Improving Engagement in HIV Care Using a Data-to-Care and Patient Navigation System in Louisiana, United States

Susannah Anderson, PhD, MPH* • Catherine Henley, MPH • Katherine Lass, MPH, LMSW • Samuel Burgess, MA, MSHCM • Eric Jenner, PhD, MMC

Abstract

An estimated 57% of persons living with HIV (PLWH) in the United States are not connected to regular medical care or have lapsed from regular care (Centers for Disease Control and Prevention, 2018), increasing risk of HIV progression and transmission and delaying viral suppression. The state of Louisiana has consistently ranked in the top five US states for HIV case rates. We evaluated the impact of a combined data-to-care and patient navigation system that was implemented in 3 cities in Louisiana from 2013 to 2015. The program, LA Links, used a surveillance system to identify PLWH who were not in regular health care and connected them to a patient navigator. During the intervention period, persons who lapsed from care were 17% more likely to reengage in care than persons in the comparison group, and persons newly diagnosed during the intervention period were 56% more likely to link to care.

Key words: discrete-time hazard analysis, linkage to care, out-of-care persons living with HIV, surveillance system

The Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, 2018) estimated that, at the end of 2015, 1.1 million persons aged 13 years and older were living with HIV in the United States. Early diagnosis of infection and connection to care are essential for addressing the significant burden of HIV, but many persons living with HIV (PLWH) in the United States are undiagnosed or are not connected to regular HIV care. Of those persons living with both diagnosed and undiagnosed HIV in the United States at the end of 2015, approximately 15% were unaware of their status; 57% were not retained in continuous care; and 54% were not virally suppressed (CDC, 2018).

For PLWH, the best health outcomes are achieved through systematic progression through the HIV care continuum—from HIV diagnosis to linkage to care, HIV treatment, and finally to viral suppression (Gardner, McLees, Steiner, Del Rio, & Burman, 2011). The first step in the HIV care continuum is to ensure that PLWH are diagnosed in a timely manner. This can be achieved through routine testing of all adolescents and adults, testing during pregnancy, and repeat testing of persons at higher risk of infection (Branson et al., 2006; Workowski & Bolan, 2015).

Once diagnosed, it is essential that PLWH are linked to HIV health care and provided with appropriate support to remain in care, and that they consistently receive antiretroviral therapy to achieve and maintain viral suppression. These steps result in reduced HIV-related morbidity and prevention of new infections through suppression of the viral load (VL; Panel on Antiretroviral Guidelines for Adults and Adolescents, 2019).

Although the structure of the HIV care continuum suggests linear and unidirectional movement from one step to the next, in reality, the framework is dynamic, and PLWH may not, for example, link to care immediately after diagnosis. Research also shows that PLWH often link to care, but then fall out of care for periods, interrupting treatment and reducing the likelihood of viral suppression (Kay, Batey, & Mugavero, 2016).

Maintaining consistent HIV care is associated with slowing the progression of disease, achieving viral suppression more quickly, and reducing the possibility of

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Susannah Anderson, PhD, MPH, is an Assistant Professor, Department of Social and Behavioral Sciences, Temple University College of Public Health, Philadelphia, Pennsylvania, USA. Catherine Henley, MPH, is a Lead Research Analyst, The Policy and Research Group, New Orleans, Louisiana, USA. Katherine Lass, MPH, LMSW, is a Lead Research Analyst, The Policy and Research Group, New Orleans, Louisiana, USA. Samuel Burgess, MA, MSHCM, is Deputy Director of Programming, STD/HIV Program, Louisiana Department of Health, New Orleans, Louisiana, USA. Eric Jenner, PhD, MMC, is Director of Research, The Policy and Research Group, New Orleans, Louisiana, USA.

**Corresponding author: Susannah Anderson, e-mail: susannah.anderson@temple.edu*

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HIV transmission (Crawford, Sanderson, & Thornton, 2014; Lancet HIV, 2017; Skarbinski et al., 2015). Given the role of retention in care and viral suppression in improving individual health outcomes and limiting population-level HIV incidence, there is a critical need to implement interventions that can increase the proportion of PLWH linked to and retained in continuous care.

Improving Linkage to and Reengagement in Care

Surveillance systems, which systematically track HIV diagnoses and $CD4^+$ T cell and VL laboratory results, can be used to calculate and monitor rates of PLWH linkage to, reengagement in, and continuous retention in HIV care at the state or local level. The use of surveillance data as a public health strategy has been termed "data-to-care" and was recommended by the Centers for Disease Control and Prevention (CDC) as the ideal tool for identifying people living with diagnosed HIV who have lapsed from care or who have not yet entered care (Sweeney et al., 2013). However, despite this capacity to identify out-of-care PLWH, there is limited evidence available on data-to-care interventions that effectively reengage PLWH in care (Brennan, Browne, & Horgan, 2014; Liau et al., 2013; Mugavero, 2016; Mugavero, Amico, Horn, & Thompson, 2013; Okeke, Ostermann, & Thielman, 2014).

In 2012, the Louisiana Office of Public Health STD/HIV Program (OPH SHP) received funding through the Care and Prevention in the United States Demonstration Project, a cross-agency project funded by the US Department of Health and Human Services Secretary's Minority AIDS Initiative Fund through the CDC, to use HIV surveillance data to improve linkage to and reengagement in HIV care for PLWH living in the state. At the time of project implementation, Louisiana ranked third highest in the United States for HIV (30.3 per 100,000) and AIDS (16.9 per 100,000) estimated case rates and 11th in the estimated number of HIV and AIDS cases. That same year, the Baton Rouge Metropolitan Statistical Area ranked third in the nation for estimated AIDS case rates and fourth for estimated HIV case rates. The New Orleans Metropolitan Statistical Area ranked fifth in estimated AIDS case rates and second in estimated HIV case rates (Centers for Disease Control and Prevention, 2015). Approximately 79% of persons newly diagnosed with HIV linked to care within 90 days of diagnosis. Of all diagnosed PLWH in Louisiana, 30% were identified as being out of care, and 70% were virally suppressed (Louisiana Department of Health and Hospitals Office of Public Health STD/HIV Program, 2013).

LA Links: Data-to-Care and Patient Navigation System

In September 2013, OPH SHP implemented Louisiana Links (LA Links), a combined data-to-care and patient navigation system, in New Orleans, Baton Rouge, and Shreveport. LA Links, which has been described (Sweeney et al., 2018), uses routinely collected HIV surveillance data and cross-references these data with other secondary data sources (e.g., vital records, incarceration records, and driver's license records) to identify PLWH who are not in care (NIC) and connects them to trained public health staff who help them navigate to critical health and support services. These services include HIV health care and social services that address other barriers to care, such as transportation, health insurance, or behavioral health. The LA Links system combines components from three evidence-based approaches for improving engagement in care: intensive outreach, linkage case management, and patient navigation services (Sweeney et al., 2018). Specifically, it aims to improve engagement in HIV care for three groups of PLWH: those who are newly diagnosed and NIC, those who are previously diagnosed and NIC, and those experiencing viral suppression failure. We assess the program's impact on persons experiencing viral suppression failure in a separate analysis.

LA Links uses HIV surveillance data to generate weekly line lists of PLWH living in New Orleans, Baton Rouge, or Shreveport, who were (a) newly diagnosed and NIC, defined as persons who have not had a $CD4^+$ T-cell or VL test and are 6–12 months after diagnosis or (b) previously diagnosed and NIC, defined as PLWH who have not had a $CD4^+$ T-cell or VL test recorded in 12–36 months. The line lists of eligible PLWH are then shared with linkage-to-care coordinators (LCCs). LCCs have backgrounds in nursing or social work and are trained in medication management, medical case management, and HIV treatment adherence counseling. LCCs attempt to contact individuals on their lists, explain the purpose of LA Links, and enroll PLWH in the program. Once enrolled, LCCs work with individual PLWH for 90 days or more, guiding them through the process of linking to or reengaging in care, offering treatment adherence counseling, and referring them to critical support and prevention services.

Our Study

In this article, we evaluate and report on the estimated impact of the LA Links system on linkage and reengagement rates in Louisiana for a population of

individuals who are known to be disengaged from care. Specifically, the research questions assessed in this study were as follows:

- Are newly diagnosed and NIC PLWH, living in regions where a data-to-care and patient navigation system is offered, more likely to link to care when the intervention is operational as compared to when only care-as-usual services are offered?
- Are previously diagnosed and NIC PLWH, living in regions where a data-to-care and patient navigation system is offered, more likely to reengage in care when the intervention is operational as compared to when only care-as-usual services are offered?

Method

The purpose of our evaluation was to determine whether implementation of a combined data-to-care and patient navigation system improved linkage and reengagement outcomes for PLWH who were NIC relative to when only care-as-usual services were offered. We examined these engagement outcomes causally using quasi-experimental methods for two separate populations of PLWH who were not engaged in the continuum of care: (a) newly diagnosed clients who had not yet linked to care and (b) previously diagnosed and out-of-care persons. LA Links was simultaneously implemented across Baton Rouge, New Orleans, and Shreveport. We assessed the effectiveness of the system through the "natural experiment" that was occasioned by the discrete shift of turning the system on. We compared outcomes for PLWH who were NIC when the system was operative and care-as-usual services were still being offered with PLWH who were NIC when only care-as-usual services were provided. To account for secular trends and time-variant changes in programs or policies, we conducted sensitivity analyses that included statistical controls for these factors.

Data

Data for the study came exclusively from the OPH SHP surveillance database. The database included demographic information and laboratory test results for all PLWH in Louisiana except for those who received care in Veterans Affairs facilities. The full set of individuals who were initially eligible for inclusion in the analytic study samples and included in the original data set consisted of records for 16,909 persons, which represented more than two-thirds of all PLWH in Louisiana. We converted these data into a person-period data set, in which each individual had one record for each month during the study period when they met study eligibility criteria but had not yet experienced the outcome of interest.

Eligibility and Selection

The general eligibility criteria for inclusion into our evaluation required that an individual (a) be diagnosed with HIV and included in the surveillance database; (b) be identified as living in one of the three regions (New Orleans, Baton Rouge, or Shreveport) where LA Links was implemented during the intervention or comparison periods; and (c) have an HIV diagnosis date or a $CD4^+$ T-cell or VL test between the study period of September 24, 2010, and October 17, 2015. Participants were then selected into one of two analytic samples based on whether they were newly diagnosed and NIC or previously diagnosed and NIC. Participants were selected into the newly diagnosed group and NIC sample (Group 1) if they met all three general eligibility criteria and transitioned into being newly diagnosed and NIC during the study period, operationally defined as having no recorded $CD4^+$ T-cell or VL test within 6 months of their HIV diagnosis date. Participants were selected into the previously diagnosed and NIC sample (Group 2) if they met all 3 general eligibility criteria, transitioned into being previously diagnosed and NIC during the study period, operationally defined as experiencing a 12-month gap between recorded $CD4^+$ T-cell or VL tests, and were not newly diagnosed or identified as being in treatment failure (having 2 recent VL tests with more than 1,000 copies per mL) in the same intervention or comparison period. In our benchmark analysis, we excluded from our Group 2 sample any individual who was categorized as out of care but who has only $CD4^+$ T-cell or VL test was their initial diagnosis test. These individuals would likely have been contacted by LCCs before transitioning into out-of-care status at 12 months.

Assignment to Intervention and Comparison Conditions

The initiation of LA Links was used as an assignment mechanism to allocate PLWH to either the intervention or comparison group. Individuals who met eligibility criteria during the 2-year period when LA Links was initially operational were assigned to the intervention group, and those who met the eligibility criteria during the 2-year period before LA Links implementation were assigned to the comparison group. A summary of selection and assignment rules for the two analytic samples and conditions is illustrated in Figure 1.

Pre-LA Links		LA Links	
Comparison		**Intervention**	
Group 1: Newly diagnosed and NIC Outcome of interest: Linkage to care			
Oct. 18, 2011	Oct. 17, 2013	Oct. 18, 2013	Oct. 17, 2015
All PLWH with data maintained in the surveillance database, identified as living in the public health regions where LA Links was implemented, were newly diagnosed in the 2 years prior to the implementation of LA Links, and did not have a CD4+ T cell or VL test on record in the first 6 months after diagnosis.		All PLWH with data maintained in the OPH SHP surveillance database, identified as living in the public health regions where LA Links was implemented, were newly diagnosed in the 2 years following the implementation of LA Links, and did not have a CD4+ T cell or VL test on record in the first 6 months after diagnosis.	
Group 2: Previously diagnosed and NIC Outcome of interest: Reengagement in care			
Sep. 24, 2011	Sep. 23, 2013	Sep. 24, 2013	Sep. 23, 2015
All PLWH with data maintained in the OPH SHP surveillance database, identified as living in the public health regions where LA Links was implemented, and were newly out-of-care in the 2 years prior to the implementation of LA Links but have not been newly diagnosed or identified as being in treatment failure during this 2-year period.		All PLWH with data maintained in the OPH SHP surveillance database, identified as living in the public health regions where LA Links was implemented, and were newly out-of-care in the 2 years following the implementation of LA Links but have not been newly diagnosed or identified as being in treatment failure during this 2-year period.	

Figure 1. Analytic sample eligibility and assignment. *Note.* NIC = not in care; PLWH = person(s) living with HIV; OPH SHP = Louisiana Office of Public Health STD/HIV Program.

OPH SHP initiated LA Links for previously diagnosed and NIC individuals earlier than for newly diagnosed and NIC individuals. The resulting intervention and comparison periods were, therefore, slightly different for the two samples. As depicted in Figure 1, the newly diagnosed and NIC study period ran from October 18, 2011 to October 17, 2015. The previously diagnosed and NIC study period ran from September 24, 2011 to September 23, 2015. The amount of time an individual could participate in either study period ranged from 0 to 24 months and was a function of the date on which they met eligibility and selection requirements and whether the outcome was realized in the study period or if they were censored out.

Outcome Definition

There were two outcomes of interest in the study: (a) linkage to care and (b) reengagement in care. Outcome variables were constructed from laboratory data, which included dates for any recorded $CD4^+$ T-cell or VL test. Linkage to care was operationally defined as having a $CD4^+$ T-cell or VL test in a study period after being categorized as newly diagnosed and NIC in the same study period (Bamford, Ehrenkranz, Eberhart, Shpaner, & Brady, 2010). A $CD4^+$ T-cell or VL test within 5 days of diagnosis was not considered linkage to care because some sites may not have administered $CD4^+$ T-cell or VL tests at the time of diagnosis; having the test within 5 days of diagnosis might not indicate linkage to sustained HIV health care. Reengagement in care was operationally defined as receiving a $CD4^+$ T-cell or VL test in a study period after being categorized as previously diagnosed and NIC in that same study period.

For statistical analysis, variables were reconfigured as dichotomous indicators of whether and in which month the outcome was realized. Briefly, once a participant met eligibility and selection criteria, the outcome indicator was coded as either a 0 or 1. For each of the discrete periods (months) that the outcome (linkage or reengagement to care) did not occur, the value for that period was coded 0. If the outcome did occur (as defined by the date of $CD4^+$ T-cell or VL test), the outcome indicator was coded as one for that discrete period. Using discrete-time hazard models (discussed below), we predicted the likelihood of linking to care or engaging in care for each period.

Care-as-Usual Services and Ancillary Programs Offered During the Study Period

The natural experiment used in our evaluation compared outcomes for persons who became either newly diagnosed and NIC or previously diagnosed and NIC

during the time of LA Links program implementation to outcomes for persons who entered into either of those statuses in the 2 years before program implementation. Other HIV care available to PLWH in the areas served by LA Links before and during program implementation included (a) care-as-usual services through community-based HIV organizations; (b) the OPH SHP Partner Services program, in which disease intervention specialists identified and counseled newly diagnosed PLWH and encouraged them to link to health care; and (c) several short-term, pilot linkage and retention programs. Care-as-usual services varied in each region, depending on the funding and identified needs of each area, but generally included case management, dental care, direct emergency financial assistance, housing assistance, medication assistance, mental health therapy and counseling, nutrition services, outreach, substance abuse treatment and counseling, and transportation assistance. Care-as-usual services and the OPH SHP Partner Services program were available to PLWH throughout the comparison and intervention periods.

In addition to care-as-usual services, the OPH SHP identified three pilot linkage and retention programs implemented during the study period in similar geographic areas. An agency network linkage and retention strategy (Positive Charge) was offered to PLWH from August 2010 to July 2014; a bidirectional public health and medical record data sharing system (Louisiana Public Health Information Exchange) was in place in select medical facilities from 2009 through the end of the study period; and a pay-patients-for-performance intervention (Health Models) was implemented in several HIV health care clinics from September 2013 to September 2015. We conducted sensitivity analyses (described below) that statistically controlled for the potential effects of each of these programs on our outcomes.

Statistical Analysis

We first conducted baseline equivalence analysis to determine whether there were any statistically significant differences between the treatment and comparison groups. Measures of difference were reported in terms of mean differences in pooled *SD* units for theoretically relevant and available baseline characteristics and were calculated according to Hedges' *g* effect size formula.

We assessed the impact of LA Links on linkage to care and reengagement in care using discrete-time hazard models. We used this statistical technique to estimate the impact of the system in terms of the relative risk of linking to or reengaging in care for each condition. We inferred impact if the parameter of interest, β_1, was statistically significant (using a 2-tailed test where $p < .05$). If the parameter estimate was in the hypothesized direction and substantial, we had evidence that the system was meaningfully improving linkage/reengagement outcomes for the study population. The discrete-time hazard model was well suited for data such as these, which include censored observations where the sample includes members who do not experience the event during the study period and, therefore, have unknown event times.

Before selecting a preferred analytic model, we explored several specifications for the effect of time and covariate inclusion. These statistics are reported in Supplemental Digital Content (Tables 1 and 2, http://links.lww.com/JNC/A4) along with the identification of the preferred analytical model. Model selection statistics indicated that the third- and fifth-degree polynomials were optimal; however, we reported the general specifications of time because they had fewer restrictions, were the most accurate reflections of the data (least deviance), and were easier to explain. The results for the general specification were substantively identical to the polynomial functions. Goodness-of-fit statistics indicated that the preferred model for Group 1 should not include covariates, but for Group 2 should include covariates.

We conducted several sensitivity studies to assess the robustness of our design and analytic decisions. Because the comparison period directly preceded the intervention period, we assessed for the presence of a secular trend in our outcomes over time by including a calendar indicator in our model. This variable captured the effects of any cumulative improvement in outcomes associated with when an individual became eligible for LA Links during the entire study period, regardless of membership in the intervention or comparison groups. Additional sensitivity analyses conducted were (a) excluded (linkage model) or included (reengagement model) individuals from the sample who were in virologic failure; (b) included a covariate to control for individuals who were exposed to Louisiana Public Health Information Exchange (linkage and reengagement models); (c) included a covariate to control for individuals who were exposed to Positive Charge (linkage and reengagement models); (d) excluded individuals who were exposed to Health Models (linkage and reengagement models); (e) modified the definition of out of care from 12 to 13.5 months without a $CD4^+$ T-cell or VL test (reengagement model only); and (f) included individuals diagnosed in the year before the study window (reengagement model only). All analyses were conducted in STATA 13 (StataCorp, 2013). Our study was part of a larger project determined

by the CDC not to constitute human participant research; therefore, institutional review board approval was not required.

Results

A total of 843 persons met the inclusion criteria for the newly diagnosed and NIC sample, of whom 314 linked to care during the study period. In the previously diagnosed and NIC sample, 5,714 persons met the inclusion criteria, of whom 2,404 linked to care during the study period. In both samples, approximately half of eligible persons resided in the New Orleans area; approximately one third resided in the Baton Rouge area; and the remainder resided in the Shreveport area. Newly diagnosed persons in the intervention group were more likely to link to care than those in the comparison group (43% vs. 33%, $p < .001$), and they linked to care more quickly (156 vs. 184 days). Previously diagnosed persons in the intervention group were also more likely to reengage in care than those in the comparison group (44% vs. 40%, $p < .001$) and in a shorter period (133 vs. 141 days).

Equivalence of the Intervention and Comparison Groups

Baseline equivalence tests indicated that the intervention and comparison groups were well-balanced (Tables 1 and 2). For most of the observed covariates, the standardized mean difference was remarkably small, especially when we remember that the groups had not been synthetically matched or weighted. The similarity of intervention and comparison groups was entirely a function of the natural experiment assignment. The previously diagnosed and NIC sample was uniformly balanced across all background characteristics, including sex, which reflected the proportionate breakdown of all PLWH in the state, where men were 3 times more likely to have HIV than women (Louisiana Department of Health and Hospitals Office of Public Health STD/HIV Program, 2013). Location of diagnosis in the newly diagnosed and NIC sample was the only baseline covariate that appeared imbalanced (>0.25). Proportionately, more participants in the comparison group were diagnosed in an unknown location, and in the intervention group, more individuals were diagnosed in an inpatient facility or hospital. One possible explanation for this difference may be the proximity in time of the comparison period to the displacement effects of Hurricane Katrina. Another related hypothesis is that the imbalance was in the data (i.e., measurement error due to miscategorization that persisted after the storm).

The intervention and comparison groups were well-balanced with regard to participant sex, although men represented a greater proportion of both samples. Our sample reflected the distribution of HIV infection in Louisiana, where men comprised a greater proportion of PLWH as well as new HIV and new AIDS diagnoses (Louisiana Department of Health and Hospitals Office of Public Health STD/HIV Program, 2013). We adjusted for sex in our analyses and did not find differences in program impact based on participant sex.

Program Impact

Results from our preferred statistical models indicated that implementing a combined data-to-care and patient navigation system had a significant and meaningful impact on linkage and reengagement outcomes. Table 3 describes impact effects from the preferred models in likelihood ratio terms. Full model results are reported in Supplemental Digital Content (Tables 1 and 2, http://links.lww.com/JNC/A4).

Persons living with HIV who were newly diagnosed and NIC during the intervention period were 56% more likely (adjusted hazard ratio [aHR]: 1.56; 95% confidence interval [1.24–1.96]) to link to care as PLWH meeting the same criteria in the comparison period. That is, for every 10 newly diagnosed people who linked to care in the care-as-usual system, 16 linked to care when the combined data-to-care and patient navigation system was operational.

Results were similar but more modest for previously diagnosed PLWH. Estimates suggested that, because of the intervention, previously diagnosed and NIC individuals were 17% more likely (adjusted hazard ratio: 1.17; 95% confidence interval [1.08–1.27]) to reengage in care when the combined data-to-care and patient navigation system was in place. To extend the example above, for every 10 previously diagnosed but out-of-care PLWH who linked to care in the care-as-usual system, 12 PLWH linked to care when the combined data-to-care and patient navigation system was operational.

Likelihood of Engaging in Care Over Time

One way of visualizing the impact is to plot conditional probabilities of linking to or reengaging in care for the contrasted conditions for each month of predicted exposure. The top two panels of Figure 2 illustrate the estimated conditional probability of linking to care (left panel) and reengaging in care (right panel). These conditional probabilities were produced by our preferred models. The lighter line on top illustrates the month-to-

Table 1. Baseline Equivalence of Comparison and Intervention Groups, Newly Diagnosed Sample

	Comparison (n = 482)	Intervention (n = 361)	Standardized Difference
Age			
Age at HIV diagnosis	33.2	33.2	0.00
Age at study entry	33.7	33.7	0.00
Race			
Black/African American	76.3%	77.6%	0.03
White	17.4%	15.5%	−0.05
Other	6.2%	6.9%	0.03
Ethnicity			
Hispanic/Latino	5.2%	4.7%	−0.02
Sex			
Male	80.3%	79.8%	−0.01
Female	17.8%	19.7%	0.05
Transgender	1.9%	0.6%	−0.12
Location of HIV diagnosis			
Blood bank	3.5%	3.0%	−0.03
Family planning/OBGYN clinic	1.0%	0.6%	−0.05
HIV clinic/counseling and testing site	14.9%	15.2%	0.01
Emergency department	11.8%	12.7%	0.03
Corrections facility	6.2%	5.0%	−0.05
Drug treatment center	0.0%	0.8%	0.13
Inpatient facility/hospital	9.3%	17.7%	0.25
Unknown (out-of-state)	23.7%	9.1%	−0.40
Outpatient facility/clinic	16.4%	19.9%	0.09
Infectious disease/STD clinic	12.0%	15.8%	0.11
Other	1.0%	0.0%	−0.14
Public health region of residence			
1	53.3%	46.3%	−0.14
2	29.9%	34.6%	0.10
7	16.8%	19.1%	0.06
Mean percent of individuals in zip code			
Living in poverty	25.8%	25.7%	−0.01
Without health insurance	18.7%	18.4%	−0.04
Unemployed	6.5%	6.4%	−0.01

(*continued on next page*)

Table 1. (*continued*)

	Comparison (n = 482)	Intervention (n = 361)	Standardized Difference
With at least a high school education	82.9%	83.6%	0.11
Who take public transportation to work	5.1%	4.7%	−0.09
Who walk to work	4.2%	4.2%	−0.00

The following are WWC Standards for establishing baseline equivalence according to standardized differences: ≤0.05 equivalence established; >0.05 to ≤0.25 equivalence established with statistical adjustment; and >0.25 equivalence not established.
Note. OBGYN = obstetrics/gynecology; STD = sexually transmitted disease; WWC = What Works Clearinghouse.

month risk of linking to care or reengaging in care, respectively, when LA Links was operational, while the darker line illustrates the same when only care-as-usual services were offered. The vertical distance between the two lines is a visual representation of the impact of the system at each discrete period. Month 1 in each graphic represents the point in time when each individual met the study eligibility criteria and entered the sample. In the top left panel, there is a predicted 7.5% likelihood of linking to care in the first month when care-as-usual services were offered; however, when the data-to-care and patient navigation system was operational, probability of linking to care in the first month was nearly 12%. For the previously diagnosed sample, the impact was more modest but still significant. Participants who became NIC while care-as-usual services were offered were predicted to have a 12% likelihood of reengaging in care in the first month, while those who became NIC when the new system was operational were expected to have an almost 14% probability of reengaging in care.

The bottom panels of Figure 2 plot the cumulative probability of remaining out of care. The lighter line illustrates the month-to-month risk of the intervention group remaining out of care, while the darker line illustrates the same for the comparison group. The vertical distance between the two lines is a visual representation of the impact of the system over time, that is, it shows the difference in likelihood of linking to care between the intervention and comparison groups. After 2 years, newly diagnosed and NIC individuals in the intervention group had a greater than 60% probability of linking to care, whereas comparison participants only had a 45% probability. Model estimates indicated that at the end of 2 years, previously diagnosed and NIC individuals in the intervention group had a 60% chance of reengaging in care compared with a 54% chance for those who were only exposed to care-as-usual services.

Substantive findings produced by the preferred models persisted after conducting all planned sensitivity analyses that tested for the possibility that other factors, aside from LA Links, influenced our outcomes of interest over time. In addition to specifying the analytic model with and without additional covariates and regional controls, to assess the robustness of our estimates, we included sensitivity tests for all known state and regional linkage programs that may have been operational in New Orleans, Baton Rouge, and Shreveport during the study period. None of the alternative programs were totally confounded with the LA Links intervention. We also conducted tests to examine the possibility that a secular trend of improved linkage over time might explain the observed outcomes. Results, however, were substantively identical. In both the newly diagnosed and previously diagnosed samples, the inclusion of a linear trend indicator increased the magnitude of the intervention effect, and this estimate remained significant.

Discussion

Our findings show that LA Links had a positive, statistically significant, and meaningful impact on linkage to care and reengagement in care. Newly diagnosed individuals exposed to the combined data-to-care and patient navigation system were 56% more likely to link to care, and previously diagnosed individuals were 17% more likely to reengage in care than those exposed to the care-as-usual system.

We addressed a significant gap in the literature on interventions that affected reengagement in HIV care. The CDC has recommended use of surveillance systems to track diagnoses (Sweeney et al., 2013), but most linkage programs target individual-level factors (Liau et al., 2013). Research has demonstrated the effectiveness of patient navigation systems and case management

Table 2. Baseline Equivalence of Comparison and Intervention Groups, Previously Diagnosed Sample

	Comparison (n = 2,676)	Intervention (n = 3,038)	Standardized Difference
Age			
Age at HIV diagnosis	33.3	32.6	−0.06
Age at study entry	43.2	43.1	−0.01
Race			
Black/African American	73.1%	71.2%	−0.04
White	22.8%	24.4%	0.04
Other	4.1%	4.4%	0.01
Ethnicity			
Hispanic/Latino	2.8%	2.9%	0.01
Sex			
Male	67.6%	68.1%	0.01
Female	31.1%	30.5%	−0.01
Transgender	1.3%	1.3%	0.00
Location of HIV diagnosis			
Blood bank	2.0%	1.9%	−0.01
Family planning/OBGYN clinic	0.6%	1.0%	0.04
HIV clinic/counseling and testing site	5.3%	6.9%	0.07
Emergency department	3.6%	4.1%	0.02
Corrections facility	4.9%	4.6%	−0.01
Drug treatment center	0.3%	0.3%	0.00
Inpatient facility/hospital	22.5%	21.9%	−0.01
Unknown (out-of-state)	17.2%	17.3%	0.00
Outpatient facility/clinic	22.8%	22.3%	−0.01
Infectious disease/STD clinic	20.1%	19.2%	−0.02
Other	0.7%	0.5%	−0.03
Public health region of residence			
1	50.8%	51.6%	0.02
2	36.0%	34.4%	−0.03
7	13.2%	14.0%	0.02
Mean percent of individuals in zip code			
Living in poverty	25.8%	25.7%	−0.01
Without health insurance	18.6%	18.5%	−0.02
Unemployed	6.5%	6.5%	0.01

(*continued on next page*)

Table 2. (*continued*)			
	Comparison (*n* = 2,676)	**Intervention (*n* = 3,038)**	**Standardized Difference**
With at least a high school education	82.3%	82.6%	0.05
Who take public transportation to work	4.9%	4.8%	−0.01
Who walk to work	4.1%	4.2%	0.02

The following are WWC Standards for establishing baseline equivalence according to standardized differences: ≤0.05 equivalence established; >0.05 to ≤0.25 equivalence established with statistical adjustment; and >0.25 equivalence not established.
Note. OBGYN = obstetrics/gynecology; STD = sexually transmitted disease; WWC = What Works Clearinghouse.

(Higa, Crepaz, & Mullins, 2016; Liau et al., 2013; Okeke et al., 2014). We built on previous research in our description of an effective systems-level approach to improving linkage to and reengagement in care that used surveillance systems to identify persons who had lapsed from care or who had never linked to care, to provide patient navigation services. The results should prove broadly useful because there is an absence of published empirical work that has examined the combined efficacy of linkage and reengagement interventions (Higa et al., 2016).

Findings indicated that the data-to-care and patient navigation system had a more substantial impact on newly diagnosed individuals versus previously diagnosed PLWH. The program could be particularly beneficial for newly diagnosed PLWH because it addresses specific barriers to initiating care for newly diagnosed PLWH. Staff delivering the intervention were trained to provide information about accessing HIV care and guiding individuals through the process of identifying providers and making appointments. Research has indicated that some reasons for delayed entry into care after HIV diagnosis include having limited or inaccurate information about HIV care, available services, and importance of treatment, and feeling overwhelmed or ashamed of their HIV status, but that active referrals, whereby a trained individual helps connect the newly diagnosed individual to care, are desired (Garland et al., 2011; Mayer, 2011). The LA Links program offered such targeted navigation to facilitate connection to care.

Table 3. **Risk of Linkage to and Reengagement in Care, Preferred Models for Both Samples**			
	Hazard Ratio	**95% CIs**	***p* Value**
Linking to care	1.56	1.24–1.96	<.001
Reengaging in care	1.17	1.08–1.27	<.001

Note. CI = confidence interval.

For previously diagnosed individuals who lapsed from regular care, the data-to-care and patient navigation system had a significant but more modest impact. Previously diagnosed individuals who fell out of care during the intervention period were more likely to reengage in care and reengage earlier than those who fell out of care during the care-as-usual period. The literature suggested that individuals disengaged from health care faced appreciably more barriers than PLWH who remained in care, and these barriers inhibited successful retention in care (Berger et al., 2016; Tobias et al., 2007; Yehia et al., 2015). These findings point to a need to provide more robust services to the previously diagnosed and NIC group to address the elements inhibiting engagement (Liau et al., 2013).

Methodologically, our study contributes to the literature by using a quasi-experimental design that minimizes selection bias. Random assignment was not possible. We considered alternative designs that included the use of matched contemporaneous intervention and comparison groups. However, matching data were deemed insufficient (only basic demographic data and location of diagnosis were available at baseline), and there were no arguably equivalent comparison groups because the system was conducted regionwide. Even if sufficient matching data were available, empirical research suggests that a matched comparison with participants from another region would not have removed unobserved selection bias. Research has demonstrated that quasi-experimental studies must use a comparison group that is in close geographic proximity to the treatment group to be causally valid (Bloom, Michalopoulos, & Hill, 2005; Cook, Shadish, & Wong, 2008; Glazerman, Levy, & Myers, 2003).

Rather than relying on matching or weighting, we aimed to produce causal estimates of the effect of the

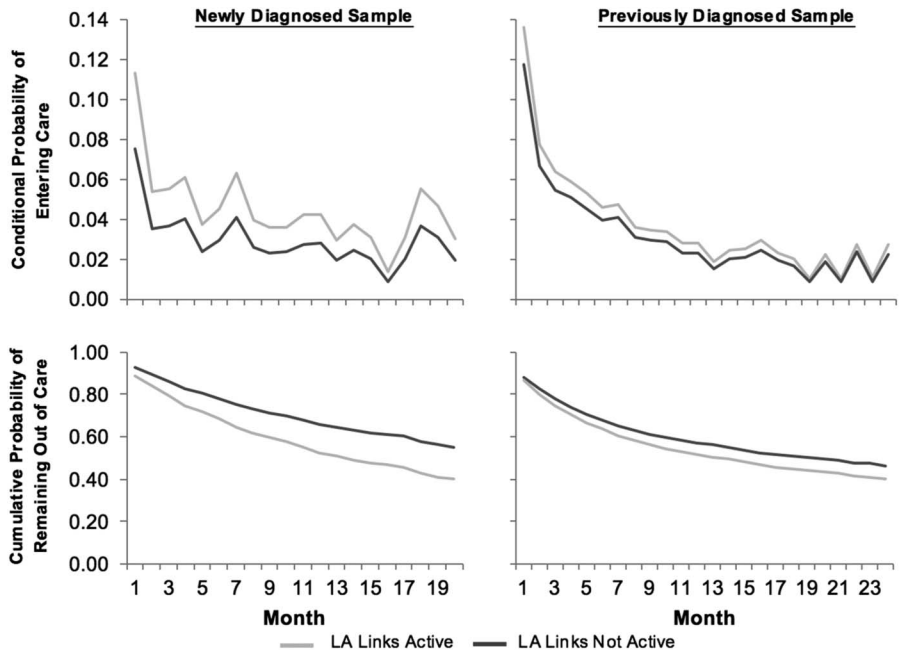

Figure 2. Month-by-month conditional probability of entering care and cumulative probability of remaining out of care for both samples, by intervention and comparison groups. *Note*: Month one represents the first month that an individual in the sample transitions to out-of-care status, which may occur at any point during the intervention or comparison windows. Months 21–24 are not included in the newly diagnosed sample figures because no events occurred during these months.

system by comparing outcomes for people who lived in the same regions before and after the system was implemented. We implemented a natural experiment that capitalized on the exogenous assignment of individuals to intervention and comparison conditions. The assignment mechanism created groups that were well-balanced across most baseline characteristics. Without random assignment, we cannot know the distribution of unobserved characteristics, but this equivalency is compelling evidence that the estimated impacts were not attributable to preexisting differences in the two groups. Nor was selection bias lurking beneath a set of statistically balanced observed covariates. The comparison group was not synthetically matched nor was it comprised of PLWH who selected out (or were selected out) of the intervention group. Moreover, the comparison and intervention groups came from the same regions. The balance that we observed at baseline was a product of the assignment mechanism alone. Findings were robust to alternative specifications. Benchmark effects persisted with alternative model specifications, alternative explanatory factors, and the inclusion of a secular trend variable. Our use of a natural experiment demonstrated how an empirical approach can be used to produce causal estimates in a case when only administrative data are available and covariates are too limited to assume ignorable treatment assignment.

As is detailed in the analytic approach below, our evaluation did not estimate the effect of directly receiving LA Links services; it estimated the average effect of the data-to-care and patient navigation system on all eligible PLWH. The contrast, in other words, was not the receipt of different services but the set of services offered by two competing systems. This approach was attractive because it produced the broadest estimate of the impact of the treatment system, one that was relevant to policy decisions, and because it mitigated selection effects that would be present in more targeted estimates.

The evaluation had several real limitations. First, it remains possible that historical factors may have influenced benchmark impact estimates. If changes in or efficacy of services for PLWH occurred during the study period (2011–2015) and we failed to account for these services (adequately) in our models, results will be biased upward. Second, it is also possible that unobserved characteristics of PLWH in these regions changed over time. If this is true, the internal validity of the estimates from our preferred models could be undermined by selection effects. Third, the eligibility inclusion criteria or error in data may have lead to nondifferential misclassification of sample members in the intervention or comparison groups, which could attenuate or exaggerate impact estimates. Fourth, the evaluation investigates the impact of a combined data-to-care and patient navigation system in a few regions in a single state. Generalizing findings beyond these populations and settings may not be justified. The population that is represented

in our analytic samples may be more—or less—responsive to the intervention than other populations.

Because intervention and comparison groups were separated in time, impact estimates were subject to bias from historical effects. We accounted for two distinct types of historical influence in our empirical models. We used time-variant program indicator variables to statistically control for known alternative programs that could have influenced linkage or reengagement outcomes differentially for the intervention and comparison groups. Estimates of impact remained substantively unchanged with the inclusion of each of these control variables. Because historical bias need not be episodic, we also allowed for the possibility that outcomes were improving gradually over time, for reasons other than the LA Links system being investigated here. Intervention and comparison groups could have been differentially influenced by a secular trend of more effective services, or reduced barriers, over time. For example, systemwide transformations of available services, such as shifts in national or state budget allocations for HIV service provision, the implementation of the Affordable Care Act, or changes in insurance coverage for antiretroviral therapy, could influence effect estimates. We statistically accounted for this by including a term that controlled for a linear improvement in linkage and reengagement outcomes over the duration of the study period. Even with this term included in both empirical models, however, estimates of impact remained substantively unchanged.

Additional studies are needed. A confirmatory study, such as a small scale randomized controlled trial, could validate our results by removing the questions of unobserved differences and the possibility of historical effects. Exploratory and qualitative research could help better understand dose–response relationships and which PLWH are more influenced by the intervention and why. This could make the system more effective and broaden its impact. A cost study could also highlight whether the intervention is sufficiently cost-effective to warrant allocation of limited resources. In any case, the findings have policy relevance for development or implementation of successful linkage and reengagement programs. Our research addressed a priority public health issue at the state and national levels (the need to better understand how to link, reengage, and retain PLWH in continuous care) and provided insight into a field lacking evidence (Brennan et al., 2014; Higa et al., 2016; Liau et al., 2013; Mugavero et al., 2013; Okeke et al., 2014).

The components necessary to replicate our combined data-to-care and patient navigation intervention are limited, requiring a functional HIV surveillance system and several dedicated and trained public health staff, and represent a means to focus services on individuals who are out of care and potentially reduce health disparities.

Key Considerations

- For PLWH who are newly diagnosed and have not yet linked to care, data-to-care programs that use surveillance in combination with patient navigation may be an effective method for identifying newly diagnosed persons and connecting them to needed services.
- For PLWH who have lapsed from regular medical care, data-to-care programs that use surveillance in combination with patient navigation may be an effective method for identifying out-of-care persons and connecting them to needed services.
- Data-to-care programs that identify PLWH who are not in regular health care may represent a strategy for reducing health disparities related to HIV by identifying persons who are most in need of services and connecting them to care.

Conclusion

Our findings suggest that LA Links may be an effective intervention to link and reengage individuals in HIV care. Despite potential limitations, the results provided compelling evidence that an intervention using surveillance data to identify and contact out-of-care PLWH coupled with navigation services and treatment adherence counseling to connect them to health care and support services, increases the likelihood that newly diagnosed PLWH will link to care, and previously diagnosed PLWH will reengage in care.

Disclosures

The authors report no real or perceived vested interests related to this article that could be construed as a conflict of interest.

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