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The Impact of Integrated HIV Care on Patient Health Outcomes

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Abstract

Background—Control of viral replication through combination antiretroviral therapy (cART) improves patient health outcomes. Yet many HIV-infected patients have co-morbidities that pose social and clinical barriers to achieving viral suppression. Integration of subspecialty services into HIV primary care may overcome such barriers.

Objective—Evaluate effect of Integrated HIV Care on suppression of HIV replication.

Research Design—A retrospective cohort study of HIV patients from five Veterans Affairs healthcare facilities 2000–2006.

Subjects—Patients with >3 months of follow-up, sufficient baseline HIV severity, on cART.

Measures—We measured and ranked Integrated Care at the facilities. These rankings were applied to patient visits to form an index of Integrated HIV Care utilization. We evaluated effect of Integrated HIV Care utilization on likelihood of achieving viral suppression while on cART, controlling for demographic and clinical factors using survival analysis.

Results—The 1,018 HIV-infected patients eligible for analysis had substantial barriers to responding to cART: 93% had co-morbidities with mean 3.2 co-morbidities per patient (S.D.=2.0); 52% achieved viral suppression in median 231 days (S.D.=411.6). Patients visiting clinics which offered hepatitis, psychiatric, psychological and social services in addition to HIV primary care were 3.1 times more likely to achieve viral suppression than patients visiting clinics which offered only HIV primary care (Hazard ratio=3.1, p<.001).

Conclusions—Patients who visited Integrated HIV Care clinics were more likely to achieve viral suppression while on cART. Future research should investigate which elements of Integrated Care are most associated with viral control and what role provider experience plays in this association.

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INTRODUCTION

The ability of combination antiretroviral therapy (cART) to suppress replication of the Human Immunodeficiency Virus (HIV) has provided enormous clinical and survival benefits to HIV-infected persons.[1–4] Unfortunately, not all patients derive this benefit. Although the dosing frequency and side effects of cART have improved since the introduction of cART in the mid-1990s, adherence to treatment regimen remains a challenge for many HIV-infected patients and is a principal reason for failure to suppress viral replication, emergence of antiretroviral resistance, and disease progression.[5–9]

Poor medication adherence in HIV-infected patients is related to the complexity of the treatment regimen, medication side effects, patient beliefs in the effectiveness of treatment, and access to medical care.[10,11] In addition, co-morbidities such as substance abuse disorders, mental health disorders, hepatitis C infection, diabetes, and heart disease, which are common in HIV-infected patients, complicate treatment plans and are associated with lower adherence to cART.[12–18]

The consequences of poor adherence to antiretroviral therapy have led to the development of multiple patient-centered interventions to modify patient behavior such as providing pagers to remind patient to take their medications or education regarding the importance of adherence and management of side effect profiles.[19,20] While these interventions are important, relatively less attention has been paid to addressing co-morbidities in order to improve adherence and consequent viral suppression. The most common way that HIV clinics address co-morbidities is by integrating non-infectious disease providers such as psychiatrists and social workers into HIV primary care. Various degrees of such integration have been implemented in portions of the Department of Veterans Affairs (VA) healthcare system as well as other healthcare systems in the U.S.[21–30] In their most developed form, these VA clinics provide on-site pharmacy services, mental health care, urgent care, substance abuse treatment, women's healthcare and case management. [30] Formal analyses that evaluate the benefit of such programs are lacking, however.[31] To better understand the relationship of Integrated HIV Care to patient health outcomes, we conducted a retrospective cohort study to evaluate the association of patient utilization of Integrated HIV Care with the likelihood of achieving viral suppression among HIV-infected patients receiving care at five VA healthcare facilities in Southern California and Nevada.

METHODS

Conceptual model

We defined Integrated HIV Care (IHC) to be a care model in which specialists from multiple disciplines collaborate within a geographically and temporally constrained clinic environment to provide HIV-infected patients with onsite primary care, HIV specialty services and other services such as treatment for hepatitis C, mental health, substance abuse, social services, etc. We adopted the Donabedian model[32] to examine the impact of IHC on viral suppression among HIV-infected patients. In this conceptual model, IHC (i.e., structure) influences the way in which providers manage patients' co-morbidities and encourage patients to adhere to medications (i.e., process), hence influencing viral suppression (i.e., outcomes). We hypothesized that IHC enables providers within multidisciplinary teams to manage co-morbidities more effectively and promote better adherence to antiretroviral medication regimens; as a result, patients with co-morbidities who utilized IHC more frequently would be more likely to achieve suppression of HIV replication.

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Study design

We conducted a retrospective cohort study of HIV-infected patients receiving care from five Veterans Affairs healthcare facilities in the Western United States from October 2000 to April 2006. We interviewed the chiefs of the HIV clinics at these facilities to measure and rank levels of IHC at their clinics. These rankings were applied to patient visits obtained from electronic medical records to form an index of IHC utilization. Using survival analysis, we analyzed the effect of IHC utilization on the likelihood of achieving viral suppression while on cART, controlling for demographic and clinical factors.

Data sources

We obtained administrative and clinical data of inpatient and outpatient encounters from a VA regional electronic data warehouse. The data were longitudinal and comprehensive, including patient demographics, date and time of health service, type of provider, location of service, laboratory tests and results, pharmacy prescriptions and refills, purpose of visit or reason for admission (diagnostic codes), and service provided (surgical and procedure codes). In addition to using these electronic medical data, we interviewed the chiefs of the Infectious Disease clinics at the five VA facilities to obtain the descriptions of integrated services that comprised their HIV clinics.

Inclusion criteria

An HIV-infected patient had to have a viral load ≥5,000 at study entry, at least two HIV clinic visits per year, and at least a three-month supply of cART during the observation period. Patients who met these criteria were included in the analysis regardless of whether they achieved viral suppression or not. cART was determined by synchronous receipt of two nucleoside/nucleotide analogues and at least one protease inhibitor, non-nucleoside reverse transcriptase inhibitor, or fusion inhibitor. Patients were identified as being HIV-infected if they had qualified under any of the following criteria: two or more outpatient visits with a recorded diagnosis of HIV infection, one or more inpatient stays with a diagnosis of HIV infection,[33] two or more positive plasma HIV-1 RNA assays, or a positive HIV antibody test with a confirmatory Western Blot test. Diagnoses of HIV infection were defined by the ICD-9-CM codes listed in Appendix 1.

Statistical methods

To assess the effect of IHC utilization on time to viral suppression adjusted for patient demographic and clinical characteristics, we used survival analysis with the Cox regression method in which the hazard function was determined by the rates at which patients achieved viral suppression over time. The dependent variable was the time from cART initiation to the first achievement of viral suppression. Although the study span was 2000–2006, each patient had their own observation period starting from the entry date when they started cART after their viral load was first recorded as being ≥5,000 HIV-1 RNA copies/mL to the date when they achieved viral suppression below 400 copies/mL. Patients who had not achieved viral suppression by the end of the study period (i.e. loss to follow-up) were assigned a “right-censored” time counting from study entry to their last visit. The independent variables included patient age, race and ethnicity, marital status, co-payment for VA medical costs as a proxy for income, lack of housing, sexually transmitted diseases, co-morbidities, baseline HIV viral load and $CD4^+$ cell count, treatment-naive versus treatment-experienced, access to cART medication as determined by pharmacy data, and utilization of IHC as determined by clinic visits. Baseline $CD4^+$ cell counts and viral loads were based on the first lab tests taken upon patient entry into the study. All viral load values were $\log_{10}$-transformed. Access to cART medication was computed by refill frequency during the observation period.[34] Appendix 1 provides details of the diagnostic codes and laboratory

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tests used to determine the co-morbidities. Patients were considered as treatment naïve if they had an HIV positive antibody test and a subsequent viral load ≥5000 at study entry, followed by the first cART prescription. Patients were considered as treatment-experienced if they had records of receipt of cART prior to study entry. For those patients whose HIV status was determined by ICD-9 codes or positive viral loads and who initiated cART after study entry but did not have record of positive HIV antibody tests, we could not determine whether they were treatment-naïve or treatment-experienced; therefore we assigned such patients an unknown status.

To measure patient utilization of IHC, we first ranked the comprehensive level of IHC of the HIV clinics. We classified these clinics into four levels of comprehensiveness based on the number of services and the amount of resources devoted to each service (Table 1). Level I clinics offered walk-in services provided by a mid-level provider only (i.e., a nurse practitioner or physician assistant). Level II clinics offered more comprehensive care than Level I with the presence of an HIV physician specialist and a dedicated pharmacist. In addition to all services available in Level II clinics, Level III clinics offered psychiatric and social services. Level IV clinics offered the most comprehensive care with the addition of a psychologist. Various study facilities offered different IHC clinics on different days of the week at different locations. For example, facility E offered Level IV clinic on Tuesday afternoons, Level III clinic on Monday and Wednesday mornings, Level II clinic on Friday mornings, and Level I (walk-in) clinic on the other times of the week. The distribution of IHC users across the five VA facilities is shown in Table 2.

Since more than half of the patients visited multiple IHC clinics, we evaluated their utilization of IHC by the following index:

In this index, the total days of observation referred to the number of days between study entry and viral suppression or loss to follow-up. We quantified the four IHC levels as 1, 2, 3, and 4. The index gave each patient a score that weighed the frequency of HIV clinic visits by these IHC levels. Patients who visited clinics of higher IHC level were assigned higher scores. Thus a patient with one visit to a Level IV clinic every 90 days would receive a score of 4 as would a patient with two visits to a Level II clinic during the same period.

We conducted two survival analyses. In the first analysis, we included all study patients and evaluated the effect of IHC utilization index on time to viral suppression, adjusted for the demographic and clinical variables mentioned above. The second analysis was similar to the first one except that we included the subset of patients who visited only one IHC level and that we replaced the IHC utilization index by the categorical variable indicating the levels of the IHC clinics and the number of visits to the clinics per quarter. In both analyses, the effects were assessed by adjusted hazard ratios. Similar to the interpretation of risk ratios, hazard ratio values of less than 1 indicated negative association (i.e., less likely to achieve viral suppression) whereas a value greater than 1 indicated positive association (i.e., more likely to achieve viral suppression), and a value equal to 1 indicated no association (i.e., no change in likelihood of viral suppression). Since patients who received care at the same facilities might experience similar health outcomes, we adjusted the regression model for intra-facility clustering. Finally, we conducted a sensitivity analysis to examine how choices of baseline viral load threshold other than 5,000 counts would affect the study results. All statistical analyses were programmed in SAS[35] and STATA[36].

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RESULTS

A total of 2,883 patients were identified as being HIV-infected. Of these, 1,018 (35.3%) patients met the inclusion criteria. Table 3 presents the baseline demographic and clinical characteristics of the study patients. Overall, the patients had substantial potential barriers to responding to antiretroviral therapy. Approximately 18% of the patients had a history of homelessness; 93% had one or more co-morbid conditions with a mean of 3.2 co-morbidities per patient (S.D.=2.0). The most prevalent co-morbidities were mental disorders (55.5%), prior or current hepatitis B infection (48.8%), hepatitis C infection (33.1%), and illicit drug or alcohol use (31.4%). Analysis of prior treatment indicated that 497 (48.8%) patients were treatment-experienced whereas 187 (18.4%) patients were treatment naïve. We could not determine whether the remaining 334 (32.8%) patients were treatment experienced or naïve because of insufficient information. Comparing users of the four IHC levels, we found that the four groups were different in their compositions of race/ethnicity, homelessness, baseline HIV viral load and $CD4^+$ cell counts (all p-values<0.01). For example, users of Level III had the lowest baseline HIV viral loads while users of Level I were most likely to be homeless. Despite these differences, all four groups were similar in co-morbidity prevalence, access to cART, and frequency of visits to HIV clinics. These similarities indicate that the need for integrated HIV care was comparable among the four groups.

We used Kaplan-Meier method to estimate the cumulative probability of viral suppression among patients who accessed only one IHC level. Figure 1 shows the Kaplan-Meier curves depicting the cumulative probability of viral suppression stratified by IHC levels. The plot shows that by the 9^{th} month (i.e. 270^{th} day) of cART, Level IV users had 60% probability of viral suppression while Level I, II, and III users all had 32% probability of viral suppression. By the 27^{th} month (i.e. 810^{th} day) of cART, Level IV users had 80% probability of viral suppression; Level III users had 60% probability; Level I and II users both had 53% probability. By the end of the study, the probability of viral suppression was 95% for Level IV users, 87% for Level III users, 83% for Level II users, and 60% for Level I users. All comparative differences were statistically significant at p-values <0.01. In summary, the higher the IHC level, the higher the cumulative probability of viral suppression.

In subsequent analyses, we adjusted for the demographic and clinical differences among the four groups when assessing the effect of IHC levels on time to viral suppression. Table 4 shows the adjusted hazard ratios obtained from two survival analyses, the first involving all study patients (n=1,018) and the second involving the subset of patients who accessed only one level of IHC clinics (n=514). From the first analysis, we found that once-married patients and those with high income were more likely to achieve viral suppression than those who were never married (Hazard ratio HR=1.34, CI=1.21–1.50) and had low income (HR=1.14, CI=1.01–1.30). Conversely, homeless patients were less likely to achieve viral suppression (HR=0.78, CI=0.67–0.90). Patients who had higher baseline $CD4^+$ cell counts were more likely to achieve viral suppression (HR=1.06, CI=1.05–1.08). Most importantly, patients who had more access to cART were much more likely to achieve viral suppression (HR=3.13, CI=2.22–4.40). In analyses that controlled for these demographic and clinical factors, patients who had a higher index of IHC utilization were more likely to achieve viral suppression (HR=1.10, CI=1.09–1.11). From the second analysis, we found that there was no difference in viral suppression between patients who visited clinics of Level I and Level II. However, patients who visited clinics of Level III and Level IV were 1.7 times and 3.1 times more likely to achieve viral suppression than those who visited clinics of Level II (Level III: HR=1.74, CI=1.06–2.85. Level IV: HR=3.10, CI=1.76–5.47). Regardless of IHC levels, patients who visited clinics more frequently were more likely to achieve viral suppression (HR=1.42, CI=1.32–1.53).

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Sensitivity analysis

We examined the sensitivity of our results to the choice of baseline viral load. We repeated the survival analysis with baseline viral load values varying between 1,000 and 10,000 counts (instead of 5,000). Regardless of the viral load choices, the results were consistent.

DISCUSSION

We evaluated the virological response to combination antiretroviral therapy in 1,018 HIV-infected veterans who received care at five VA healthcare facilities. We found that patients who visited HIV clinics with more integrated specialty services were more likely to achieve viral suppression. In particular, patients visiting clinics which offered hepatitis, psychiatric, psychological and social services in addition to primary care and HIV specialty services were three times more likely to achieve viral suppression than patients visiting clinics which offered only primary care and HIV specialty services. This effect had been adjusted for patients' access to antiretroviral medication and demographic and clinical factors.

We believe that our results are generalizable to care settings beyond the VA. VA HIV-infected patients are older and have more co-morbidities than generally reported.[37–39] However, with the improved outcomes being seen with HIV treatment, the HIV-infected patient population is generally aging and becoming more susceptible to co-morbidities, and the VA population may represent the future of the U.S. HIV epidemic in that respect.[40–42] Except for being overwhelmingly male, the income status and racial/ethnic distribution of HIV-infected veterans is similar to that of many other HIV-infected populations in the U.S. The median time to viral suppression of our study patients is longer than that reported in modern clinical trials of treatment-naïve patients, reflecting the fact that majority of our study patients experienced multiple co-morbid conditions and prior failures to respond to treatment.

The principal limitation of our study is that unmeasured differences between the patients seen at the differing clinics and unmeasured differences in the skills of the providers who staff those clinics, rather than the comprehensiveness of care, may have accounted for our findings.[43,44] However, we note that our statistical models have corrected for patient demographic and clinical factors that are previously reported to modulate the effectiveness of antiretroviral therapy. In addition, provider surveys indicate that the distribution of physician experience and expertise in the management of HIV infection is similar among persons staffing the Level II, III, and IV clinics. Indeed, in many instances the same physicians provide services in more than one type of clinic. Another limitation is that we did not explicitly compare the potency of antiretroviral therapy (e.g., the use of ritonavir-boosted protease inhibitors, triple nucleoside therapy or hard-gel saquinavir) in the patient population[2,6] or the complexity of antiretroviral therapy (i.e., doses per day, pills per day or dietary restrictions). However, the availability of laboratory and pharmacy records monitoring patient viral loads and access to antiretroviral medications is the same at all clinic levels; as is the policy to provide care as recommended by national guidelines.[6,45] Although we accounted for treatment-experienced status in the analysis, we could not account for the unmeasured duration of cART prior to study entry, which might be associated with viral suppression. The limitations of our statistical analysis are that the quantification of the four IHC levels in the IHC utilization index was arbitrary and that the retrospective nature of this study limited our ability to consider whether temporal changes in clinic structure and operations might have impacted our results.

This study made use of the electronic medical records maintained by the Veterans Health Administration.[46,47] Since HIV-infected veterans who are VA heath care users receive over 70% of their total care and obtain 98% of their prescriptions through the VA[37], these records

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allowed us to access nearly complete records of patient demographics, receipt of antiretroviral prescriptions, clinic visits, relevant laboratory results, and medical co-morbidities such as hepatitis B and C, mental illnesses, drug or alcohol use, STDs, diabetes, heart disease, COPD, tuberculosis, cirrhosis, stroke, and cancer. However, the VA electronic database had several limitations such as high rates of missing race data and diagnostic coding errors, which could affect the quality of the present data analysis.[48,49]

Literature shows that co-morbid conditions such as alcohol abuse, substance use and mental health disorders, all of which impede patient adherence to cART,[13–15,18] are highly prevalent in HIV-infected patients.[41] The Veteran Affairs Healthcare system has implemented Integrated HIV care in which subspecialty programs are integrated into HIV clinics to address co-morbid conditions and medication adherence. However, our study is one of the few to evaluate the relationship between the level of services provided by an integrated HIV care clinic and patient health outcomes.[31] We believe that IHC clinics at the VA facilities may have effectively addressed co-morbidities and encouraged medication adherence. Based on our finding that frequency of visits was a strong predictor for viral suppression, we suggest not only that resources should be allocated to integrate subspecialty services into HIV primary care clinics but also that providers should channel patients toward these clinics and retain them in care. Future studies should examine which specific elements of IHC are most associated with viral control and what role provider experience plays in this association. Finally, these results may be relevant not only to the care of HIV-infected patients but also to the provision of care of patients with other complex medical issues that require principal care in subspecialty clinics.

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APPENDIX 1

Diagnostic codes and laboratory tests

HIV infection

ICD-9 codes: 042., 042.1, 042.2, 042.9, 043.0, 043.1, 043.2, 043.3, 043.9, 044.9, 079.53, V08

Lab tests: Positive HIV antibody test, positive confirmatory Western Blot, viral load

Hepatitis B infection

ICD-9 codes: 070.20, 070.21, 070.22, 070.23, 070.3, 070.30, 070.31, 070.32, 070.33, 070.52.

Lab tests: positive HBV surface antigen.

Hepatitis C infection

ICD-9 codes: 070.41, 070.44, 070.51, 070.54, 070.6, 070.70, 070.71, 070.9, 571.40, 571.41, 571.49, 571.5, 571.8, 571.9, 573.3, 573.8, V02.62

Lab tests: positive HCV antibody test or HCV viral load test

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Depression

ICD-9 codes: 295, 297, 298, 311, 296.2, 296.3, 296.9

PTSD

ICD-9 codes: 309.81, 296.1, 296.4, 296.5, 296.6, 296.7, 296.80, 296.81, 296.89, 296.11, 296.41, 296.51, 296.45, 296.65, 296.46, 296.56, 296.66

Schizophrenia

ICD-9 codes: 295

Drug/alcohol use:

ICD-9 codes: 304.00, 304.01, 304.02, 304.03, 304.20, 304.21, 304.22, 304.23, 304.40, 304.41, 304.42, 304.43, 304.60, 304.61, 304.62, 304.63, 304.70, 304.71, 304.72, 304.73, 304.90, 304.91, 304.92, 304.93, 305.50, 305.51, 305.52, 305.53, 305.60, 305.61, 305.62, 305.63, 305.70, 305.71, 305.72, 305.73, 305.90, 305.91, 305.92, 305.93, 291.0, 291.1, 291.2, 291.3, 291.4, 291.5, 291.81, 291.89, 291.9, 571.2, 292.0, 292.11, 292.12, 292.2, 292.81, 292.82, 292.83, 292.84, 292.89, 292.9

Sexually Transmitted disease includes gonorrhea, chlamydia, syphilis, herpes ICD-9 codes: 054.10, 054.11, 054.12, 054.13, 054.19, 098.xx, 099.40, 099.41, 099.50, 099.51, 099.52, 099.53, 099.54, 099.55, 099.56, 099.59, 099.8, 099.9, 090.0, 090.1, 090.2, 090.3, 090.40, 090.41, 090.42, 090.49, 099.56, 090.5, 090.6, 090.7, 090.9, 091.0, 091.1, 091.2, 091.3, 091.4, 091.50, 091.51, 091.52, 091.61, 091.61, 091.69, 091.7, 091.81, 091.82, 091.84, 091.89, 091.9, 092.0, 092.9, 093.0, 093.1, 093.20, 093.21, 093.22, 093.23, 093.24, 093.81, 093.82, 093.89, 093.9, 094.0, 094.1, 094.2, 094.3, 094.51, 094.52, 094.7, 094.81, 094.82, 094.83, 094.84, 094.85, 094.86, 094.87, 094.89, 094.9, 095.0, 095.1, 095.2, 095.3, 095.4, 095.5, 095.6, 095.7, 095.8, 095.9, 096.0, 097.0, 097.1, 097.9

Diabetes

ICD-9 codes: 362.01, 362.02, 250, 250.94, 250.95, 250.96, 250.97, 250.98, 250.99

Heart disease

ICD-9 codes: 410, 413, 414.8, 414.9, 415.0, 416, 422, 421, 423, 425, 428, 429

Chronic obstructive pulmonary disease

ICD-9 codes: 491, 492, 493, 494

Tuberculosis

ICD-9 codes: 010, 011, 012, 013, 014, 015, 016, 017, 018

Stroke

ICD-9 codes: 430, 431, 432, 432.0, 432.1, 432.9, 434, 434.0, 434.00, 434.01, 434.1, 434.10, 434.11, 434.9, 434.90, 434.91, 435, 435.0, 435.1, 435.2, 435.3, 435.8, 435.9, 436, 997.02, 438, 438, 438.0, 438.11, 438.12, 438.20, 438.21, 438.22, 438.30, 438.31, 438.32, 438.40, 438.41, 438.42, 438.50, 438.51, 438.52, 438.53, 438.81, 438.82, 438.84, 437, 437.0, 437.1, 437.3, 437.4, 437.5, 437.6, 437.7, 437.8, 437.80, 437.81, 437.89, 437.9, 438.10

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Cirrhosis

ICD-9 codes: 456, 572.2, 070.20, 070.21, 070.22, 070.41, 070.42, 070.44, 070.49, 070.6, 070.71, 070.0, 348.30, 348.31, 348.39, 572.3, 572.4, 572.8

Cancer

ICD-9 codes: 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160 161, 162, 163 164, 165, 166, 167, 168, 169, 170, 171, 172, 174, 175, 176, 177, 178, 179, 180, 181, 182 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208

Lack of housing

ICD-9 codes: V60.0

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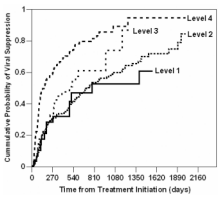

FIGURE 1.
Cumulative Probability of Viral Suppression Stratified by Integrated HIV Care Levels

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TABLE 1

Four Levels of Integrated HIV Care Clinics

Components of Integrated HIV Care	Services	Levels			
		IV	III	II	I
Nurse practicioner, physician assistant	To follow patients on HIV treatment.	x	x	x	x
Clinical coordinator	To link patients to community-based programs for food, dental care, home care, etc.	x	x	x	x
HIV physician specialist	To provide diagnosis, counseling and treatment for HIV infection	x	x	x	
Dedicated pharmacist	To help patients with cART refills, side effects, food restriction, etc.	x	x	x	
Social worker	To help patients with housing, transportation, disability benefits, etc.	x	x		
Psychiatrist	To provide psychiatric diagnosis and treatment for substance abuse and mental illnesses.	x	x		
Psychologist	To provide counseling for substance abuse and mental illnesses	x			

Remark: ‘x’ indicates that the specialists are available at the HIV clinics to offer on-site services to HIV-infected patients.

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TABLE 2

Distribution of Integrated HIV Care Users across the Five VA Facilities

Facilities	Number of users (column percent)					
	Level I	**Level II**	**Level III**	**Level IV**	**Multi levels**	**Total**
A		131 (45.6%)				131 (12.9%)
B		143 (49.8%)				143 (14.1%)
C	1 (3.3%)		36 (69.2%)		85 (16.9%)	122 (12.0%)
D	8 (26.7%)			91 (62.8%)	201 (39.9%)	300 (29.5%)
E	21 (70.0%)	13 (4.5%)	16 (30.8%)	54 (37.2%)	218 (43.3%)	322 (31.6%)
Total	30 (100%)	287 (100%)	52 (100%)	145 (100%)	504 (100%)	1018 (100%)

Remark: Facilities A and B had Level II clinics only. Facility C had Level I and Level III clinics with a total of 122 patients, 1 of whom visited Level I only, 36 patients visited Level III only while the other 85 patients visited both levels. Similarly, facility D had Level I and Level IV clinics while facility E had all four levels.

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TABLE 3

Baseline Demographic and Clinical Characteristics of Study Patients Stratified by Integrated HIV Care Levels

Characteristics	Integrated HIV Care Users					Total n=1,018
	Level I only n=30	Level II only n=287	Level III only n=52	Level IV only n=145	Multi-levels n=504	
Age (mean, s.d.)	51.7 (9.5)	50.9 (9.4)	55.1 (8.8)	49.4 (9.6)	50.2 (9.2)	50.6 (9.4)
Male (%)	100.0	98.3	98.1	98.6	98.8	98.6
Race/ethnicity (%)						
▪ Caucasian	26.7	31.0	53.9	35.2	33.1	33.7
▪ African American	43.3	19.5	15.4	28.3	29.4	26.1
▪ Hispanic	3.3	6.3	0.0	4.8	6.6	5.8
▪ Asian, Native American	13.3	3.5	3.9	4.8	5.4	4.9
▪ Missing	13.3	39.7	26.9	26.9	25.6	29.5
Marital status (%)						
▪ Never married	60.0	50.2	57.7	60.0	59.3	56.8
▪ Married	6.7	7.7	7.7	5.5	5.8	6.4
▪ Widow, divorced, etc.	33.3	42.2	34.6	34.5	34.9	36.8
No co-payment for VA medical cost, proxy for low income (%)	80.0	74.9	76.9	79.3	77.4	77.0
Lack of housing (%)	56.7	7.3	3.9	20.0	23.6	18.1
Sexual transmitted diseases (%)	20.0	11.2	23.1	16.6	19.4	16.9
-Percentage of patients with any co-morbidities	80.0	92.7	88.5	93.1	94.3	92.9
-Number of co-morbidities per patient (mean, s.d.)	3.0 (2.1)	3.0 (1.9)	2.7 (1.8)	3.0 (1.9)	3.4 (2.0)	3.2 (2.0)
Co-morbidities (%)						
▪ Mental disorders	46.7	46.3	40.4	60.7	61.3	55.5
▪ HBV infection (prior/current)	46.7	43.2	42.3	48.3	53.0	48.8
▪ HCV infection	20.0	37.6	28.9	25.5	33.9	33.1

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Characteristics	Integrated HIV Care Users					Total n=1,018
	Level I only n=30	Level II only n=287	Level III only n=52	Level IV only n=145	Multi-levels n=504	
▪ Drug/alcohol use	36.7	25.4	17.3	33.1	35.5	31.4
▪ Cancer	10.0	14.6	15.4	14.5	17.9	16.1
▪ Heart disease	20.0	14.3	21.2	15.9	12.5	14.2
▪ COPD	16.7	13.9	17.3	13.1	9.1	11.7
▪ Tuberculosis	13.3	3.8	0.0	15.2	16.5	11.8
▪ Diabetes	10.0	10.1	19.2	13.1	10.5	11.2
▪ Cirrhosis	3.3	23.7	1.9	2.8	3.8	9.1
▪ Stroke	3.3	2.4	1.9	2.1	2.4	2.4
Baseline HIV RNA (copies/mL) (%)						
▪ 5K–30K	56.7	39.0	61.5	39.3	38.9	40.7
▪ 31K–60K	16.7	17.1	17.3	16.6	17.9	17.4
▪ 61–90K	10.0	9.1	19.2	15.2	23.2	17.5
▪ >90K	16.7	34.8	1.9	29.0	20.0	24.6
Median	25.7K	42.5K	18.0K	48.7K	49.4K	43.0K
Mean	40.6K	159.0K	30.5K	94.8K	87.2K	104.2K
S.D.	38.5K	335.5K	27.0K	13.7K	14.3K	214.3K
S.D. Baseline $CD4^+$ cell count (%)						
▪ <50	10.0	15.7	1.9	6.9	12.1	11.8
▪ 50–200	10.0	25.8	23.1	31.7	23.6	25.0
▪ 201–350	23.3	25.4	26.9	27.6	30.4	28.2
▪ >350	56.7	33.1	48.1	33.8	33.9	35.1
Median	374.0	244.0	313.2	263.0	274.5	271.0
Mean	428.0	287.1	342.9	303.1	296.6	301.1
S.D.	298.5	231.0	202.0	222.7	212.2	222.5
Treatment status (%)						
▪ Experienced	40.0	46.7	76.9	44.1	49.0	48.8

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Characteristics	Integrated HIV Care Users					Total n=1,018
	Level I only n=30	Level II only n=287	Level III only n=52	Level IV only n=145	Multi-levels n=504	
▪ Naïve	36.7	8.4	7.7	26.9	21.6	18.4
▪ Unknown	23.3	45.0	15.4	29.0	29.4	32.8
Frequency of cART refills (mean, s.d)	77.8% (26.4)	80.2% (26.9)	82.9% (24.9)	81.1% (28.5)	74.1% (30.6)	77.4% (29.1)
Number of visits to IHC clinics per quarter (mean, s.d)	1.9 (2.1)	2.6 (3.1)	1.8 (2.0)	3.1 (2.5)	3.1 (3.6)	2.8 (3.2)

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TABLE 4

Predictors of Time from Treatment Initiation to Viral Suppression

Predictors	Adjusted Hazard ratios (95% CI)	
	All study patients (n=1,018)	Patients accessing only one IHC level (n=514)
Age (per one extra year)	0.99 (0.98, 1.00)	1.00 (0.99, 1.01)
Marital status (ref=Never married)		
▪ Married	1.11 (0.90, 1.38)	1.00 (0.60, 1.66)
▪ Widow, divorced, separated, other	1.34 (1.21, 1.50)*	1.32 (1.17, 1.47)*
Co-payment for VA medical costs (yes vs. no)	1.14 (1.01, 1.30)*	1.02 (0.92, 1.13)
Lack of housing (yes vs. no)	0.78 (0.67, 0.90)*	0.96 (0.61, 1.50)
Sexual transmitted diseases (yes vs. no)	1.20 (0.92, 1.55)	1.52 (0.95, 2.42)
Number of co-morbidities (per one extra condition)	1.01 (0.94, 1.09)	0.97 (0.92, 1.02)
Baseline HIV viral load (per one Log_{10}-unit increase)	0.91 (0.72, 1.15)	0.86 (0.76, 0.96)*
Baseline $CD4^+$ cell count (per 100 count increase)	1.06 (1.05, 1.08)*	1.10 (1.05, 1.16)*
Treatment status (ref=naïve)		
▪ Experienced	0.91 (0.77, 1.08)	0.95 (0.70, 1.30)
▪ Unknown	1.04 (0.91, 1.19)	1.08 (0.77, 1.52)
Frequency of cART refills (per one extra day of supply) £	3.13 (2.22, 4.40)*	3.97 (2.44, 6.46)*
IHC utilization index (per one unit increase)	1.10 (1.09, 1.11)*	N/A
IHC utilization (compared to Level II)	N/A	
▪ Level I		1.07 (0.90, 1.26)
▪ Level III		1.74 (1.06, 2.85)*
▪ Level IV		3.10 (1.76, 5.47)*
Number of visits to IHC clinics per quarter (per one extra visit per quarter)	N/A	1.42 (1.32, 1.53)*

Remarks: Stars * indicate that the hazard ratios were significant at p-value <0.05. Symbol

£ refers to frequency of cART refills as a measure for the percentage of time in which patients had access to cART.