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Superior Outcomes and Lower Outpatient Costs with Scale-up of Antiretroviral Therapy at the GHESKIO Clinic in Port-au-Prince, Haiti

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Abstract

Background—Treatment protocols and prices of antiretroviral therapy (ART) have changed over time. Yet limited data exist to evaluate the impact of these changes on patient outcomes and treatment costs in resource-poor settings.

Methods—We compared patient-level data on outcomes, utilization, and cost for the first two years of ART for a cohort of adult patients initiating ART in 2003–2004 and a cohort initiating ART in 2006–2008 at the GHESKIO clinic in Port-au-Prince, Haiti. Costs were measured from the health center perspective. Multivariate analyses were conducted to account for the potential impact of differences in disease severity at baseline.

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Results—With the exclusion of patients who transferred care, 92% (167/181) of patients in the 2006–2008 cohort and 75% (150/200) in the 2003–2004 cohort were alive and in-care at the end of the study period. The mean cost per patient for the two-year study period was US$723 for the 2006–2008 cohort vs. US$1,191 for the 2003–2004 cohort, a cost difference of US$468 ($p<0.0001$). The mean cost per patient alive and in-care at the end of the two-year study period was US$744 for the 2006–2008 cohort vs. US$1,489 for the 2003–2004 cohort ($p<0.0001$).

Conclusions—HIV treatment outcomes in Haiti have improved over time while treatment costs declined by over 50% per patient alive and in-care at the end of the two-year study period. The major drivers in the reduction of treatment costs were the lower price of ART, lower costs for laboratory testing, and lower overhead costs.

Keywords

HIV; AIDS; cost; outcomes; antiretroviral therapy; Haiti

INTRODUCTION

The number of people on antiretroviral therapy (ART) for HIV in low- and middle-income countries increased to about eight million by the end of 2011, out of approximately 14.8 million people who were eligible for treatment [1, 2]. Though ART scale-up is viewed as widely successful, future levels of international aid remain uncertain [3]. With increasing budgetary constraints, reductions in treatment costs may determine the feasibility of providing universal coverage for patients who qualify for ART [2]. Several studies have evaluated HIV treatment costs in resource-poor settings [4–15]. However, ART prices and treatment protocols have changed over time, yet data are limited on the impact of these changes on patient outcomes and treatment costs [9, 13, 16].

Over the last decade, ART prices in resource-poor settings have declined substantially. The mean purchase price of the ten highest-volume ART medications in President's Emergency Plan for AIDS Relief (PEPFAR) programs decreased by 42% from 2005 to 2008 [7]. Laboratory protocols have also changed over time. The DART (Development of Antiretroviral Therapy in Africa) trial conducted in Uganda and Zimbabwe found no rationale for routine costly monitoring for ART-related toxicity because these tests failed to affect outcomes [17, 18]. We reached similar conclusions in a study we conducted in Haiti [19]. Others have demonstrated that less frequent CD4 cell monitoring can be cost-saving, without reducing life expectancy [17, 20]. To conserve financial and human resources, some HIV programs have decreased the frequency of ART visits or shifted tasks from physicians to nurses and other providers [21–25].

To evaluate trends in quality and cost of treatment in Haiti over time, we compared patient outcomes, health care utilization, and cost for the first two years of HIV treatment in a cohort initiating ART at the Haitian Group for the Study of Kaposi's Sarcoma and Opportunistic Infections (GHESKIO) in 2003 and 2004 and a cohort initiating ART from 2006 to 2008.

METHODS

Study Setting, Patients, and Treatment Protocols

GHESKIO is the largest provider of HIV treatment services in the Caribbean. In March 2003, GHESKIO began providing ART free-of-charge for all patients meeting World Health Organization (WHO) criteria, which at the time of this study included patients with CD4 cell count <200 cells/mm^3 or an AIDS-defining condition [26]. By the end of 2006, about 1400 patients had been started on ART at GHESKIO; by the end of 2008, this had increased to over 4,000 patients, and by end of 2010, over 7500 patients had initiated ART [27].

We compared outcomes, utilization and cost of all health services between the two cohorts from the health center perspective for the first two years of ART. The earlier cohort included 218 ART-naïve adults (age >17 years) consecutively initiated on ART at GHESKIO from December 23, 2003 to May 20, 2004. The cost of the first year of treatment for this cohort has been published previously [10]. The later cohort included 186 randomly selected ART-naïve adults (age >17 years) who were started on ART at GHESKIO from January 12, 2006 to December 19, 2008; data for this cohort were collected as part of a separate costing analysis of HIV treatment in Haiti conducted by the Health Systems 20/20 Project, funded by the United States Agency for International Development (USAID).

For both cohorts, first-line ART included efavirenz or nevirapine. In the 2003–2004 cohort, clinic visits were scheduled monthly. For the 2006–2008 cohort, visit frequency in the second year was reduced to every second or third month among clinically stable patients. At each visit, patients were seen by a physician or nurse and by a pharmacist who dispensed ART and provided adherence counseling. Additional counseling was provided by a social worker upon referral by a clinician.

Laboratory testing protocols for the 2003–2004 cohort included CD4 cell count, complete blood count (CBC), creatinine, liver function tests, and glucose prior to ART initiation, and at six-month intervals in follow-up for patients on ART. In the 2006–2008 cohort, CD4 cell count was done at baseline, and then annually, with other tests conducted only as clinically indicated.

Outcomes, Utilization and Cost of Services

To determine treatment outcomes, we calculated the proportion of patients who were alive and in-care, lost to follow-up (LTFU), or dead at the end of the two-year study period, after excluding patients who were transferred to other clinics. We determined health care services utilized at GHESKIO from the day of initiation through the first two years of ART for all patients in each cohort.

Cost estimates were obtained using the micro-costing approach described by Drummond et al. in which a unit cost was applied to each component of health care utilized (see Table 1) [28]. All costs are reported in 2010 US dollars. Costs for the 2003–2004 cohort were inflated to 2010 US dollars using the medical care component of the US consumer price index.

Medication use was extracted from the GHESKIO electronic medical record. Medication doses and start and stop dates were recorded for ART and TB medications. For other medications, we used standard doses provided by the GHESKIO staff. We obtained the cost of ART medications for Haiti from the WHO Global Price Reporting Index [29]. The cost for TB medications was set at the price of the International Dispensary Association (IDA), a non-profit distributer, plus 20% for importing and storage fees [30]. Other medications were purchased from non-profit and local distributors in an approximately equal ratio, so the cost was set at the average of IDA and local prices. All laboratory tests were conducted in the GHESKIO lab and documented in the medical records. The unit cost for each laboratory test had previously been calculated by GHESKIO accounting staff, and included reagents, equipment, and labor, as has been documented in prior publications [19, 31].

Labor costs were assigned for each visit date based on the type of service, average visit duration, and hourly labor cost, using GHESKIO annual salaries for each job category. The same method was used to calculate labor costs for the 2003–2004 and 2006–2008 cohorts. As previously described, the average duration of each service was determined by time and motion studies for HIV physician (15 minutes), nurse (18 minutes), pharmacist (8 minutes), and counseling visits (20 minutes) [31]. Physician visit duration was increased by 50% to account for follow-up activities such as chart documentation and phoning patients [10, 31].

Overhead costs included labor for administrative staff, electricity and gas, building maintenance and security, phone and communication, computers, and furniture and office supplies. These were allocated to each visit from actual expenditures based on clinic volume (adjusted for the duration of patient visits), and square footage, as in previous GHESKIO costing studies [10, 31].

Unadjusted Analysis

Each of the resources utilized by each patient during the two-year study period was multiplied by its unit cost and summed to yield total cost for the 2003–2004 and 2006–2008 cohorts. The total costs for each cohort were divided by the number of patients in the cohort to determine the mean cost per patient. We also calculated the mean cost per month that patients were alive and in-care. Finally, we calculated the cost per patient alive and in-care at the end of the two-year study period excluding patients transferred during the study period.

Differences between the two cohorts in age, gender, education, income, baseline weight, baseline CD4 cell count, and initial ART regimen were compared using the Chi-square test for binary variables and Wilcoxon rank-sum test for continuous variables. Differences in costs were compared using the Wilcoxon rank-sum tests to account for potential skewness. Total facility-level cost components included overhead, labor, laboratory tests, chest radiographs, medications, and transportation subsidies. Costs were not discounted given the short time period of the study.

Adjusted Analysis

As a sensitivity analysis, multivariate analyses were conducted to account for the potential impact of significant baseline differences in characteristics across cohorts on the cost of

treatment; variables with statistically different baseline mean values (p-value ≤ 0.05) were included in the multivariate model. Generalized linear models, assuming a normal distribution and identity link function, were run for the first year, second year and two-year study period on the total costs and each cost component, as well as the number of days on ART. Robust standard errors were reported.

RESULTS

The 2003–2004 cohort included 218 patients who initiated ART from December 23, 2003 to May 20, 2004 and were followed for up to two years; the last day in the study period was May 19, 2006. The 2006–2008 cohort was also studied for up to two years and included 186 patients who initiated ART from January 12, 2006 to December 19, 2008; the last day in the study period for the follow-up cohort was December 18, 2010. Baseline cohort characteristics are presented in Table 2. Age, gender, income, and baseline CD4 cell count were not significantly different across cohorts. In the 2006–2008 cohort, fewer patients had no school or primary school only (40% vs. 56%; p=0.0016). They also had heavier median baseline weight (51 vs. 48 kg; p=0.0241 for women and 59 vs. 56 kg; p=0.0190 for men). First-line regimens in the 2006–2008 cohort were more likely to include efavirenz (59% vs. 46%; p=0.0107) and less likely to include nevirapine (37% vs. 54%; p=0.0004).

The proportion of patients alive and in-care at the end of the study period was 92% (167 of 181) in the 2006–2008 cohort and 75% (150 of 200) in the 2003–2004 cohort, after excluding patients who transferred to other clinics (5 in the 2006–2008 and 18 in the 2003–2004 cohort). Four patients (2%) died in the 2006–2008 cohort, and 10 (6%) were LTFU. Forty-five patients (23%) died in the 2003–2004 cohort, and five (2%) were LTFU. As a result, the mean number of days in care for the two-year study period was about 20% longer for the 2006–2008 cohort (695 versus 575 days; p<0.0001).

Utilization and Cost for the First Year of Treatment

The mean cost for the first year of treatment was US$439 for the 2006–2008 cohort and US $608 for the 2003–2004 cohort, a difference of US$169 (p<0.0001). The 2006–2008 cohort had more days in care during the first year of treatment (357 vs. 305 days; p<0.0001), and the cost per month alive and in-care dropped by over 40% compared with the 2003–2004 cohort (US$37 vs. US$64; p<0.0001). The price of ART declined over time resulting in first year mean ART costs of US$157 in the 2006–2008 cohort and US$254 in the 2003–2004 cohort, a difference of US$97 (p<0.0001). The cost of ART per month alive and in-care was 50% lower in the 2006–2008 cohort (US$13 vs. US$26; p<0.0001). See Table 4 for the cost of the first year of treatment, and Table 5 for the cost of treatment per month alive and in-care.

The first year utilization and prices of laboratory tests were lower in the 2006–2008 cohort. The cost of laboratory testing was US$78 in the 2006–2008 cohort and US$125 for the 2003–2004 cohort, a cost difference of US$47 (p<0.0001). This decline was due to lower costs for some laboratory tests and less frequent testing for ART-associated toxicity and CD4 cell count for the 2006–2008 cohort.

Both cohorts had a mean number of 12 HIV visits during the first year of treatment. Total labor costs were higher in the 2006–2008 cohort (US$65 vs. US$58; p<0.0001), due to a greater proportion of physician visits (instead of nurse visits). Even so, the 2006–2008 cohort had lower overhead costs (US$80 vs. US$99), as the costs of building maintenance and security, generator fuel, and storage of medications were divided by a larger patient population as the number of patients receiving HIV care at GHESKIO increased over time.

Utilization and Cost for the Second Year of Treatment

The mean cost for the second year of treatment was US$297 for the 2006–2008 cohort, and US$752 for the 2003–2004 cohort, a difference of US$455 (p<0.0001). This cost difference was larger than the first year of treatment (see Table 4). The mean number of days in care for the second year was similar across cohorts (344 vs. 347 days, p=0.5812).

ART costs for the second year of treatment were lower in the 2006–2008 cohort (US$143 vs. US$373; p<0.0001). The total cost of laboratory testing for the 2006–2008 cohort was about one-fourth that of the 2003–2004 cohort (US$43 vs. US$180; p<0.0001). The 2006–2008 cohort also had fewer HIV visits than the 2003–2004 cohort during the second year of treatment (7 vs. 12 visits). As a result, total labor costs were lower in the 2006–2008 cohort (US$31 vs. US$52; p<0.0001). Overhead costs in the 2006–2008 cohort were reduced by over half, compared to the 2003–2004 cohort (US45 vs. US$101; p<0.0001) due to fewer visits and lower overhead costs per visit.

Cost of Treatment for the Two-Year Study Period

The mean total cost of treatment per patient for the two-year study period was US$723 for the 2006–2008 cohort and US$1,191 for the 2003–2004 cohort, a difference of US$468 (p<0.0001). The cost per patient alive and in-care at the end of the study period for the 2006–2008 cohort (US$786) was less than 50% that of the 2003–2004 cohort (US$1,588).

The mean cost of ART per patient for the two-year study period was US$293 in the 2006–2008 cohort and US$544 in the 2003–2004 cohort, a difference of US$251 (p<0.0001). The total cost of laboratory testing per patient was US$118 for the 2006–2008 cohort and US $264 for the 2003–2004 cohort, a cost difference of US$146 (p<0.0001). The mean number of HIV visits per patient was 19 in the 2006–2008 cohort and 22 in the 2003–2004 cohort, (p<0.0001), resulting in a lower total cost of labor. Overhead costs were also lower in the 2006–2008 cohort, compared with the 2003–2004 cohort (US$123 vs. US$177; p<0.0001).

Sensitivity Analyses

We conducted sensitivity analyses to evaluate the impact of differences in baseline variables on treatment costs. The baseline comparison showed that education, weight, and first-line ART regimen were all statistically significantly different (p<0.05) across cohorts (see Table 2); these variables were included in the multivariate analysis. The multivariate analysis using the generalized linear model showed that the total health system cost of treatment in the 2006–2008 cohort remained significantly lower than the 2003–2004 cohort in both the first and the second year with an adjusted difference in total treatment cost of US$196 (95% confidence interval [CI]: US$154 to US$238; p<0.0001) per patient for the first year and US

$485 (95% confidence interval [CI]: US$444 to US$527; p<0.0001) per patient for the second year (see Table 4); the adjusted difference per month alive and in-care was US$29 (95% CI: US$25 to US$32; p<0.0001) for the first year and US$42 (95% CI: US$38 to US $46; p<0.0001) for the second year of treatment (see Table 5). The confidence intervals of the point estimates from the adjusted analyses on first and second year treatment costs as well as costs per month alive and in-care cover the point estimates from the corresponding unadjusted analyses.

DISCUSSION

The use of HIV services has changed over time. Per patient treatment costs have been reduced, and this has been associated with an improvement in treatment outcomes. Ninety-two percent of patients who initiated ART from 2006 to 2008 were alive and in-care at two years after ART initiation, compared with 75% of those who initiated ART from 2003 to 2004. This outcome is comparable to that of GHESKIO patients enrolled in research studies and to that of the best academic centers in the United States [32]. Though the 2006–2008 cohort had about 20% more days in care, the total cost of treatment for the two-year study period was nearly 40% lower than the 2003–2004 cohort. The cost per patient alive and in-care at the end of the study period in the 2006–2008 cohort was less than half that of the 2003–2004 cohort (US$786 vs. US$1,588). The cost reductions were mainly due to lower ART prices, lower laboratory testing costs, and lower overhead costs due to fewer visits and lower overhead costs per visit.

The largest decrease in overall cost was due to the near 50% reduction in ART costs in the 2006–2008 cohort, compared with the 2003–2004 cohort. Our finding reflects the decreased purchase price for ART in other PEPFAR programs [7]. Even with these reductions, ART still comprised about 40% of the total cost of treatment in the 2006–2008 cohort. Further cost reductions are anticipated in the future through the use of alternative sources of raw materials, streamlining production, and innovations in product formulation [33].

Reductions in costs for laboratory testing also contributed to the drop in treatment costs. Multiple studies have demonstrated that routine laboratory monitoring for ART-related toxicity has minimal clinical impact and is not cost effective [17–19]. Others have demonstrated that reducing the frequency of CD4 cell monitoring can be cost saving, without reducing life expectancy [20]. In response, the GHESKIO clinic protocol changed from routinely monitoring for ART-related toxicity with chemistry and hematology panels every six months, to testing only those patients with symptoms of toxicity; CD4 cell testing for clinically stable patients was reduced from every six months to annually.

Though viral load testing has been shown to improve long-term outcomes, and to be cost-effective for use in resource-poor settings, we conducted very few viral load tests due to lack of funding [20]. Most other low-income countries also lack resources to regularly monitor viral load. Even though our outcomes in the 2006–2008 cohort are superior over the two-year time horizon of our study, better long-term outcomes may result if viral load tests are performed. This would help early identification and intervention for non-adherent patients as well as earlier detection of virologic failure [20, 34, 35].

There were fewer ART visits during the second year of treatment in the 2006–2008 cohort. Some countries routinely see ART patients even less frequently, at quarterly or semi-annual intervals [21, 25]. Task shifting from physicians to nurses and other providers would likely save additional resources without compromising patient outcomes [21–24]. We did not have sufficient nurses to widely implement this strategy during the study period, but nurse training in Haiti is a high priority [36]. A specialized program for nurses (SNP) has been put in place at GHESKIO in collaboration with Quisqueya University, focusing on HIV, tuberculosis and nutrition. At present, about 50% of HIV-infected patients are seen by SNP at GHESKIO, further reducing the care cost [36].

We attribute our high rate of retention in care, in part, to the transportation subsidies provided to patients in both cohorts, which should continue despite fiscal constraints. Numerous studies have reported that transportation costs are a barrier to retention in care for patients on ART and that low cost interventions can improve retention in ART care [37–39].

This is the first study to report the change in patient-level HIV treatment outcomes and costs for the first two years of HIV treatment in a resource-poor setting. We found that factors such as lower ART prices, lower utilization of laboratory tests, and lower overhead costs with ART scale-up have resulted in a substantial decrease in the cost of HIV treatment, even though outcomes improved over time. Other studies have reported that rapid cost reductions in the first one to two years following the introduction of ART treatment in a clinic can occur if expenditures are monitored and program efficiency reviewed [9, 13].

Some sites have lowered costs beyond those we report from Haiti. Larson et al. report HIV treatment costs of only about $US20 per month from three sites in Kenya [11]. The ART regimen provided to the patients in the Kenyan study (stavudine/lamivudine/nevirapine) cost only US$28 per year, but is associated with a high rate of toxicity [24]. Using tenofivir in place of stavudine in the first-line regimen improves survival and is cost-effective by international standards [40]. Kenyan guidelines now recommend the use of tenofovir/lamivudine/efavirenz at a cost of approximately US$172 per year [11, 26]. The Kenyan sites also reported very low costs for laboratory testing, ranging from US$29 to US$36 per patient, with no radiology studies. One-year retention in care in the Kenya studies (82%) is comparable with other resource-poor settings. A Nigerian costing study also reported very low laboratory costs of US$10 during the first year of ART, with no reported outcomes [4]. Further study is needed to evaluate potential long-term consequences of these treatment strategies.

Our study had several limitations. It is a single site study from a large urban clinic. It did not include the cost of hospitalization, though this was a minor cost in other GHESKIO studies [10, 31]. Although previous literature suggests that baseline demographics and treatment characteristics may impact both cost and outcomes, the adjusted results confirm the findings of the unadjusted analysis and indicate that differences in costs between the two cohorts remain irrespective of observed differences in ART regimen, education and weight at baseline [4, 10, 41, 42].

In conclusion, we found that ART outcomes have improved over time while costs per patient have declined dramatically. Costing analyses were important in evaluating potential areas for cost savings. The major drivers in the reduction of treatment costs were the lower price of ART, lower costs for laboratory testing, and lower overhead costs.

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Table 1

Unit Costs

Cost	2006–2008 Cohort (2010 US$)	2003–2004 Cohort (2006 US$)
ART and TB medications (monthly cost)		
First-line ART		
Efavirenz and zidovudine/lamivudine	13	31
Nevirapine and zidovudine/lamivudine	11	17
Second-line ART (abacavir, tenofovir, and lopinavir/ritonavir	62	122
Laboratory and other tests (cost per test)		
ALT and AST (combined)	10	14
Creatinine	5	7
Complete blood count	5	11
CD4 cell count	30	30
Viral Load Test	150	150
Chest radiograph	35	24
Labor costs (per visit)		
Physician	4	4
Nurse	1	1
Pharmacist	1	1
Social worker	1	1
Overhead (per physician visit)	6	7

Table 2

Patient Characteristics at Baseline

	2006–2008 Cohort (n=186)	2003–2004 Cohort (n=218)	p-value
Age – median (IQR)	39 (30, 47)	40 (34, 47)	0.2686
Female gender – no. (%)	94 (51)	122 (56)	0.2371
No school or primary only – no. (%)	74 (40)	121 (56)	0.0016
Income <US$ 1 per day	110 (59)	147 (67)	0.0637
Weight (kg) – median (IQR)			
Females	51 (45, 61)	48 (43, 56)	0.0241
Males	59 (52, 65)	56 (49, 61)	0.0190
CD4 cell count – median (IQR)	116 (53, 179)	108 (40, 180)	0.3588
Initial ART Regimen – no. (%)			
Includes efavirenz	109 (59)	100 (46)	0.0107
Includes nevirapine	68 (37)	118 (54)	0.0004
Other	9 (5)	0 (0)	0.0008

Table 3

Health Care Utilization Per Patient

First Year of Antiretroviral Therapy					
	2006–2008 Cohort (n=186)		**2003–2004 Cohort (n=218)**		**p-value**
	Mean Utilization (95% CI)	**Median Utilization (IQR)**	**Mean Utilization (95% CI)**	**Median Utilization (IQR)**	
Number of days in care	356.9 (290.4, 423.4)	365.0 (365.0, 365.0)	304.6 (69.6, 539.6)	365.0 (365.0, 365.0)	<0.0001
Laboratory Tests					
ALT and AST	1.3 (0.0, 3.1)	1.0 (1.0, 2.0)	1.5 (0.0, 3.0)	2.0 (1.0, 2.0)	0.0007
Creatinine	1.3 (0.0, 3.1)	1.0 (1.0, 2.0)	1.5 (0.0, 3.0)	2.0 (1.0, 2.0)	0.0007
Complete blood counts	1.2 (0.0, 2.9)	1.0 (1.0, 2.0)	1.2 (0.0, 2.8)	1.0 (1.0, 2.0)	0.8983
CD4 cell counts	1.2 (0.0, 2.6)	1.0 (1.0, 2.0)	1.0 (0.0, 2.3)	1.0 (1.0, 1.0)	<0.0001
Viral load tests	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	1.0000
Chest radiographs	0.1 (0.0, 1.0)	0.0 (0.0, 0.0)	0.4 (0.0, 1.7)	0.0 (0.0, 1.0)	<0.0001
HIV Visits					
Total HIV visits	11.8 (5.6, 18.0)	12.0 (10.0, 14.0)	12.0 (2.1, 21.9)	13.0 (10.0, 15.0)	0.0013
Physician ART visits	9.8 (3.6, 16.0)	10.0 (8.0, 11.0)	5.1 (0.0, 11.5)	4.0 (3.0, 7.0)	<0.0001
Nurse ART visits	3.0 (0.0, 6.6)	3.0 (1.0, 4.0)	7.9 (0.0, 16.6)	9.0 (5.0, 11.0)	<0.0001
Pharmacist ART visits	11.8 (5.6, 18.0)	12.0 (10.0, 14.0)	12.0 (2.1, 21.9)	13.0 (10.0, 15.0)	0.0013

Second Year of Antiretroviral Therapy					
	2006–2008 Cohort (n=178)*		**2003–2004 Cohort (n=169)***		**p-value**
	Mean Utilization (95% CI)	**Median Utilization (IQR)**	**Mean Utilization (95% CI)**	**Median Utilization (IQR)**	
Number of days in care	343.6 (204.7, 482.5)	365.0 (365.0, 365.0)	347.0 (228.8, 465.1)	365.0 (365.0, 365.0)	0.5812
Laboratory Tests					
ALT and AST	0.4 (0.0, 1.8)	0.0 (0.0, 1.0)	1.8 (0.2, 3.5)	2.0 (1.0, 2.0)	<0.0001
Creatinine	0.4 (0.0, 1.8)	0.0 (0.0, 1.0)	1.8 (0.1, 3.4)	2.0 (1.0, 2.0)	<0.0001
Complete blood counts	0.8 (0.0, 2.6)	1.0 (0.0, 1.0)	2.1 (0.4, 3.7)	2.0 (2.0, 3.0)	<0.0001
CD4 cell counts	0.9 (0.0, 2.5)	1.0 (0.0, 2.0)	2.0 (0.4, 3.6)	2.0 (2.0, 2.0)	<0.0001
Viral load tests	0.0 (0.0, 0.2)	0.0 (0.0, 0.0)	0.00 (0.0, 0.0)	0.0 (0.0, 0.0)	0.3327
Chest radiographs	0.0 (0.0, 0.5)	0.0 (0.0, 0.0)	0.1 (0.0, 0.8)	0.0 (0.0, 0.0)	0.0766

Second Year of Antiretroviral Therapy					
	2006–2008 Cohort (n=178)*		**2003–2004 Cohort (n=169)***		**p-value**
	Mean Utilization (95% CI)	**Median Utilization (IQR)**	**Mean Utilization (95% CI)**	**Median Utilization (IQR)**	
HIV Visits					
Total HIV visits	7.2 (0.1, 14.2)	7.0 (4.0, 10.0)	12.2 (6.2, 18.2)	13.0 (12.0, 14.0)	<0.0001
Physician ART visits	4.5 (0.0, 10.4)	4.0 (2.0, 7.0)	5.2 (0.2, 10.1)	5.0 (4.0, 6.0)	0.0110
Nurse ART visits	2.6 (0.0, 6.9)	3.0 (0.0, 4.0)	7.1 (2.0, 12.2)	8.0 (6.0, 9.0)	<0.0001
Pharmacist ART visits	7.2 (0.1, 14.2)	7.0 (4.0, 10.0)	12.2 (6.2, 18.2)	13.0 (12.0, 14.0)	<0.0001

Table 4

Treatment Cost per Patient per Year in Care – US$ 2010

First Year of Antiretroviral Therapy							
	Mean Cost (95% CI)		**Unadjusted**		**Adjusted**		
	2006–2008 Cohort (n=186)	**2003–2004 Cohort (n=218)**	**Cost Difference**	**p-value**	**Cost Difference**	**95% CI**	**p-value**
Medications							
ART	157 (19, 294)	254 (0, 535)	−97	<0.0001	−122	(−142, −101)	<0.0001
Non-ART medications	47 (0, 100)	51 (0, 145)	−4	0.1548	−4	(−12, 3)	0.2562
Total medication costs	204 (47, 361)	306 (0, 631)	−102	<0.0001	−126	(−150, −101)	<0.0001
Laboratory Tests							
ART Toxicity Monitoring	25 (0, 57)	52 (2, 102)	−26	<0.0001	−28	(−32, −24)	<0.0001
CD4 cell counts	37 (0, 78)	33 (0, 79)	4	0.0098	4	(0, 8)	0.0686
Total Lab Costs	78 (0, 155)	125 (0, 253)	−47	<0.0001	−50	(−61, −40)	<0.0001
Chest radiographs	5 (0, 36)	11 (0, 47)	−7	<0.0001	−6	(−10, −2)	0.0032
Labor Costs							
Physician	44 (18, 69)	29 (0, 60)	15	<0.0001	16	(13, 19)	<0.0001
Nurse	4 (0, 9)	14 (0, 32)	−10	<0.0001	−11	(−12, −10)	<0.0001
Pharmacist	13 (7, 20)	12 (2, 22)	1	0.0931	1	(0, 2)	0.0187
Total labor	65 (32, 97)	58 (6, 110)	6	<0.0001	7	(2, 11)	0.0035
Overhead	80 (41, 119)	99 (18, 181)	−19	<0.0001	−20	(26, −13)	<0.0001
Transportation subsidies	7 (4, 11)	9 (2, 16)	−1	<0.0001	−1	(−2, −1)	<0.0001
Total health system cost	439 (190, 688)	608 (72, 1143)	−169	<0.0001	−196	(−238, −154)	<0.0001

Second Year of Antiretroviral Therapy							
	Mean Cost (95% CI)		**Unadjusted**		**Adjusted**		
	2006–2008 Cohort (n=178)	**2003–2004 Cohort (n=169)**	**Cost Difference**	**p-value**	**Cost Difference**	**95% CI**	**p-value**
Medications							
ART	143 (0, 312)	373 (10, 736)	−231	<0.0001	−257	(−286, −229)	<0.0001
Non-ART medications	30 (0, 68)	34 (0, 86)	−4	0.6603	−5	(−10, 1)	0.0952
Total medication costs	172 (0, 361)	407 (35, 779)	−235	<0.0001	−262	(−292, −232)	<0.0001

Second Year of Antiretroviral Therapy							
	Mean Cost (95% CI)		**Unadjusted**		**Adjusted**		
	2006–2008 Cohort (n=178)	**2003–2004 Cohort (n=169)**	**Cost Difference**	**p-value**	**Cost Difference**	**95% CI**	**p-value**
Laboratory Tests							
ART Toxicity Monitoring	10 (0, 37)	70 (15, 125)	−60	<0.0001	−60	(−65, −56)	<0.0001
CD4 cell counts	28 (0, 76)	69 (14, 124)	−41	<0.0001	−41	(−47, −35)	<0.0001
Total Lab Costs	43 (0, 124)	180 (48, 313)	−138	<0.0001	−138	(−151, −126)	<0.0001
Chest radiographs	1 (0, 17)	3 (0, 23)	−1	0.0868	−2	(−4, 0)	0.0243
Labor Costs							
Physician	18 (0, 42)	25 (1, 49)	−7	<0.0001	−7	(−10, −4)	<0.0001
Nurse	3 (0, 9)	12 (3, 21)	−9	0.7465	−9	(−10, −8)	<0.0001
Pharmacist	8 (0, 15)	12 (6, 19)	−5	<0.0001	−5	(−6, −4)	<0.0001
Total labor	31 (0, 64)	52 (23, 82)	−21	<0.0001	−22	(−25, −18)	<0.0001
Overhead	45 (1, 88)	101 (51, 150)	−56	<0.0001	−57	(−62, −52)	<0.0001
Transportation subsidies	5 (0, 9)	9 (5, 13)	−4	<0.0001	−4	(−5, −4)	<0.0001
Total health system cost	297 (0, 598)	752 (297, 1207)	−455	<0.0001	−485	(−527, −444)	<0.0001

Table 5

Treatment Cost per Patient per Month Alive and In-Care – US$ 2010

First Year of Antiretroviral Therapy							
	Mean Cost (95% CI)		**Unadjusted**		**Adjusted**		
	2006–2008 Cohort (n=186)	**2003–2004 Cohort (n=218)**	**Cost Difference**	**p-value**	**Cost Difference**	**95% CI**	**p-value**
Medications							
ART	13 (2, 25)	26 (4, 48)	−13	<0.0001	−15	(−16, −13)	<0.0001
Non-ART medications	4 (0, 8)	6 (0, 20)	−2	0.3208	−2	(−3, −1)	0.0004
Total medication costs	17 (4, 30)	32 (4, 60)	−15	<0.0001	−16	(−18, −14)	<0.0001
Laboratory Tests							
ART Toxicity Monitoring	2 (0, 5)	5 (0, 14)	−3	<0.0001	−3	(−4, −3)	<0.0001
CD4 cell counts	3 (0, 7)	3 (0, 9)	0	0.0207	0	(0, 1)	0.8448
Total Lab Costs	7 (0, 14)	13 (0, 33)	−7	<0.0001	−7	(−8, −5)	<0.0001
Chest radiographs	0 (0, 3)	2 (0, 9)	−1	<0.0001	−1	(−2, −1)	<0.0001
Labor Costs							
Physician	4 (1, 6)	4 (0, 10)	0	<0.0001	0	(0, 1)	0.8009
Nurse	0 (0, 1)	1 (0, 3)	−1	<0.0001	−1	(−1, −1)	<0.0001
Pharmacist	1 (0, 2)	1 (1, 2)	0	0.0281	0	(−1, 0)	0.0054
Total labor	6 (2, 9)	7 (0, 13)	−1	0.1525	−1	(−2, −1)	<0.0001
Overhead	7 (3, 11)	10 (5, 15)	−3	<0.0001	−3	(−4, −3)	<0.0001
Transportation subsidies	1 (0, 1)	1 (0, 1)	0	<0.0001	0	(0, 0)	<0.0001
Total health system cost	37 (15, 59)	64 (17, 112)	−27	<0.0001	−29	(−32, −25)	<0.0001

Second Year of Antiretroviral Therapy							
	Mean Cost (95% CI)		**Unadjusted**		**Adjusted**		
	2006–2008 Cohort (n=178)	**2003–2004 Cohort (n=169)**	**Cost Difference**	**p-value**	**Cost Difference**	**95% CI**	**p-value**
Medications							
ART	13 (0, 35)	33 (2, 65)	−20	<0.0001	−22	(−25, −19)	<0.0001
Non-ART medications	3 (0, 6)	3 (0, 8)	0	0.6357	−1	(−1, 0)	0.034
Total medication costs	16 (0, 39)	36 (3, 69)	−20	<0.0001	−22	(−26, −19)	<0.0001

Second Year of Antiretroviral Therapy							
	Mean Cost (95% CI)		**Unadjusted**		**Adjusted**		
	2006–2008 Cohort (n=178)	**2003–2004 Cohort (n=169)**	**Cost Difference**	**p-value**	**Cost Difference**	**95% CI**	**p-value**
Laboratory Tests							
ART Toxicity Monitoring	1 (0, 4)	6 (0, 14)	−5	<0.0001	−5	(−6, −5)	<0.0001
CD4 cell counts	3 (0, 8)	6 (0, 13)	−4	<0.0001	−4	(−4, −3)	<0.0001
Total Lab Costs	4 (0, 14)	16 (0, 35)	−12	<0.0001	−12	(−14, −11)	<0.0001
Chest radiographs	0 (0, 2)	0 (0, 2)	0	0.0869	0	(0, 0)	0.0376
Labor Costs							
Physician	2 (0, 4)	2 (0, 5)	−1	<0.0001	−1	(−0.85, −0.32)	<0.0001
Nurse	0.30 (0, 1)	1.03 (0, 2)	−1	<0.0001	−1	(−1, −1)	<0.0001
Pharmacist	1 (0, 1)	1 (1, 2)	0	<0.0001	0	(0, 0)	<0.0001
Total labor	3 (0, 6)	5 (2, 7)	−2	<0.0001	−2	(−2, −2)	<0.0001
Overhead	4 (0, 8)	9 (5, 12)	−5	<0.0001	−5	(−5, −4)	<0.0001
Transportation subsidies	0 (0, 1)	1 (0, 1)	0	<0.0001	0	(0, 0)	<0.0001
Total health system cost	27 (0, 60)	67 (25, 109)	−40	<0.0001	−42	(−46, −38)	<0.0001