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Permalink

<https://escholarship.org/uc/item/1nr4987t>

Journal

JAIDS Journal of Acquired Immune Deficiency Syndromes, 75(3)

ISSN

1525-4135

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Publication Date

2017-07-01

DOI

10.1097/qai.0000000000001385

Peer reviewed

Title: Effects of a Laboratory Health Information Exchange Intervention on Antiretroviral Therapy Use, Viral Suppression and Racial/Ethnic Disparities

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Running head: Health Information Exchange & HIV Disparities:

Word Counts: Running head: 5; Abstract: 247, Text: 3492

References: 55

Tables: 5

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The authors report no conflicts of interest related to this work.

Research Support:

This research was supported by a grant from the Health Resources and Services Administration (HRSA-07-046). Dr. Cunningham also received partial support for his time on this manuscript from: NIH/NIA (P30-AG021684), NIH/NIMHD (P20-MD000182), NCATS (TL1TR001883), NIH/NIDA (R01-DA030781). Drs. Bell, Cunningham and Mr. Nakazono had partial support from the National Center for Advancing Translational Science (UL1TR000124). Dr. Ford received partial support from NIH/NINR (1R01-N4014789-01) and the UCLA California Center for Population Research (CCPR) through support from the Shriver National Institute of Child Health and Human Development (5R24HD041022).

ABSTRACT

Background: Although antiretroviral therapy (ART) is available to treat HIV+ persons and prevent transmission, ineffective delivery of care may delay ART use, impede viral suppression (VS) and contribute to racial/ethnic disparities along the continuum of care. This study tested the effects of a bi-directional laboratory health information exchange (LHIE) intervention on each of these outcomes.

Methods: We used a quasi-experimental, interrupted time series design to examine whether the LHIE intervention improved ART use and VS, and reduced racial/ethnic disparities in these outcomes among HIV+ patients (N=1,181) in a comprehensive HIV/AIDS clinic in Southern California. Main outcome measures included ART pharmacy fill and HIV VL lab data extracted from the medical records over three years. Race/ethnicity and an indicator for the intervention (after vs. before) were the main predictors. The analysis involved three-stage, multivariable logistic regression with generalized estimating equations (GEE).

Results: Overall, the intervention predicted greater odds of ART use (OR=2.50; 95% CI=2.29-2.73; P<0.001) and VS (OR=1.12; 95% CI=1.04-1.21; P<0.05) in the final models that included sociodemographic, behavioral, and clinical covariates. Prior to the intervention, there were significant Black/White disparities in ART use OR=0.75 (0.58-0.98; P=0.04) and VS OR=0.75 (0.61-0.92; P=0.001). After the intervention, the Black/White disparities decreased after adjusting for sociodemographics and the number of HIV care visits, and Latinos had greater odds than Whites of ART use and VS, adjusting for covariates.

Conclusions: The intervention improved overall ART treatment and VS, and reduced Black/White disparities. LHIE interventions may hold promise if implemented among similar patients.

Key Words:

health information exchange; Health IT Intervention; Racial/Ethnic Disparities; Antiretroviral Therapy; HIV Viral Load; HIV Outcomes; Electronic medical record / Electronic health record

INTRODUCTION

Potent antiretroviral therapy (ART) medications are widely available to treat people living with HIV (PLWH) and prevent transmission to partners in the community; however, ineffective communication between physicians, labs, and pharmacies may delay the delivery of ART, hamper viral suppression (VS) and contribute to racial disparities along the continuum of care.^{1,2} Blacks have the highest incidence of HIV infections, the highest prevalence of undiagnosed HIV and the greatest mortality among racial/ethnic groups.³⁻⁵ They are least likely to be linked to and retained in care, to receive ART, and to achieve HIV RNA VS.^{6,7} Latinos are disproportionately affected, as well. The annual incidence of HIV among Latinos is approximately three times that of Whites.⁸ Latinos are also more likely than Whites to be diagnosed with advanced disease⁹ and less likely to receive ART.^{10,11}

While the National HIV/AIDS Strategy emphasizes the need for innovative interventions to reduce HIV-related disparities, increase access to ART and improve outcomes along the continuum of care for PLWH,^{12,13} few interventions or policies have been shown to reduce racial/ethnic gaps in HIV treatment and outcomes. Facilitating the delivery of ART and achieving VS are critical to achieving these goals. Increasingly, health care providers adopt health information exchange (HIE) systems to help them maintain clinical information, laboratory test results, and ART prescription filling associated with HIV care visits.^{14,15} These systems work on top of existing electronic medical records (EMR).

While some evidence suggests EMRs help improve the quality of healthcare in general,¹⁶⁻¹⁸ the applicability of HIE to HIV care and the extent to which it can reduce disparities is less well studied.^{15,19} One recent study used a public health HIE system to alert providers of patients who had been out of HIV care when they presented to emergency departments in Louisiana.¹ A quality improvement (QI) project in New Jersey utilized a serial cross-sectional design to document improvement in four of seven QI indicators for HIV care and health status over two years after implementation of a web-based health information support system that included alerts to providers about indicated tests and treatment.¹⁴

Bell and colleagues previously reported on process of care changes after adding a laboratory health information exchange (LHIE) system to an existing EMR in a HIV care clinic. They found that when patients had clinically important increases in viral load (n=171), providers responded by changing the ART regimen an average of 6 days earlier after LHIE implementation than before.²⁰ Despite these findings, there is limited evidence that HIE systems improve ART use and VS outcomes. Furthermore, whether an HIE system intervention designed to improve care and outcomes for overall populations can also reduce racial/ethnic disparities in these outcomes has not yet been established.

This study had two main goals. First, we examined whether a novel, bi-directional LHIE intervention would increase the rates of ART use and VS. Second, we examined the effect of the intervention on racial/ethnic disparities in these outcomes, and identified factors contributing to the disparities among a stable cohort from a large HIV clinic in Southern California. We hypothesized that the LHIE intervention would increase the rates of ART use and VS overall, and reduce the magnitude of Black/White and Latino/White disparities in ART use and VS over the three year study period.

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METHODS

Study Design

To evaluate the effect of our bi-directional LHIE intervention on ART use and VS among a cohort of patients in HIV care, we employed a quasi-experimental, interrupted time series design over a three-year period. At the time of the study, no clinic of similar patient size and EMR system maturity was available to serve as a comparison clinic. Therefore, neither a randomized controlled trial, nor a two-sample interrupted time series was feasible. To diminish the possibility of spurious results from a pre-post design, we used an extended observational period. We collected baseline data prospectively one year pre-intervention and followed-up for two years post-intervention.

Setting and Participants

This study was conducted from December 2007 through November 2011 among PLWH receiving care at a HIV clinic in Southern California. Beginning December 2008 and continuing through January 2009, we developed and implemented a multi-level (i.e., operating at the system and provider levels) LHIE intervention and linked clinical, administrative, and pharmacy data from the EMR to create the analytic dataset. The dataset contained detailed information on patients' sociodemographic characteristics, HIV risk factors, clinical factors (CD4 count and HIV RNA VL), ART medications, and HIV care visits. Eligibility criteria were: (1) ≥ 18 years of age, (2) documented HIV-positive status, and (3) at least one face-to-face visit with a HIV provider during the one year pre-intervention period, and had at least one visit during the post-intervention study period. The final cohort included 1,181 PLWH who visited one of the following types of provider during the study period: physician, nurse practitioner, social worker, case-manager or adherence counselor. This study was approved by the Institutional Review Boards of UCLA and the participating clinic.

Intervention

The multi-level LHIE intervention study featured implementation of a bi-directional exchange of laboratory information (between ordering physician and laboratory staff) through an existing EMR system.²⁰ In the LHIE system, the provider uses the EMR to order labs. Upon receiving the electronic requisitions, the lab performs the tests, and deposits the results into the EMR. A color-coded system cues providers for action regarding any abnormal results.

Trainings accompanied the LHIE system enhancements. During the initial three months, physicians and staff underwent weekly trainings on the system and workflow changes. After launching the intervention, they moved to online tutorials; physician and administrative leaders continued meeting with staff bi-weekly for two additional months. The system programmer continued problem solving as needed.

Measures

Primary Outcomes. We measured monthly ART use, using pharmacy data on prescription fills, and VS, using laboratory data from VL tests. All ART regimens were potent combinations, according to standard criteria.²¹ We obtained all pharmacy records of ART prescriptions filled each month to construct a variable indicating ART use. We obtained all VL results conducted during the study period, to construct a variable for undetectable VL. Based on the detection threshold of the clinic's laboratory assay, undetectable VL, or VS, was operationalized as ≤ 75 copies u/L.

Covariates. Sociodemographic characteristics, HIV risk group and clinical factors were assessed as covariates. Sociodemographic characteristics included race/ethnicity, sex, age category, income level (federal poverty level [FPL]), and insurance status (private, Medicare, Medicaid, and uninsured). Race/ethnicity comprised four categories: non-Hispanic/Latino White

(referent), non-Hispanic/Latino Black, Hispanic/Latino, and other race/ethnicity, which included persons reporting non-Hispanic Asian/Pacific Islander and non-Hispanic Native American backgrounds. Additional covariates included HIV risk group, CD4 cell count level, and number of HIV care visits in the study period.

Survey Methods

The survey was described in detail previously.²⁰ Eligible participants were 18 years of age or older, documented HIV+, and received care onsite. We conducted face-to-face, anonymous, cross-sectional interviews before (November 2008; n=100) and after (February 2011; n=126) the intervention with consecutive patients recruited from clinic waiting rooms. The instrument included four *secondary outcome measures* on the patient-physician relationship: a 4-item general communication scale, a similar 4-item scale assessing communication about HIV-related lab tests (viral load and CD4 count), a 4-item provider trust scale, and a 2-item overall satisfaction with care scale.

Data Analysis

There were two sets of analyses: (1) longitudinal examination of EMR data with mediation analysis of intervention effects and (2) cross-sectional, pre/post survey data analysis of the four secondary survey measures.

In the longitudinal analysis, we examined the effects of the intervention on ART use, VS and racial/ethnic disparities in these outcomes. We conducted two parallel series of staged, multivariable logistic regression analyses with generalized estimating equations (GEE) and an exchangeable matrix to assess whether the intervention helped mediate the longitudinal relationship of race/ethnicity with (1) ART use, and (2) VS outcomes.²²⁻²⁴ GEE adjusts for the clustering of variance that results from both repeated assessments of patients over time and similarities among patients of the same providers. The forward model-building process began with race/ethnicity as the sole predictor. To this baseline bivariate model, Model A added the

other main predictor, the LHIE intervention indicator, and we assessed changes in the race/ethnicity adjusted odds ratio (AOR) and 95% confidence interval (95% CI). Model B added sociodemographic factors, HIV risk group and CD4 count. The final model, Model C, added the number of HIV care visits. Analyses were completed using STATA Version 11.0.²⁵ Given a baseline sample size of 1181, assuming 30% attrition, and 80% power (Type I error 0.05) the minimal detectable difference was 3.1% for ART and 8.5% for VL.

For the pre/post survey data analysis, we used one-way ANOVA with Duncan's Multiple Range adjustment²⁶ to compare racial/ethnic groups on the baseline and final interview scores, respectively, for each measure. Then, using two sample t-tests we compared the baseline and final interview scores within each racial/ethnic group. Finally, we examined multivariable linear regressions of each measure on race/ethnicity, risk group, income, homelessness, insurance status, and CD4 count, pre- and post-intervention.

RESULTS

Sample Characteristics

Non-Hispanic Blacks (22%), and Hispanic/Latinos (28%), made up more than half the sample (N=1,181) (Table 1). The majority of participants were males (89%), between ages 35-49 (59%), and MSM (68%). Approximately 47% had incomes at or below 100% of the FPL and 30% were uninsured. Two-thirds (66%) had a CD4 cell count less than 350 cells/mL and 17% reported three or fewer HIV care visits. Baseline levels of ART and VS did not differ significantly by race/ethnicity. Over the three-year period, ART use increased from 79% at baseline to 93%, and VS increased from 39% to 49%. The bivariate correlation between ART use and VL at baseline was 0.50, $P < 0.0001$.

ART Use

The intervention was associated with more than twice the odds of ART use in the baseline bivariate analysis (odds ratio [OR] = 2.22; 95% CI: 2.07 - 2.39; P=0.0001; Table 2). The magnitude of the association increased steadily across each model stage (A – C) that adjusted for additional sample characteristics (in the fully adjusted model, AOR = 2.50; 95% CI: 2.29 - 2.73; P=0.0001). Regarding racial/ethnic disparities, Blacks had 25% lower odds of ART use than Whites in the bivariate analysis (OR=0.75, 95% CI=0.58 – 0.98, P<0.05). In the next stage (Model A), which added the intervention indicator, the AOR for Blacks moved to AOR=0.83 with a confidence interval crossing the null (95% CI=0.65 – 1.07; P = 0.22), indicating the intervention mediated the decrease in the Black/White disparity. The final model (Model C) revealed a dose-response relationship between the number of HIV care visits and ART use: 1-3 visits (AOR=0.34; 95% CI=0.23 - 0.51; P<0.001) and 4-5 visits (AOR=0.42; 95% CI= 0.31 - 0.59; P<0.001) compared to those with \geq eight visits. Moreover, the intervention remained a significant predictor of ART use in the fully adjusted model. The bivariate association with ART use was not significant for Latinos; however, the point estimates increased and the 95% CIs narrowed with each subsequent model containing sociodemographic characteristics. In the fully adjusted model, the odds of ART use were 77% higher for Latinos than for Whites (Model C: AOR=1.77; 95% CI=1.36 - 2.31; P<0.001).

Viral Suppression (VS)

Overall, the odds of VS increased 16% and 12% in the bivariate and fully adjusted models, respectively, upon implementation of the intervention (Model C: AOR=1.12; 95% CI=1.04 - 1.21; P<0.01; Table 3). In the bivariate analysis of racial/ethnic disparities, Blacks had 25% lower odds of VS compared with Whites (OR=0.75, 95% CI=0.61 – 0.92; P<0.01). While the intervention variable did not initially eliminate this disparity, after adjustment for

sociodemographic characteristics and CD4 count, the magnitude of the Black/White disparity in VS decreased to AOR = 0.81 (95% CI = 0.66 – 1.00; P=0.05). Furthermore, in the final model that adjusted for the number of HIV care visits (Model C AOR=0.85; 95% CI= 0.69 – 1.05; P=0.14), the Black/White differences in VS were eliminated. A dose-response relationship between the number of visits and VS was also evident in this model (Model C): 1-3 visits in the previous year (AOR=0.26; 95% CI=0.17 – 0.41; P<0.001), 4-5 visits (AOR=0.38; 95% CI=0.28 – 0.50; p<0.001), and 6-7 visits (AOR=0.73; 95% CI=0.62 – 0.86; P<0.001), compared to those with ≥ 8 visits. As with the findings for ART use, the odds of VS were higher for Latinos than Whites in the fully adjusted model (Model C: AOR=1.33; 95% CI=1.11 – 1.59; P< 0.001), but not in the bivariate model. Furthermore, the intervention remained a significant predictor of VS in the fully adjusted model.

Patient-Physician Relationship Survey Results

We compared cross-sectional survey responses to the four patient-physician relationship measures between groups at baseline and within the racial/ethnic groups before and after the LHIE intervention (Table 4). At baseline Blacks reported the lowest scores on each of the four dimensions, but the disparity was only significant (P<0.05) for physician communication. Following the intervention, Blacks' scores were similar to the other groups' on every dimension. Correspondingly, Blacks' had the greatest improvement in scores for every dimension, although the only significant increase in mean scores was for Whites on the lab test communication scores (P=0.01). Multivariable analyses, pre- and post-intervention, produced similar findings: pre-intervention compared to Whites, Blacks had significantly lower scores for physician communication and overall satisfaction, while Latinos had lower trust (Table 4). Post-intervention, there were no difference by race/ethnicity on any measure.

DISCUSSION

One of the most vexing problems in the HIV epidemic is the persistence of racial/ethnic disparities along multiple steps of the care continuum. Most relevant to the current study, Blacks are less likely than Whites to receive ART medications, adhere to them, and have suppressed virus – the essential goals of care.^{7,27,28} We observed odds of ART use and VS that were approximately 25% lower among Blacks than Whites prior to implementation of our LHIE intervention, and a significant attenuation of the disparities after its implementation. In addition to closing the gap between Blacks and Whites, the intervention significantly increased ART use and VS over the three-year study period for all racial/ethnic groups. These findings were supported by the survey findings; while at baseline Blacks reported lower quality communication with physicians than others did, their scores increased after the intervention, eliminating Black/White differences in the scores. We submit that the intervention delivered key test results such as VL and CD4 count to the EMR more efficiently and facilitated communication about ART prescriptions and adherence, which together led to better outcomes.²⁹ Improved communication and satisfaction helped reduce disparities as the EMR delivered more timely, objective data enabling patients, especially Black patients, to follow recommendations.^{30,31}

These are important and unique findings because virtually no other intervention designed to improve overall HIV care has also helped reduce disparities in the outcomes. The findings raise important questions about how to achieve the combined goals of (1) fostering ART delivery and adherence in order to suppress VL for all patients, while (2) reducing racial/ethnic disparities in ART use and VS. Until now, many interventions have sought to achieve either one or the other of these two major goals of the National HIV/AIDS Strategy.¹³ For instance, interventions that are successful among Blacks typically were designed for this population and, therefore, may be less effective for others.³² Our study shows that an intervention designed to improve care for everyone, can have the added benefit of reducing Black/White disparities in

HIV care. This is a promising finding as race-specific interventions face challenges that practice-wide interventions such as ours do not face. The potential benefits of race-specific efforts may also depend on the groups being compared. Few interventions have focused on disparities in HIV care for Blacks. Some have reduced HIV risk behavior among Black MSM or MSMW;^{33,34} however, their dissemination and sustainability may be hampered by the limited financial support available for such interventions.⁷ The potential benefits of race-specific efforts may also depend on the groups being compared. As discussed below, the finding of better ART use and VS for Latinos than Whites in the final models is particularly salutary and remarkable.

Our LHIE intervention reflects broader changes in medical practice promulgated by the HITECH Act of 2009 (during this project's study period), which was part of the Obama administration's American Recovery and Reinvestment Act of 2009 (the so-called "Stimulus" legislation).³⁵ The HITECH legislation was enacted to incentivize "meaningful use"³⁶ of EMR-based technologies in clinical care, such as the LHIE. This interplay of effects may represent a rare example of the implementation of a technology policy – the LHIE intervention - having coincidental positive effect within the same clinical population on another policy goal: the National HIV/AIDS Strategy policy goals of improving outcomes along the care continuum, and reducing HIV care disparities.^{12,37,38}

While the intervention helped close the Black/White gap in ART use and VS, sociodemographic characteristics helped explain much of the remaining gap. Notably income (for ART use) and insurance status remained significant predictors in the final models. Thus, addressing social determinants of health – income inequality and insurance reform³⁹ – may be needed to eliminate these disparities. This suggestion is consistent with at least one recent modeling study of HIV incidence among Black MSM.^{3,4} _ENREF_1

In our final regression models, the number of HIV care visits was a significant predictor of both outcomes; it helped mediate the gap between Blacks' and Whites' ART use and VS. Thus,

interventions that improve engagement and retention in care may also help improve these outcomes and reduce disparities over and above a LHIE intervention. Somewhat surprisingly, ART use and VS increased over the study period to 77% and 33% greater, respectively, among Latinos compared with Whites in the two model stages that included sociodemographic characteristics. In the bivariate analyses, the odds of each outcome did not differ significantly between Latinos and Whites. This suggests that addressing social and economic factors may boost ART use and VS to a greater degree for Latinos than for Whites. The finding of greater improvements after the intervention for Latinos compared with Whites contrasts that of national studies,⁴⁰ as well as other studies in Los Angeles and California.⁴¹ Latinos compared with Whites generally have greater delays in HIV diagnosis⁴² and treatment,⁴³ lower ART use,⁴⁴ and lower VS rates than Whites.⁴⁵

The implications of our findings notwithstanding, there were several limitations. Although a RCT is the strongest design for causal inference, it was not possible to randomly assign participants to the LHIE intervention vs. control in this study; furthermore, no appropriate group existed to serve as a control. Therefore, we used the strongest available design, a time-series intervention with repeated measures and mediation analysis. As a single site study, this investigation may have limited generalizability to other clinics or geographic areas; however, the clinic is one of the largest in the second largest epicenter of the U.S. epidemic (Los Angeles metropolitan area). Like any longitudinal study, power to detect differences in outcomes comparing subgroups diminished with attrition over time. The design also cannot exclude the possibility that secular trends in combination and daily dosing ART medications affected the findings, although it is unclear that these would affect race/ethnic groups differentially. Our measure of ART use was based on filled prescriptions rather than direct data on medications consumed, such as electronic medication monitoring bottle caps.²⁸ Moreover, although the correlation between ART use and VS was high, there was a difference of about 40 percentage

points between the absolute rates of each. This gap likely represents non-adherence to prescribed ART medications. The rates of ART use and VS observed here are very similar to those reported in a recent HIV HIE study, adding support for the validity and generalizability of our estimates.¹⁴ Although data collection was completed more than 5 years ago, low rates of adherence to ART and low rates of VS continue to be major problems, especially among Blacks.^{28,46} HIE systems may be useful ways to improve care and outcomes that have not yet reached many clinical settings. Lastly, our measure of HIV care frequency should not be considered a strict measure of the frequency of physician care visits, generally known as retention in care, as we were unable to disaggregate physician visits from visits for supportive care, such as case-manager appointments. Although our frequency categories do not correspond to those of well-known standards in the field, which now consider as few as two physician visits per year adequate retention in care,⁴⁷⁻⁴⁹ our measure is closely related to them. That's because our measure includes supportive care visits, which standard measures of retention in care usually exclude.

Important strengths of our study design include its one-year pre-intervention observation period, three-year follow-up, which is longer than a typical one-year RCT, and our sample size of more than 1,000 participants, which is considerably larger than many single site RCTs.

In summary, improving the efficiency and accuracy of EMR-coordinated information exchanged between physicians, labs, and pharmacies may facilitate timely ART use and VS. This study provides evidence that a LHIE intervention can improve HIV care and health outcomes, and reduce disparities in an urban HIV clinic population. Future research should assess its effectiveness in other populations and settings.

Acknowledgements:

This research was supported by a grant from the Health Resource and Services Administration (HRSA-07-046; PI Dr. Marcia Alcouloumre). Dr. Cunningham received partial support for his time on this study from, NIH/NIA (P30-AG021684), NIH/NIMHD (P20-MD000182), and NCATS (TL1TR001883). Drs. Bell, Cunningham and Mr. Nakazono had partial support from the National Center for Advancing Translational Science (UL1TR000124). Dr. Ford received partial support from NIH/NINR 1 R01-N4014789-01. The funders had no role in the analysis and interpretation of data or in the writing of the manuscript. We are grateful to Dr. Marcia Alcouloumre, Medical Director, St Mary's Care Center, Dr. Lubabah Ben-Ghaly for presenting a poster of an earlier version, to Dr. Chi-hong Tseng for assistance with the power analysis, and to Jimmy Ngo for assistance in preparing the manuscript.

Conflicts of Interest: No authors have conflicts of interest to disclose.

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Table 1. Characteristics of HIV+ adults Participating in the Laboratory Health Information Exchange Intervention Study (N = 1,181).

Characteristics	% (n)
Race/ethnicity	
White	46 (546)
Latino/Hispanic	28 (332)
Black/African American	22 (256)
Other*	4 (47)
Sex	
Male	89 (1035)
Female	11 (146)
Age	
18-34	14 (164)
35-49	59 (702)
50+	27 (315)
HIV risk group	
MSM [‡]	68 (798)
IDU [§]	5 (65)
Heterosexual	13 (151)
Other	14 (167)
Annual Income (Federal Poverty Level)	
≤ 100% FPL	47 (454)
101%-200% FPL	37 (409)
201%-300% FPL	8 (151)
> 300% FPL	8 (167)
Insurance status¹	
Private	26 (295)
Medicare	20 (232)
Medicaid	21 (245)
Other public insurance	3 (37)
Uninsured	30 (338)
CD4 count^{†2}	

<50 cells/mL	5 (57)
50-199 cells/mL	34 (386)
200-349 cells/mL	27 (306)
350-499 cells/mL	14 (165)
≥ 500 cells/mL	20 (235)
Number of HIV care visits^β	
1-3	17 (200)
4-5	9 (101)
6-7	25 (299)
≥ 8	49 (581)
Anti-Retroviral Therapy Use	79 (933)
Undetectable Viral Load	39 (461)
Correlation between ART and Undetectable Viral Load³	0.50

Footnotes:

*Other race/ethnicity includes Asian/Pacific Islanders and Native Americans.

†Lowest recorded CD4 count

‡MSM is defined as men who have sex with men.

§IDU is defined as intravenous drug use.

|| FPL is defined as Federal Poverty Level, a measure of income relative to family size.

β During the follow-up period.

¹Missing n= 34

²Missing n= 32

³P < 0.0001

Table 2. Multivariable Logistic GEE Regressions of ART Use Over The Three Year Study Period with Race/Ethnicity, the Laboratory Health Information Exchange Intervention, and Covariates (N=1181)

Characteristics (reference group)	Bivariate Regressions [†]	Staged Multivariable Regressions [†]		
	OR (95%CI)	Model A AOR (95%CI)	Model B AOR (95%CI)	Model C AOR (95%CI)
Race/ethnicity (White)				
Black / African American	0.75 (0.58-0.98) [‡]	0.83 (0.65-1.07)	0.93 (0.71-1.23)	1.10 (0.82-1.49)
Latino / Hispanic	1.13 (0.88-1.45)	1.22 (0.97-1.54)	1.72 (1.33- 2.22)	1.77 (1.36-2.31)
Other*	1.28 (0.72-2.28)	1.06 (0.65-1.72)	1.90 (1.09-3.31) [‡]	1.93 (1.11-3.38) [‡]
LHIE intervention				
	2.22 (2.07-2.39)	2.26 (2.09- 2.43)	2.37 (2.18- 2.57)	2.50 (2.29-2.73)
Age (18-34)				
35-49	1.50 (1.15-1.96) [§]		1.61 (1.21-2.13) [§]	1.52 (1.13-2.05) [§]
50+	2.51 (1.81-3.48)		2.41 (1.70- 2.57)	2.21 (1.54-3.18)

		3.41)	
Gender (female)			
Male	0.96 (0.69-1.34)	1.26 (0.82-1.93)	1.60 (1.01-2.52) [‡]
HIV risk group (MSM)			
IDU	1.01 (0.64-1.60)	1.06 (0.67-1.69)	1.15 (0.71-1.85)
Heterosexual	1.00 (0.74-1.36)	1.11 (0.74-1.65)	1.56 (1.00-2.45) [‡]
Other	0.91 (0.68-1.21)	1.46 (1.00-2.11) [‡]	1.46 (0.99-2.16)
Insurance (private)			
Medicare	0.78 (0.56-1.08)	0.64 (0.45-0.93) [‡]	0.65 (0.44-0.96) [‡]
Medicaid	0.66 (0.48-0.91) [‡]	0.66 (0.45-0.95) [‡]	0.62 (0.42-0.91) [‡]
Other public insurance	0.66 (0.37-1.18)	1.79 (0.77-4.14)	2.03 (0.77-5.35)
Uninsured	0.41 (0.31-0.54)	0.38 (0.27-0.52)	0.34 (0.24-0.48)
Annual Income/FPL (> 300% FPL)			
≤ 100% FPL	0.47 (0.30-0.73)	0.55 (0.33-0.91) [‡]	0.50 (0.29-0.87) [§]
101%-200% FPL	0.72 (0.45-1.15)	0.84 (0.50-1.41)	0.82 (0.47-1.45)
201%-300% FPL	0.95 (0.51-1.78)	1.29 (0.67-2.46)	1.25 (0.47-1.45)

CD4 count (≥ 500 cells/mL)

<50 cells/mL	0.81 (0.51-1.30)	1.13 (0.68-1.89)	1.04 (0.61-1.76)
50-199 cells/mL	1.13 (0.85-1.50)	1.34 (0.99-1.80)	1.40 (1.02-1.92) [‡]
200-349 cells/mL	1.05 (0.78-1.42)	0.93 (0.69-1.26)	0.87 (0.64-1.20)
350-499 cells/mL	0.96 (0.67-1.36)	0.73 (0.52-1.03)	0.80 (0.56-1.15)

Number of HIV care visits (≥ 8)^β

1-3	0.29 (0.20-0.42)		0.34 (0.23-0.51)
4-5	0.40 (0.29-0.55)		0.42 (0.31-0.59)
6-7	0.88 (0.68-1.15)		0.93 (0.72-1.21)

Footnotes:

* Other race/ethnicity including Asian/Pacific Islanders and Native Americans.

[†]Bivariate GEE regressions including only the predictor variables shown in each row. Multivariable GEE regressions including covariates as shown in each model column - Model A: Race/ethnicity, Intervention; Model B: Race/ethnicity, Intervention, Age, Gender, Risk Group; Model C: Race/ethnicity, Intervention, Age, Gender, Risk Group, FPL, Insurance Type, Annual Income, CD4 count, and HIV Care Visits.

[‡] $p < .05$, [§] $p < .01$, ^{||} $p < .001$

[§]During the follow-up period.

Table 3. Multivariable GEE Regressions of Viral Suppression (VS) Over the Three Year Study Period with Race/Ethnicity, the Laboratory Health Information Exchange Intervention, and Covariates (N=1181)

Characteristics (reference group)	Bivariate Regressions [†]	Staged Multivariable Regressions [†]		
	OR (95% CI)	Model A AOR (95% CI)	Model B AOR (95% CI)	Model C AOR (95% CI)
Race/ethnicity (White)				
Black/African American	0.75 (0.61-0.92) [§]	0.76 (0.62-0.94) [§]	0.81 (0.66-1.00) [‡]	0.85 (0.69-1.05)
Latino/Hispanic	1.08 (0.92-1.28)	1.08 (0.91-1.28)	1.32 (1.11-1.58) [§]	1.33 (1.11-1.59) [§]
Other*	1.13 (0.79-1.63)	1.13 (0.79-1.63)	1.41 (0.97-2.05)	1.36 (0.94-1.96)
LHIE intervention	1.16 (1.09-1.25) [‡]	1.16 (1.09-1.27) [§]	1.15 (1.07-1.24) [§]	1.12 (1.04-1.21) [§]
Age (18-34)				
35-49	1.60 (1.28-2.00)		1.55 (1.23-1.96)	1.54 (1.23-1.95)
50+	2.45 (1.92-		2.37 (1.83-3.09)	2.22 (1.71-

	3.12)		2.88)
Gender (female)			
Male	1.08 (0.86-1.36)	1.19 (0.88-1.47)	1.17 (0.87-1.58)
HIV risk group (MSM)			
IDU	0.78 (0.57-1.07)	0.94 (0.67-1.32)	0.99 (0.70-1.39)
Heterosexual	0.98 (0.79-1.21)	1.22 (0.93-1.62)	1.21 (0.91-1.60)
Other	1.37 (1.10-1.72) [§]	1.79 (1.38-2.30)	1.67 (1.30- 2.16)
Insurance (private)			
Medicare	0.93 (0.76-1.15)	0.82 (0.65-1.05)	0.85 (0.66-1.08)
Medicaid	0.75 (0.61-0.92) [§]	0.74 (0.58-0.95) [§]	0.69 (0.54-0.88) [§]
Other public insurance	0.80 (0.53-1.20)	0.79 (0.52-1.22)	0.72 (0.47-1.09)
Uninsured	0.61 (0.51- 0.74)	0.70 (0.56-0.87)	0.68 (0.55- 0.85)
Annual Income/FPL (> 300% FPL)			
≤ 100% FPL	0.61 (0.47-	0.78 (0.57-1.06)	0.80 (0.59-1.08)

	0.79)		
101%-200% FPL	0.96 (0.73-1.25)	1.10 (0.81-1.49)	1.12 (0.82-1.52)
201%-300% FPL	0.94 (0.67-1.34)	1.01 (0.71-1.45)	1.07 (0.74-1.53)
CD4 count (≥ 500 cells/mL)			
<50 cells/mL	0.68 (0.46-0.99) [‡]	0.73 (0.50-1.06)	0.72 (0.49-1.05)
50-199 cells/mL	0.94 (0.77-1.15)	0.91 (0.74-1.12)	0.86 (0.70-1.06)
200-349 cells/mL	0.90 (0.73-1.11)	0.96 (0.78-1.20)	0.97 (0.78-1.20)
350-499 cells/mL	0.93 (0.72-1.18)	1.06 (0.82-1.36)	1.18 (0.91-1.52)
Number of HIV care visits (≥ 8)[§]			
1-3	0.28 (0.19-		0.26 (0.17-
	0.40)		0.41)
4-5	0.36 (0.27-		0.38 (0.29-
	0.46)		0.50)
6-7	0.77 (0.66-0.90) [§]		0.73 (0.62-0.86) [§]

Footnotes:

*Includes Asian/Pacific Islanders and Native Americans.

[†]Bivariate logistic GEE regressions including only the predictor variables shown in each row. Multivariable logistic GEE regressions including covariates as shown in each model - Model A: Race/ethnicity, Intervention; Model B: Race/ethnicity, Intervention, Age, Gender, Risk Group; Model C: Race/ethnicity, Intervention, Age, Gender, Risk Group, FPL, Insurance Type, Annual Income, CD4 Count, and HIV Care Visits.

[‡] $p < .05$, [§] $p < .01$, ^{||} $p < .001$

^β During the follow-up period.

ACCEPTED

Table 4. Bivariate and Multivariable Comparisons of Physician Relationship Measures between Racial/Ethnic groups, Pre- and Post-Intervention, and within Racial/Ethnic groups Over Time

Physician Relationship Measures (# items/scale; Alpha) ¹	Baseline, mean (n) (n=100)	Final, mean (n) (n=126)	Difference of means over time	Multiple Linear Regression Coefficient ³ pre - LHIE	Multiple Linear Regression Coefficient ³ post - LHIE
General communication (4; 0.92)					
White ^{&}	87.2 (51) ^{a,b}	90.3 (50)	3.1	Ref	Ref
Black	79.2 (16) ^b	89.6 (32)	10.4 [#]	-15.6 [‡]	-2.1
Latino	88.0 (30) ^{a,b}	89.5 (31)	1.5	-3.6	0.4
Other ⁺	100 (3) ^a	87.8 (13)	-12.2 [#]	NA	NA
Lab test communication[!] (4; 0.95)					
White	84.3 (51)	93.6 (39)	9.28 [‡]	Ref	Ref
Black	77.1 (16) [#]	89.3 (25)	12.25 [#]	-13.2	-5.1
Latino	82.2 (29)	90.4 (27)	8.26	-7.3	-0.3
Other ⁺	97.2 (3)	86.1 (12)	-11.12 [#]	NA	NA
Trust in Physician[!] (4; 0.94)					
White	90.2 (51)	92.4 (50)	2.18	Ref	Ref
Black	85.9 (16)	92.4 (32)	6.45	-3.0	-0.8
Latino	91.3 (30)	92.7 (31)	1.49	-12.6 [‡]	2.5
Other ⁺	97.9 (3)	89.9 (13)	-8.01	NA	NA
Overall Satisfaction with care[!] (2; 0.69)					
White	85.1 (51)	87.3 (50)	2.20	Ref	Ref
Black	73.4 (16) [#]	84.4 (32)	10.94 [#]	-20.2 [§]	-4.9
Latino	77.9 (30)	86.29 (31)	8.37	-12.3 [‡]	-0.6
Other ⁺	91.7 (3)	87.5 (13)	-4.17	NA	NA

Footnotes:

* Two-sample t-tests between baseline and final interview within each race/ethnic group

^{a, b}Means with the same letter are not significantly different, $P < 0.05$ in Duncan's Multiple Range Test.²⁸ Thus, Blacks had significantly lower communication scores only from Other race/ethnicity at baseline.

¹ None of the other means were significantly different from one another, $P > 0.05$.

⁺Other includes Asian, Pacific Islanders, Native Americans in analyses of the survey.

¹Cronbach's Alpha – internal consistency reliability

²Two sample t-tests compared the baseline and final interview scores within each racial/ethnic group

³Unstandardized coefficient of multiple linear regression of each scale on race/ethnicity, risk group, income, homelessness, insurance status, CD4 count.

[&] Other race was combined with White in the regression analyses because of small sample size

[#] $P < 0.10$, [‡] $p < .05$, [§] $p < .01$, ^{||} $p < .001$

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