prevention in the first six months 2016 and action plan in the last six months in 2016. Hanoi.

19. Schmitt JK, Stuckey CP (2004) AIDS—no longer a death sentence, still a challenge. South Med J 97: 329–330. doi: 10.1097/00003188-200405000-00007 PMID: 15108821
20. Mitchell CG, Linsk NL (2004) A multidimensional conceptual framework for understanding HIV/AIDS as a chronic long-term illness. Soc Work 49: 469–477. PMID: 15281702

21. Go Vietnam (2012) Vietnam AIDS Response Progress Report 2012. Hanoi, Vietnam: National Committee for AIDS, Drugs and Prostitution Prevention and Control.

22. Duong AT, Kato M, Bales S, Do NT, Minh Nguyen TT, Thanh Cao TT, et al. (2014) Costing analysis of national HIV treatment and care program in Vietnam. J Acquir Immune Defic Syndr 65: e1–7. doi: 10.1097/QAI.0b013e3182a17d15 PMID: 23846564

23. Posse M, Meheus F, van Asten H, van der Ven A, Baltussen R (2008) Barriers to access to antiretroviral treatment in developing countries: a review. Trop Med Int Health 13: 904–913. doi: 10.1111/j.1365-3156.2008.02091.x PMID: 18466183

24. National Committee for AIDS DaPPaC (2012) National Strategy on HIV/AIDS Prevention and Control toward 2020 and the vision to 2030. Hanoi.

25. Health VMo, Group HP (2013) Joint Annual Health Review 2013: Towards Universal Health Coverage. Hanoi, Vietnam.

26. Lim TW, Frangakis C, Latkin C, Ha TV, Minh NL, Zelaya C, et al. (2014) Community-level income inequality and HIV prevalence among persons who inject drugs in Thai Nguyen, Vietnam. PLoS One 9: e90723. doi: 10.1371/journal.pone.0090723 PMID: 24618892

27. Lim T, Zelaya C, Latkin C, Quan VM, Frangakis C, Ha TV, et al. (2013) Individual-level socioeconomic status and community-level inequality as determinants of stigma towards persons living with HIV who inject drugs in Thai Nguyen, Vietnam. J Int AIDS Soc 16.

28. VAAC VAoHAC (2014) Report on the current situation of HIV infection in 2013. Hanoi, Vietnam.

29. Braveman PA, Cubbin C, Egerter S, Williams DR, Pamuk E (2010) Socioeconomic Disparities in Health in the United States: What the Patterns Tell Us. Am J Public Health 100: S186–196. doi: 10.2105/AJPH.2009.166082 PMID: 20147693

30. Giordano TP, Guzman D, Clark R, Charlebois ED, Bangsberg DR (2004) Measuring adherence to antiretroviral therapy in a diverse population using a visual analogue scale. HIV Clin Trials 5: 74–79. doi: 10.1310/JFXH-G3X2-EYM6-D6UG PMID: 15116282

31. Koblin AB, Sheth NU (2011) Levels of adherence required for virologic suppression among newer antiretroviral medications. Ann Pharmacother 45: 372–379. doi: 10.1345/aph.1P587 PMID: 21386024

32. Tran BX, Ohinmaa A, Nguyen LT (2012) Quality of life profile and psychometric properties of the EQ-5D-5L in HIV/AIDS patients. Health Qual Life Outcomes 10: 132. doi: 10.1186/1477-7525-10-132 PMID: 23116130

33. Group E (2011) EQ-5D-5L User Guide: Basic information on how to use the EQ-5D-5L instrument. Rotterdam, The Netherlands.

34. Wagstaff A, Paci P, van Doorslaer E (1991) On the measurement of inequalities in health. Soc Sci Med 33: 545–557. PMID: 19622226

35. May M, Gompels M, Delpech V, Porter K, Post F, Johnson M, et al. (2011) Impact of late diagnosis and treatment on life expectancy in people with HIV-1: UK Collaborative HIV Cohort (UK CHIC) Study.

36. Phillips A, Pezzotti P (2004) Short-term risk of AIDS according to current CD4 cell count and viral load in antiretroviral drug-naive individuals and those treated in the monotherapy era. Aids 18: 51–58. PMID: 15090829

37. Egger M, May M, Chene G, Phillips AN, Ledergerber B, Dabis F, et al. (2002) Prognosis of HIV-1-infected patients starting highly active antiretroviral therapy: a collaborative analysis of prospective studies. Lancet 360: 119–129. PMID: 12126821

38. Tran DA, Shakeshaft A, Ngo AD, Rule J, Wilson DP, Zhang L, et al. (2012) Structural Barriers to Timely Initiation of Antiretroviral Treatment in Vietnam: Findings from Six Outpatient Clinics. PLoS One 7.

39. equity PfH (2011) HEALTH EQUITY IN VIETNAM: Toward Targets With Equity. Hanoi.

40. Tran BX, Duong AT, Nguyen LT, Hwang J, Nguyen BT, Nguyen QT, et al. (2013) Financial burden of health care for HIV/AIDS patients in Vietnam. Trop Med Int Health 18: 212–218. doi: 10.1111/tmi.12032 PMID: 23210600

41. Turner BJ (2002) Adherence to antiretroviral therapy by human immunodeficiency virus-infected patients. J Infect Dis 185 Suppl 2: S143–151.

42. Rougemont M, Stoll BE, Elia N, Ngang P (2009) Antiretroviral treatment adherence and its determinants in Sub-Saharan Africa: a prospective study at Yaounde Central Hospital, Cameroon. AIDS Res Ther 6: 21. doi: 10.1186/1742-6405-6-21 PMID: 19821997

43. Tran BX, Nguyen LT, Nguyen NH, Hoang QV, Hwang J (2013) Determinants of antiretroviral treatment adherence among HIV/AIDS patients: a multisite study. Glob Health Action 6: 19570. doi: 10.3402/gha.v6i0.19570 PMID: 23497956
44. Montarroyos UR, Miranda-Filho DB, Cesar CC, Souza WV, Lacerda HR, Albuquerque Mde F, et al. (2014) Factors related to changes in CD4+ T-cell counts over time in patients living with HIV/AIDS: a multilevel analysis. PLoS One 9: e84276. doi: 10.1371/journal.pone.0084276 PMID: 24505247

45. Tran BX (2012) Quality of life outcomes of antiretroviral treatment for HIV/AIDS patients in Vietnam. PLoS One 7: e41062. doi: 10.1371/journal.pone.0041062 PMID: 22911742

46. Entezar Mahdi R, Majdzadeh R, Foroughshahi AR, Nasehi M, Lameei A, Naieni KH (2014) Inequality of leprosy disability in Iran, clinical or socio-economic inequality: an extended concentration index decomposition approach. Int J Prev Med 5: 414–423. PMID: 24829728

47. Sozmen K, Unal B (2014) Socioeconomic Inequalities in Non-Communicable Diseases and Self Assessed Health in Turkey. Iran J Public Health 43: 736–748. PMID: 26110144

48. Alaba O, Chola L (2014) Socioeconomic inequalities in adult obesity prevalence in South Africa: a decomposition analysis. Int J Environ Res Public Health 11: 3387–3406. doi: 10.3390/ijerph110303387 PMID: 24662998

49. Van Tam V, Pharris A, Thorson A, Alfven T, Larsson M (2011) "It is not that I forget, it's just that I don't want other people to know": barriers to and strategies for adherence to antiretroviral therapy among HIV patients in Northern Vietnam. AIDS Care 23: 139–145. doi: 10.1080/09540121.2010.507741 PMID: 21259125

50. Duong BD (2011) Adapting Treatment 2.0 in Vietnam—Towards universal and sustainable access.

51. Suthar AB, Rutherford GW, Horvath T, Doherty MC, Negussie EK (2014) Improving antiretroviral therapy scale-up and effectiveness through service integration and decentralization. AIDS 28 Suppl 2: S175–185.