Clinical and Economic Effects of a Pharmacist-Administered Antiretroviral Therapy Adherence Clinic for Patients Living with HIV

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ABSTRACT

BACKGROUND: Pharmacists have demonstrated the ability to improve patient adherence to antiretroviral therapy (ART).

OBJECTIVE: To determine the clinical and economic effects of a pharmacist-administered ART adherence clinic for patients living with human immunodeficiency virus (HIV).

METHODS: This pilot study with a pretest-posttest design examined the effect of a pharmacy adherence clinic on patient HIV viral load and CD4 count over a 6-month period. Patients with documented adherence problems were referred to the clinic. The pharmacist counseled patients at baseline and met with patients 1-2 weeks, 6 weeks, 3 months, and 6 months after starting ART. A societal perspective net cost analysis of the pharmacy adherence clinic was conducted to assess the economic efficiency of the intervention.

RESULTS: Twenty-eight patients were enrolled in the study, and 16 patients reached completion. Median HIV RNA significantly decreased from 48,000 copies/mL (interquartile range [IQR] = 16,750-139,000) to undetectable (< 20 copies/mL) at 6 months for all study participants who completed the full intervention ($P = 0.001$). In the 3 months following the intervention, we estimated that it prevented approximately 0.13 secondary HIV infections among the sexual partners of the 16 participants who completed the intervention. The total cost of the intervention was $16,811 ($1,051 per patient), which was less than the future savings in averted HIV-related medical care expenditures ($49,702).

CONCLUSIONS: A pharmacy adherence clinic that focused on early and sustained ART adherence interventions helped patients with documented medication adherence problems achieve an undetectable HIV RNA. The intervention was highly cost saving, with a return of nearly $3 in future medical care savings per dollar spent on the intervention.

What is already known about this subject

- Adherence to human immunodeficiency virus (HIV) antiretroviral therapy (ART) yields quality of life and survival benefits to the person living with HIV and reduces the chance of transmission of HIV to other individuals.
- Adherence counseling, before and after ART initiation, has been shown to improve ART adherence.
- Multidisciplinary care teams that include pharmacists have a positive effect on ART adherence in HIV-infected patients.

What this study adds

- This study demonstrated that a pharmacist-led ART adherence clinic operating within a multidisciplinary care clinic can help HIV-infected patients with documented medication adherence problems achieve HIV viral suppression.
- In addition to the positive clinical effect, this intervention was highly cost saving, with a return of $2.96 in future medical care savings for each dollar spent on the adherence intervention.
- Under conservative assumptions of the durability of this intervention, the adherence clinic also showed significant prevention of HIV transmission to the partners of the adherence clinic participants.

Nearly all persons living with human immunodeficiency virus (HIV) who adhere to antiretroviral therapy (ART) active against their virus attain an undetectable HIV RNA viral load (< 50 cells/mm^{3}). Early ART initiation and viral suppression, or maintaining an undetectable HIV viral load, is critical to the health and longevity of persons living with HIV (PLWH).[1,2] Moreover, PLWH who achieve an undetectable viral load are less likely to transmit HIV to their sexual partners than are PLWH with unsuppressed virus.[3] Viral suppression therefore has significant benefits for the individual patient and for public health. Unfortunately, only 30% of the approximately 1.2 million PLWH in the United States have achieved viral suppression.[4]

Successful virologic suppression and immune reconstitution requires patients to remain approximately 95% adherent to their prescribed ART regimens.[5] Given the high level of ART adherence required to achieve and maintain long-term viral suppression, innovative mechanisms are needed to improve ART adherence. Pharmacists have specialized knowledge of medication use and adherence strategies that may be applied to the clinical management of HIV-infected patients. In addition, many pharmacists may welcome the opportunity to play an expanded role in HIV patient care.[6]

Previous research has reported the positive effects that pharmacists can have on patient CD4 counts, viral loads, and/or ART adherence.[7-12] Although evidence suggests that early initiation and subsequent adherence to ART regimens result in the greatest patient-level benefit, only 2 studies have measured the

effect of early adherence interventions by pharmacists on ART adherence and/or clinical outcomes.[13,14] A systematic review of the effect of pharmacists on HIV treatment outcomes called for cost-effectiveness analyses of pharmacist interventions to be performed.[15] However, there is a paucity of data describing the cost-effectiveness of pharmacist interventions aimed at improving HIV treatment outcomes.[16,17] Moreover, the effect of pharmacist-directed adherence interventions on subsequent HIV transmission is unknown.

The purpose of this study was to (a) evaluate the clinical effect (CD4 counts and viral load) of a pharmacist-led ART adherence clinic that focused on early and sustained adherence counseling and (b) assess the economic efficiency from a societal perspective of this adherence intervention.

◼ Methods

Study Setting

A pharmacist-led ART adherence clinic was held 2 half-days per week at the University of New Mexico Truman Health Services (THS), a primary care clinic providing multidisciplinary services to approximately 1,200 HIV-infected patients. Pharmacists did not work in the clinic outside of the 2 half-days per week on which the adherence clinic was held. The adherence clinic was staffed by licensed pharmacist clinicians with prescriptive authority who provided medication adherence counseling to patients referred to the clinic by their primary care providers (PCPs).

THS PCPs referred patients to the adherence clinic for 1 or more of the following reasons: (a) initiation or reinitiation of ART; (b) ART failure, defined by a viral load > 400 copies/mL at 24 weeks or following previous viral suppression; (c) high risk for treatment failure; (d) potential or diagnosed adverse drug reaction; or (e) other adherence or pharmaceutical care issues, as determined by the PCP. Patients at high risk for treatment failure included those who had previously failed to adhere to ART or other medications, as well as patients with polypharmacy, a busy life schedule, active substance abuse, mental illness such as depression, and/or homelessness.

Study Participants

Adherence clinic patients were eligible for study inclusion if they were (a) referred to the clinic by their PCPs for medication adherence concerns between December 1, 2011, and June 1, 2013; (b) aged ≥ 18 years; (c) without HIV dementia as determined by their PCPs; (d) consented to participation in the study; and (e) were able to read and understand English. This study was approved by the University of New Mexico Human Research Review Committee and conforms to the Declaration of Helsinki.

Sociodemographic and clinical characteristics of participants were recorded from the electronic medical record and patient interviews at baseline and included age, gender, race/ethnicity, HIV risk factor, ART adherence barriers, highest level of education completed, and any comorbid psychiatric

conditions. Participants also completed the Substance Abuse and Mental Illness Symptoms Screener (SAMISS) questionnaire to screen for mental illness and/or substance abuse. The SAMISS is part of the standard of care in the adherence clinic and has been shown to be a good initial screening tool for substance abuse and mental illness in an outpatient HIV clinic.[18]

Adherence Intervention

The adherence clinic was designed to ensure a regularly scheduled, initial patient follow-up by a pharmacist, allowing for early identification and management of ART-related side effects and adherence barriers following ART initiation or reinitiation, in order to improve long-term medication adherence and clinical outcomes.[19] The focus on early and sustained adherence counseling was applied to all patients initiating ART during the study period, regardless if they had been prescribed ART in the past. In this context, "early" is used in reference to each patient's ART initiation during the study period. The initial adherence clinic visit lasted approximately 1 hour, after which participants were prescribed ART. Patients returned to the adherence clinic for 30-minute follow-up visits with the pharmacist at 1-2 weeks, 6 weeks, 3 months, and 6 months. Standard-of-care visits with PCPs at the THS did not occur until at least 6 weeks after ART initiation. Participants were allowed a grace period of ±1 week when making follow-up appointments.

Pharmacists in the adherence clinic focused their efforts on medication and disease state education. During each appointment, pharmacists performed the following as indicated or appropriate: medication reconciliation; screening for opportunistic infection prophylaxis; assessing patient adherence to ART; screening for ART adherence barriers; managing ART side effects and drug interactions; discussing patient CD4 counts, HIV viral loads, and the goals of ART therapy; using motivational interviewing techniques to encourage ART adherence; using patient recall and repetition rather than informational handouts; ordering laboratory tests and immunizations; providing management recommendations to PCPs; developing patient ART regimens with the PCPs; prescribing and/or refilling medications as necessary; and making referrals to specialists.

Statistical Analysis

Baseline patient-level sociodemographic and clinical characteristics were compared between the entire study population and the subpopulation of participants who completed the final 6-month follow-up visit to assess differential loss to follow-up using Pearson's chi-square test and the Wilcoxon signed-rank test. Wilcoxon signed-rank tests were used to compare participants' CD4 counts and HIV viral load obtained at ART initiation (baseline) and 6 weeks, 3 months, and 6 months after ART initiation. Statistical analyses were performed using SPSS version 20.0 (IBM, Armonk, NY).

Economic Analyses

The net cost analysis was conducted from the societal perspective and included a valuation of patient time and travel expenses, as well as costs incurred by the adherence clinic to implement the intervention.[20] All costs were expressed in 2015 U.S. dollars. Univariate sensitivity analyses and scenario analyses were conducted on key variables.

The cost to the THS of implementing the adherence intervention included salaries and fringe benefits for the pharmacists and receptionists who staffed the clinic, together with a 25% clinic operations overhead charge, which also included costs related to any social workers or supportive services to assist with obtaining ART. The time pharmacists spent with adherence clinic patients was obtained from study records. An additional 40 minutes of pharmacist time was added to each patient encounter (50 minutes for the initial encounter) to account for time pharmacists spent reviewing patient records before each appointment and recording notes after the encounter. Clinic receptionists spent an estimated 10 minutes checking in each patient and scheduling follow-up appointments.

Patient records were used to determine residential ZIP codes, which then were used to estimate a patient's travel distance and time to the clinic using Google Maps. Patient transportation costs were calculated using the government reimbursement rate of $0.575 per mile.[21] Total travel time consisted of a patient's driving time plus 20 additional minutes to park, walk from the clinic parking area to the clinic, and then walk back again. Time at the clinic included the actual time spent receiving the adherence intervention from the pharmacist; 5 minutes to check-in before the clinic appointment and 5 minutes after to schedule the next appointment; and 10 minutes of wait time. Time spent by patients traveling to and from the clinic and time spent at the clinic was valued at the New Mexico minimum wage. We valued participants' time at minimum wage based on the low per capita income of Albuquerque residents (average per capita income of $20,000 per year) and the large proportion (41.7%) of HIV-positive Ryan White Program enrollees in New Mexico who were below 200% of the federal poverty level.[22]

The cost analysis adopted an intent-to-treat approach in which the total intervention cost estimate included costs for all study patients (n = 28), regardless of whether they completed the full intervention. The effectiveness analysis conservatively assumed that patients who failed to complete the intervention received no benefit from the intervention. The average cost per patient who completed the intervention also was calculated.

The economic analyses focused on the HIV prevention benefits of the ART adherence intervention, a main goal of which was to help patients with detectable virus reduce their viral load to undetectable levels and then maintain it there. Consistent with a modeling study by Granich et al. (2009)[23] and with the findings of the HIV Prevention Trials Network 052 study,[3] our analysis assumed that PLWH who maintain an undetectable viral load through adequate ART adherence are 84%-96% less likely than PLWH with detectable virus to transmit HIV to a sex partner during a given time period—that is, the HIV transmission rate is 84%-96% smaller for PLWH with undetectable virus than for those with detectable virus.[24] While this HIV transmission rate pertains directly to sexual HIV transmission, evidence suggests that ART is also associated with reduced HIV transmission among persons who inject drugs.[25] Given the small number of injection drug users in this study sample, our analysis assumed an 84%-96% reduction in transmission for all patients.

The analysis used an HIV transmission rate model to estimate the number of secondary HIV infections that would be expected among each study participant's sex partners during the 3-month period directly following the 6-month follow-up clinic visit.[26] Two different estimates of the expected number of secondary infections were calculated for each participant with undetectable virus at the 6-month follow-up: the first estimate, S_1, assumed that the participant would maintain an undetectable viral load throughout the 3-month period, whereas the second estimate, S_2, assumed that, had the participant not received the adherence intervention, his or her viral load would have remained at detectable levels. The total number of secondary HIV infections prevented by the intervention then was estimated as $A = N * (S_2 - S_1)$, where N denotes the number of study participants with undetectable viral load at the 6-month follow-up.

The corresponding savings in averted future HIV-related medical care expenditures and lost quality-adjusted life-years (QALYs) were estimated using previously described methods.[27] Each secondary HIV infection prevented by the intervention saves society the lifetime medical care costs, T, associated with treating a case of HIV infection. The net cost of the intervention is therefore $C_{net} = C_{intv} - A * T$, where C_{intv} is the total cost of the intervention from an intention-to-treat perspective.[28] If the net cost is negative (i.e., the monetized benefits of the intervention exceed its implementation cost) then the intervention is considered cost saving.

■ Results

Twenty-eight THS patients were screened for the study and subsequently enrolled (Table 1). Most participants were male (76.4%) and Caucasian (28.6%) or Hispanic (39.3%). The most common risk factor for HIV among study participants was being a man who had sex with other men (53.6%). The most common reason patients were referred to the adherence clinic was previous nonadherence to ART (35.7%). Thus, 64.3% of patients were treatment naive. More than 78% of participants screened positive for mental illness on the SAMISS, and 28.6% of participants screened positive for substance abuse issues. All participants who screened positive on the SAMISS had at least 1 psychiatric comorbidity diagnosed by a physician.

TABLE 1	Participant Characteristics			
	Full Study Sample (N = 28)		**Intervention Completers (n = 16)**	
Age (years), median (IQR)	30	(24-45)	28	(24-39)
Male, n (%)	20	(71.4)	11	(68.8)
Race/ethnicity, n (%)				
White	8	(28.6)	4	(25.0)
Hispanic	11	(39.3)	6	(37.5)
African American	3	(10.7)	2	(12.5)
Native American	4	(14.3)	3	(18.8)
Other	2	(7.1)	1	(6.3)
HIV risk factor, n (%)				
MSM	15	(53.6)	8	(50.0)
Heterosexual contact	11	(39.3)	6	(37.5)
IDU	2	(7.1)	2	(12.5)
ART adherence barriers, n (%)				
Previous ART nonadherence	10	(35.7)	4	(25.0)
Physician referral	5	(17.5)	2	(12.5)
Previous medication nonadherence	3	(10.7)	2	(12.5)
Polypharmacy	1	(3.6)	1	(6.3)
Busy life schedule	1	(3.6)	1	(6.3)
Active substance abuse	1	(3.6))	1	(6.3)
Homelessness	1	(3.6)	0	(0.0)
> 1 ART adherence barrier	6	(21.4)	5	(31.3)
Psychiatric diagnoses, n (%)				
Depression	11	(39.3)	7	(43.8)
Depression and anxiety	4	(14.3)	3	(18.8)
Depression or anxiety with PTSD	4	(14.3)	2	(12.5)
Bipolar or other mood disorder	3	(10.7)	2	(12.5)
No psychiatric diagnosis	6	(21.4)	2	(12.5)
SAMISS, n (%)				
SA (+)/MH (+)	7	(25.0)	4	(25.0)
SA (+)/MH (-)	1	(3.6)	1	(6.3)
SA (-)/MH (+)	15	(53.6)	10	(62.5)
SA (-)/MH (-)	5	(17.9)	1	(6.3)
CD4 count (cells/mm³), median (IQR)	325	(91-435)	298	(93-427)
HIV RNA (copies/mL), median (IQR)	58,500 (21,250-155,013)		48,000 (16,750-139,000)	

ART = antiretroviral therapy; HIV = human immunodeficiency virus; IDU = injection drug use; IQR = interquartile range; MH = mental health issues; MSM = men who have sex with men; PTSD = posttraumatic stress disorder; SA = substance abuse; SAMISS = substance abuse and mental illness screener.

TABLE 2	Longitudinal Results for Patients Who Completed Adherence Intervention (n = 16)			
	Baseline	**6-Week Follow-up**	**3-Month Follow-up**	**6-Month Follow-up**
CD4 count (cells/mm³)				
Median	298	387[a]	356[b]	454[a]
Interquartile range	93-427	176-492	171-565	181-654
HIV RNA (copies/mL)				
Median	48,000	130[b]	32[b]	0[a]
Interquartile range	16,750-139,000	59-1743	0-219	0-0

Note: All comparisons between baseline and specified follow-up time point.
[a]*P < 0.001.*
[b]*P < 0.010.*
HIV = human immunodeficiency virus.

Sixteen of the 28 participants (57.1%) attended all follow-up visits, including the 6-month final follow-up visit. Four (14.3%) of the remaining participants attended at least 1 follow-up visit, and 8 participants (28.6%) did not attend any follow-up visits. Six of the patients who missed 1 or more follow-up appointments were reachable by telephone at the end of the study. The reasons cited by these participants for missing appointments centered around living and social issues. There were no statistically significant differences in patient-level characteristics between patients who completed and who did not complete the study.

Findings from the longitudinal analysis of clinical outcomes for patients who completed all follow-up visits indicated statistically significant differences in CD4 counts and viral load levels between baseline and the 6-week, 3-month, and 6-month follow-up assessments (Table 2). Specifically, median CD4 count improved from 298 cells/mm3 (interquartile range [IQR] = 93-427) at baseline to 454 cells/mm3 (IQR = 81-654) at 6 months (P = 0.001), whereas median HIV RNA viral load decreased from 48,000 copies/mL (IQR = 16,750-139,000) at baseline to all participants having an undetectable HIV RNA level at 6 months (< 20 copies/mL, P = 0.001).

The total cost of the adherence intervention as implemented (intention-to-treat cost) was $16,811, or $1,050.68 for each of the 16 patients who completed the intervention; noncompleters accounted for 22% of the intention-to-treat cost. The true mean cost per patient who completed the 5-visit intervention was $819.74. This total includes $139.24 in costs borne by patients and $680.50 in clinic-borne costs. Compensation for pharmacists' time ($528.86 per patient, on average) accounted for 78% of the total cost to the clinic for each patient who completed the adherence intervention.

The transmission rate modeling analysis indicated that the adherence intervention prevented approximately 0.134 secondary HIV infections among the sexual partners of the 16 PLWH who completed the full intervention during the 3 months following the 6-month assessment. The corresponding savings in averted future HIV-related medical care expenditures and lost QALYs were $49,702 and 0.772, respectively. Thus, the intervention was highly cost saving, with a return (savings-to-cost ratio) of $2.96 in future medical care savings for each dollar spent on the intervention.

The results of the sensitivity and scenario analyses are summarized in Table 3. In the univariate sensitivity analyses, the smallest savings-to-cost ratio was obtained when the pharmacists' hourly compensation was set to $104.77, which is 25% greater than the base-case value ($83.78). This manipulation

TABLE 3	Results of Adherence Intervention Net Cost Sensitivity and Scenario Analyses				
	Change from Base-Case Value, %[a]	Cost of Adherence Intervention, $	HIV Infections Averted	Treatment Cost Savings, $	Treatment Savings/ Intervention Cost
Base-case results	–	16,811	0.134	49,702	2.96
Pharmacist compensation					
$64.11 per hour[b]	-23.20	13,643	0.134	49,702	3.64
$104.77 per hour[b]	+25.10	20,191	0.134	49,702	2.46
Receptionist compensation					
$13.01 per hour[c]	-30.20	16,693	0.134	49,702	2.98
$27.13 per hour[c]	+45.50	16,988	0.134	49,702	2.93
Clinic overhead rate					
15%	-40.00	15,863	0.134	49,702	3.13
35%	+40.00	18,112	0.134	49,702	2.74
Value of patients' time					
$0	-100.00	15,341	0.134	49,702	3.13
$33.19/hour[d]	+343.00	21,847	0.134	49,702	2.74
Patients' round-trip travel costs					
$7.72[e]	-51.80	15,983	0.134	49,702	3.15
$24.74[e]	+54.50	18,112	0.134	49,702	2.69
Reduction in HIV transmission rate for patients with undetectable virus					
96%[f]	+6.67	16,811	0.134	49,791	2.96
84%[f]	-6.67	16,811	0.123	45,570	2.71
Lifetime HIV treatment costs					
$373,916[g]	+0.63	16,811	0.134	50,015	3.27
$368,510[g]	-0.83	16,811	0.134	49,292	2.93
Most favorable combination[h]	–	10,376	0.123	45,194	5.06
Least favorable combination[h]	–	29,457	0.145	54,352	1.53

[a]Base-case parameter values: pharmacist compensation = $83.78/hour (includes inflation-adjusted median hourly wage for pharmacists of $58.22,[33] plus benefits calculated at the average fringe benefit rate[34]); 43.9% is the average fringe benefit rate for health care and social assistance workers in the United States[34]; receptionist compensation = $18.65/hour (includes inflation-adjusted median hourly wage for receptionists of $12.96, plus benefits[35]); clinic overhead rate = 25%; value of patients' time = $7.50/hour[36]; median round-trip travel cost (includes mileage cost and patient's time cost) = $16.01, which corresponds to an 18-mile, 45-minute trip; annual HIV transmission rate without antiretroviral therapy = 0.03716; HIV transmission rate reduction for patients with undetectable viral load = 90%; and HIV-related treatment costs averted by preventing an HIV infection = $371,578.[26]
[b]Inflation-adjusted 10th and 90th percentile hourly wages for pharmacists in the United States,[33] plus U.S. average fringe benefit rate.[34]
[c]Inflation-adjusted 10th and 90th percentile hourly wages for receptionists in the United States,[35] plus U.S. average fringe benefit rate.[34]
[d]Median hourly compensation (wage plus fringe benefits) for civilian workers in the United States.[34]
[e]25th and 75th percentile round-trip travel costs for study participants who completed the intervention.
[f]The upper bound estimate (96%) is the reduction in the likelihood of HIV transmission for patients on ART with suppressed (undetectable) virus in the HTPN 052 study[3]; the lower bound estimate (84%) was selected so that the base-case estimate (90%) was the mean of the lower and upper bounds.
[g]5th and 95th percentile estimates of HIV-related treatment costs averted by preventing an HIV infection.[26]
[h]The combination of parameters that is the most favorable to the intervention consists of the top parameter of each parameter pair.
ART = antiretroviral therapy; HIV = human immunodeficiency virus.

reduced the savings-to-cost ratio by 16.74%, to 2.46. In the least favorable scenario analysis (in which all parameters were set to the value that is least favorable to the intervention), the savings-to-cost ratio decreased to 1.53, and in the most favorable scenario analysis, it increased to 5.06.

The main analyses conservatively assumed that the 16 patients who completed the intervention (all of whom had undetectable virus at the 6-month follow-up visit) would remain virally suppressed during the following 3-month period, but no longer. If instead, all 16 patients remained suppressed for 6 months, the savings-to-cost ratio would increase to 5.92. Conversely, even with all parameters set to their least favorable value, the intervention would remain cost saving provided that patients remained virally suppressed for the 2 months following the 6-month visit.

Discussion

Multidisciplinary care teams, including care teams with pharmacists, have a positive effect on the ART adherence of HIV-infected patients.[29,30] This study evaluated the clinical and economic effects of an existing pharmacist-led adherence intervention in New Mexico, the results of which support the role of clinical pharmacists within multidisciplinary care teams working with HIV-infected patients.

Clinically, all participants who completed the study experienced virologic suppression. The positive clinical results

observed in this study were likely a function of timing of the pharmacist visits before and shortly after ART initiation and the quantity of time pharmacists spent with patients. The 12 patients who did not complete the study were lost to follow-up from the adherence clinic, and no additional patient-level data were recorded for these patients during the study period. The large number of patients who were lost to follow-up may be reflective of the high-risk patient population seen in the adherence clinic.

Early initiation and adherence to ART yield quality of life and survival benefits to PLWHs and reduce the chance of HIV transmission to other individuals.[2,3] Therefore, obtaining ART adherence shortly after ART initiation is crucial. The adherence clinic was designed to ensure that pharmacists met often with patients following ART initiation. These initial visits allowed pharmacists to manage promptly any ART-related side effects or adherence barriers in order to secure optimal ART adherence from patients early in therapy. Standard of care for patients suggests that the first follow-up visit to check HIV viral load be within 2-4 weeks (and no later than 8 weeks) after ART initiation.[1] However, this high-risk group of patients might have required more immediate adherence assistance and may not have received enough one-on-one time with their PCPs to address all of their questions or barriers. Early adherence counseling following ART initiation within the first month, in addition to adherence counseling before ART initiation, has been shown to improve ART adherence, as well.[19]

Pharmacists spent approximately 3 hours with each participant who completed the study over the course of 6 months, which is much more contact than most patients would have had with their PCPs. During these 3 hours, pharmacists used motivational interviewing techniques, which has been shown to increase ART adherence.[31] Education and counseling before ART initiation by a pharmacist working as part of a multidisciplinary team also improved ART adherence.[13] This intervention focused on lengthy counseling sessions involving medication and disease state education that emphasized participant recall rather than informational handouts. All pharmacists who participated in this study had training in infectious diseases pharmacotherapy and several years of experience working with HIV-infected patients. Pharmacists in this study addressed patients' social issues, such as homelessness or substance abuse, that could be barriers to adequate ART adherence. Pharmacists also helped providers select optimal, participant-specific ART regimens based on previous medication experiences of the patient and psychosocial issues. To improve comprehension of difficult adherence concepts, pharmacists used language appropriate for the participant's education level and repeated all of the ART adherence counseling points numerous times during each appointment.

In addition to the positive clinical effect, this intervention was highly cost saving, with a return of $2.96 in future medical care savings for each dollar spent on the adherence intervention. The economic analyses were conducted on an intention-to-treat basis and therefore included costs (but no benefits) for the 12 patients who failed to complete the intervention. At a cost of $308 per patient, these noncompleters accounted for 22% of the total cost of the intervention. This finding suggests that more intensive efforts to retain patients in clinic-based adherence interventions could be a cost-effective or cost-saving adjunct to these interventions.

Not only are pharmacists well positioned to administer a medication adherence intervention because of their unique skillset, but most are compensated at a lower rate than physicians, which further increases the cost-effectiveness of pharmacist-led adherence interventions. Under conservative assumptions of the durability of this intervention, the adherence clinic also showed significant prevention of HIV transmission to the partners of the adherence clinic participants. Given the relatively low cost of the intervention and the positive effect on the participant's virologic suppression and prevention of future transmission, we strongly recommend the inclusion of pharmacists on multidisciplinary care teams to improve patient ART adherence.

Although many medication adherence studies measure adherence directly as their primary outcome, this study used the more clinically relevant outcome of viral suppression. Viral suppression is a laboratory-based measure, is not subject to biases associated with self-reported medication adherence measures, and directly measures the health and infectiousness of a PLWH.

Limitations
This study has some limitations to consider. While this study demonstrates the positive effect of pharmacist medication adherence interventions on the viral load of HIV-infected patients, low external validity is a concern because of the single center study design. However, with an increasing number of pharmacists caring for HIV-infected patients in similar adherence clinics across the United States, our results should have strong external validity, unless our study participants were different from other U.S. HIV-infected patients, and/or pharmacists were not performing similar interventions in other clinics.

The sample size is also a limitation. THS underwent numerous changes during the course of this study, which decreased the number of patients referred to the adherence clinic for the 6 months of the study. These changes included a relocation of the clinic, a change in clinic administrative leadership and nursing, and support staff turnover. Also, because we relied solely on provider referral for study participation, it is possible that physicians were more likely to refer patients to the study if they felt they would be adherent following the intervention. Thus, it is possible that our results do not apply to all nonadherent patients, but only to the types of patients referred to the

clinic by physicians. The number of patients who were lost to follow-up is a testament to how difficult it is to retain patients with documented adherence problems in HIV care.[32]

◼ Conclusions

This study demonstrated that a pharmacist-led ART adherence clinic operating within a multidisciplinary care clinic can help HIV-infected patients with documented medication adherence problems achieve HIV viral suppression, which, in turn, decreases the likelihood of HIV transmission by these patients and leads to future savings in averted HIV-related treatment costs. In this study, the savings in future treatment costs far outweighed the cost of the pharmacist-led adherence intervention. Future large-scale studies should further investigate the effect of early and sustained pharmacist ART adherence interventions on patient health and HIV transmission. In addition, HIV clinics serving patients with ART adherence problems that do not employ a pharmacist should consider hiring a pharmacist to assist these patients with ART adherence.

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