CHAIN 2013-3 Report

Models of Care: Service Linkages and HIV outcomes

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C.H.A.I.N. REPORT

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Introduction

Achieving the goals of Ending the Epidemic, as recognized by the National HIV/AIDS Strategy and an increasing number of state and jurisdictional plans (NASTAD, 2019), will require integrated systems of care that address all dimensions of wellness, not only diagnosis and treatment of disease but also social and economic factors that affect the well-being of those most affected by the epidemic (Valdiserri, 2018). Through advances in prevention, diagnosis, and treatment in the past three decades, people living with HIV (PLWH) receiving proper care are beginning to approach the life expectancy of uninfected individuals (Nakagawa, May, & Phillips, 2013). However, many PLWH have complex needs that cut across different health-care sectors including an array of chronic illness comorbidities (cardiovascular disease, diabetes, respiratory disease) as well as mental health and/or problem drug use (Bing et al., 2001; Guaraldi et al., 2011; Haldane et al., 2018; Wainberg, McKinnon, & Cournos, 2014). Equally important, challenges to securing and maintaining basic needs for housing, food, transportation, financial security and supportive services have been shown to have a significant negative impact on engagement in HIV care, clinical outcomes, and quality of life for PLWH (Aidala, Yomogida, & Kim, 2016; Centers for Disease Control and Prevention, 2018; Institute of Medicine, 2012; Weiser et al., 2011).

While the need for integrated or coordinated services has been widely recognized, the evidence base evaluating effects of service integration for individual patients is limited (Chuah et al., 2017; Haldane et al., 2018; Higa, Marks, Crepaz, Liau, & Lyles, 2012; Soto, Bell, & Pillen, 2004). Haldane et al. (2018) provided a review of interventions integrating care for HIV, hypertension, diabetes, and cardiovascular disease, and argued that the extant literature is made up of mostly descriptive papers unable to reveal program effectiveness. Similarly, Chuah et al. (2017) identified several studies documenting positive outcomes associated with integrating HIV and mental health services, but they identified a lack of evaluation of integration efforts that consider long term patient health outcomes. However, there is progress being made. The U.S. Health Resources and Services Administration (HRSA) HIV/AIDS Bureau funded a national initiative to establish and evaluate patient-centered medical homes (PCMH) to better integrate multiple medical, behavioral health, and social needs among homeless or unstably housed PLWH; preliminary results showed the benefits of integration of services on health outcomes (Phillips et al. 2018; Sarango et al. 2018).

An important contributing factor to the lack of consistent evidence on outcomes of service integration for PLWH relates to conceptualization and measurement issues. One concern is that there are a wide variety of definitions and measures of service integration used by researchers and practitioners (Armitage, Suter, Oelke, & Adair, 2009; Shigayeva, Atun, McKee, & Coker, 2010; Singer et al., 2011). These differences in data sources and measurement tools then limit cross-study comparisons. Reviews of the integration literature indicates that most studies focus on perceived benefits of integration as reported by managers and service team members, which can provide useful descriptive process measures with the potential for positive outcomes for patient care. However, studies that include actual patient outcome measures are limited (Armitage et al., 2009; Chuah et al., 2017).

There is a need for measuring service integration as experienced by the patient/client as well as at the system level, which would include possible cross-sectoral linkages (health, housing, employment, transportation, etc.), a dimension that may be missed by focusing on individual

patients as the sole object of integration (Singer et al., 2011; Strandberg-Larsen & Krasnik, 2009). Developing data tools other than, or in addition to, patient questionnaires would enable gathering a broader range of data for measuring integration and integration outcomes (Suter et al., 2017). Indicators derived from administrative or other existing databases may fill an important gap when combined with patient-centered approaches.

We conceptually define integration of HIV care as "a way of organizing care delivery," by linking services utilized by PLWH across different service sectors through organizational, structural connections that are put in place to benefit patients in terms of clinical outcomes (adapted from Strandberg-Larsen & Krasnik, 2009, p. 2). Our operational definition of service integration is based on patterns of formal or informal linkages between and among service organizations utilized by PLWH as they access medical and other providers to address their multiple health, behavioral health, and social service needs. In this regard, we focus on linkage as a type of service integration, consistent with Leutz (1999) and others' conceptualization of *linkage* as the relationships between service organizations or service systems (e.g. health care and human services) that serve a population without relying on any special provision for establishing and maintaining links. This is distinct from *coordination*, which requires structures and individuals with specific responsibility to 'coordinate,' and *full service integration*, which indicates organizational structures and processes for organizing care among a network of providers that involves information sharing, pooling of financial, professional, or other resources, and formal agreements to define relationships.

Service linkages, which may result from nothing more than a shared understanding of patient needs among providers and/or patients themselves, and when and how to initiate a referral to another service agency, are important to investigate in their own right. Evaluating linkages and outcomes from the perspective of patients and service users can provide insight into their care experiences as they attempt to meet their needs accessing a system of providers available to them within a geographically defined jurisdiction.

Study Questions

The purpose of this paper is to describe medical and social service organizational linkages and to associate the linkages to health and medical care outcomes. Our three primary research questions are:

1. What service types are more likely to be linked?
2. Are greater linkage among services associated with better medical care and health outcomes for PLWH?
3. Which, if any, specific service types, when linked with others, are associated with better health outcomes for PLWH?

Key Findings

- Case management and HIV Primary care services are the most common services to be linked with other services; 24% of case management services and 20% of HIV primary care services are linked to at least one other service category (Table 3).

- The most common pairing of service linkage was between case management and housing services, consisting of 14% of all linkages. Case management and HIV primary care and HIV primary care and other medical practitioner services are also frequently linked (Table 3, Figure 2).

- The average number of linkages per service was 0.25, that is, the average participant had 1 linkage for every 4 service types among the services they utilized.

- A greater number of service linkages was associated with increased odds of suppressed viral load (Table 4, Figure 3) and reduced odds of ER visits (Table 4)

Method

Data Source

Data are from the Community Health Advisory and Information Network (CHAIN) project, an ongoing (since 1994) community based, cohort study of PLWH in New York City and three nortern counties of Westchester, Rockland, and Putnam (Tri-County). Detailed methodology has been described elsewhere (Aidala, Lee, Abramson, Messeri, & Siegler, 2007; Messeri, Abramson, Aidala, Lee, & Lee, 2002; Messeri, Aidala, Abramson et al. 1995); a summary can be found online http://www.nyhiv.org/data_chain.html. Briefly, a two-stage probability sampling strategy was used. First, a stratified sample of medical and non-medical service providers from across NYC or the Tri-County was selected. Then, in collaboration with service staff, patients/clients were recruited, either through random selection of PLWH from an agency-provided anonymous list of clients or through on-site sequential enrollment across multiple days.

Study Sample

This study includes 4,430 in-depth interviews conducted with 1,012 individuals between 2002 and 2015. Participants were interviewed at 12-18 month intervals allowing for repeated measurements for each participant over time. A cohort of 693 participants was recruited in 2002-2004 and followed through 8 waves of interviews with an average number of 5.04 interviews during the study. To increase the sample size which was reduced due to death, relocation out of the study area, and lost to follow up, a refresher cohort was added to the study in 2009-2010; 319 participants in the refresher cohort responded to an average of 2.95 interviews (out of a maximum of 4) through 2015. Attrition for reasons other than death ($n = 247$, 24%) or migration out of New York City ($n = 85$, 8%) has remained low; the additional reasons for loss to follow up by the final interview included physical or mental incapacitation ($n = 17$, 2%) or institutionalization ($n = 12$,

1%). At each interview period, 80–90% of persons completing a prior interview were located and re-interviewed. **Table 1** presents sample characteristics at baseline.

Study Variables

      Service Linkage Variables. The CHAIN project collects information on multiple aspects of an individual's life, including need for and receipt of medical and social services, as well as demographic, behavioral and well-being measures related to these services. Study variables for this study were chosen based on the theoretical and empirical evidence suggesting the variable has an effect on health and medical care utilization outcomes among PLWH. Receipt of medical and social services during the past six months were collected including information on the organizations/clinics/agencies where each service was received. Over time, the CHAIN project has constructed a database of over 6,500 service sites, detailing the names, addresses, services, target population, and formal organizational linkages (e.g. described on websites or in agency reports) that pertain to each service provider. All agencies named were coded with an identifier that was attached to individual respondents' service utilization data.

      Table 2 provides a summary of the nine types of services explored in this study: primary HIV medical care, dental or other oral health care, care from medical practitioners such as optometry, mental health treatment, substance use treatment, housing assistance, food assistance, financial assistance, and case management services. These nine services were selected for analysis because they were used by at least 10% of participants at some point between 2002 and 2015.

Table 1. Sample characteristics at baseline interview.

Total n=1,012	%
Age	
< 36 years	10.8%
36-49 years	54.5%
50+ years	34.8%
Mean (sd)	46.1 (8.9) years
Gender	
Male	59.7%
Female	38.6%
Transgender[1]	1.6%
Race/Ethnicity	
White Non-Hispanic	8.5%
Black Non-Hispanic	54.6%
Hispanic/ Latino	34.7%
Other[1, 2]	2.2%
Income	
Annual income < $7500	25.3%
Income ≥ $7500	74.7%
Education	
Less than high school	40.6%
High school or GED	43.3%
Some college or more	16.0%
Housing Needs	
No needs	7.6%
Needs rental assistance	60.4%
Needs permanent housing	17.0%
Needs permanent, supportive housing	15.0%
Problem Substance Use[3]	
Never problem substance use	29.1%
Past problem substance use	47.8%
Current problem substance use	23.1%
Mental Health functioning	
Good mental health functioning	52.9%
Low mental health functioning[4]	47.1%
Physical Health functioning	
Good physical health functioning	30.1%
Low physical health functioning[5]	69.9%
Viral Load	
Suppressed (< 400 copies/mL)	64.2%
Unsuppressed	35.8%
HIV Diagnosis Year	
Before 1997	64.2%
1997 – 2005	31.4%
After 2005	4.4%

[1] Analyses exclude assessments of effects of Transgender identity and other racial identities due to low sample sizes

[2] Other race/ethnicity includes native Americans, Asians, and multiple races/ethnicities such as White and Asian.

[3] Problem substance use refers to use of heroin, cocaine, crack, or methamphetamine, any IDU, or problem drinking (One or more yes responses to CAGE questions or drink weekly or more often and have 5 or more drinks on those days when drinks). Current use refers to within six months of interview.

[4] MOS SF-12 Mental Health Summary Score (MCS) below 42.0 indicates a clinically significant symptomology

For each receipt of service reported during each interview, we constructed networks of linkages that represented formal connections between service providers using information about each individual agency and any parent organization of which it is a component. For example, if a participant reported Dr. Smith as his/her primary medical provider for HIV care at Hope Hospital and also went to the Social Work Department of Hope Hospital for help with housing needs and saw a case manager there who provided assistance, we treated these connections as linkages between three services: HIV primary care, case management, and housing (formal connections). We also considered linkages between agencies based on self-reported referral patterns. For HIV primary care, mental health and drug treatment, respondents were asked if they were referred by any other service provider or agency when they went to the specific provider for the first time.. If any provider or agency had referred the participant, this was classified as a service linkage (formal or informal connections). If participants identified multiple service providers within a service area, such as using multiple case managers from different organizations, each provider was assessed for a linkage between other services.

This multi-level dataset represents both formal connections by organizational structure and formal or informal connections by referral patterns. Cross-sectional and longitudinal representation of service networks were created separately. We first documented the current network of services utilized within six months of the current interview. For longitudinal analyses, we appended the current network of services utilized with all previous networks.

Level of linkages were measured by the number of linkages between and the total number of services utilized. Supplementing these global measures, we also assessed the level of linkage for each service based on the number of other services to which it was linked. We constructed these measures using the cumulative, merged networks of services to avoid issues of gaps between data collection time points.

Table 2. Services and provider types examined for service linkage analysis

Service Category[1]	Description of service providers and service utilization[2]
HIV Primary Care	Receipt of services from a doctor, nurse, or other medical provider that participant considers is in charge of his/her overall HIV health care
Dental / Oral Health Care	Receipt of services from a dentist, oral surgeon or other dental care provider for any of the following: examination, cleaning teeth, x-rays, filings, extractions, root canal, crown/bridge or denture work, gum care, oral sore treatment or other oral health related need.
Medical Practitioner	Receipt of services from a medical practitioner (separate from other medical care) such as care from an optometrist, foot doctor, chiropractor, nutritionist.
Substance Use Treatment	Receipt of professional drug or alcohol treatment including detox, in-patient or out-patient treatment, residential treatment, methadone maintenance, employee assistance program (EAP), individual treatment counselor, psychologist, or psychiatrist focused on treating substance use disorder
Housing Assistance	Receipt of assistance to secure or maintain housing (e.g. provision of housing, rental assistance, housing placement assistance), address safety, housing quality or physical access issues, or other housing-related needs.
Financial Assistance	Receipt of assistance to address financial needs including receipt of emergency funds and assistance with obtaining or maintaining benefits/entitlements such as SSI, SSDI, TANF
Mental Health Treatment	Receipt of services from professional mental health provider (psychiatrist, psychologist, specially trained social worker or therapist)
Food Assistance	Receipt of assistance with obtaining food (pantry bag, voucher) or meals (congregate or home delivered meals)
Case Management[3]	Receipt of assistance from a case manager, case worker, or other paid employee to help arrange services including revising or developing a plan for addressing needs, helping getting specific social services, periodically checking on needs, filling out forms for benefits, counselling about personal life, substance use, risk behaviors, and/or treatment adherence, or addressing other service-related need.

[1] Services accessed by at least 10% of study participants interviewed from 2002- 2015
[2] Services, treatment, or other assistance reported as receiving currently or received within the past six months of interview
[3] Considered up to four agencies or programs providing case management services

Health and Medical Service Outcome Variables. Health outcomes used are physical health functioning, adherent antiretroviral medication (ARV) use, and suppressed viral load. Physical health functioning indicated by a Physical Component Summary (PCS) >50.0 on the MOS SF-12 inventory (Ware, Kosinski, & Keller, 1994) was coded as 1 and PCS$\leq$ 50.0 was coded as 0. Adherent ARV use, coded as 1, is defined as taking any recommended ARV regimen prescribed by a physician and adherence to medication regimen is defined as a report of taking medications "exactly as prescribed, almost never missing a dose" and not missing any medications, in the two days preceding the interview. Not adherent, coded as 0, includes participants who are not taking any antiretroviral medication and participants taking medications listed under "not recommended" or "should be changed" regimens in the DHHS's guidelines in effect at the time of the interview (NIH, AIDSinfo.nih.gov).

Suppressed viral load, coded as 1, is based on respondent report (or when available, lab report) of the most recent HIV viral load as a numerical value below a reliably detectable cut point (<400 copies), or when a medical provider reported viral load test results as "undetectable," or, in a few cases, simply as "good." Viral load test results above the cut point, or provider reported as either 'detectable' or 'bad' were classified as unsuppressed viral load and coded as 0. Brief validation studies have shown good reliability of self-report for medications taken and viral load test results (Mariller, Abramson, & Sobieszczyk, 2004; Messeri, McAllister-Hollod, & Irvine, 2013).

Medical care utilization outcomes include missed medical appointments, an indicator of lack of retention in HIV care (Mugavero et al., 2012); any ER visit during the past 6 months, and any hospital inpatient stay during the past six months. Missed appointment is defined as two or more missed scheduled medical appointments in the past six months, including appointments for tests or checkups.

Covariates. Demographic variables include gender (men, women, transgender), race/ethnicity (Black, Latino, White, Other), and age (40 or less; 41-50; 51-60; 60 and over). Other race/ethnicities includes Native Americans, Asians, and multiple races/ethnicities such as White and Asian.The men category is further broken down by MSM status, which is defined based on reported lifetime experience of male-to-male sexual intercourse. Situational factors include housing needs, food insecurity, problem substance use, poverty (Annual income <$7,500), and low mental health functioning. Housing need was operationalized at four levels: none, needs rental assistance to maintain housing, needs to obtain permanent housing (i.e. currently homeless or in temporary housing), or needs permanent supportive housing (housing plus supportive services) (Aidala et al., 2016).

Food insecurity was determined using a composite measure that took into account both objective criteria based upon reports of behaviors and experiences (e.g. not having enough money for food, going an entire day without eating anything at all, etc.) as well as self-reported need for food or meal services. The self-reported use of any food or meal service was also considered evidence of participants' need for these services. The idea behind this is that these participants would fall into the "food insecure" categories if the service they are receiving is suspended, even if they are not currently food insecure. Food insecurity, specifically, was defined as participant report of one or more of the following conditions: 1) not having the money for food that they or their family needed "once in a while" or more frequently in the last six months; 2) sometimes or more frequently not having enough to eat; 3) have gone a whole day without anything at all to eat in the past 30 days; or 4) reported a need for assistance regarding food, groceries or meals in the last six months.

Individuals are considered having low mental health functioning when they score below 42 on the Mental Component Summary (MOS),MOS SF-12v2.[66] The score of 42 as a cut-off point for low mental health functioning is in accordance with the Medical Outcomes Trust guidelines. Current problem substance use is defined as use of heroin, cocaine, or crack 5 or more times in their lifetime and at least one use in the past six months, or problem drinking within the six months

prior to the interview. History of problem substance use refers to lifetime use of heroin, cocaine, or crack 5 or more times or problem drinking during their lifetime but not within the prior six months. Problem drinking is defined by one or more "yes" responses to the CAGE questionnaire[67] or drinking weekly or more during the past 6 months and having five or more alcoholic drinks when they drink.

Analysis

Longitudinal mixed effects models were used to predict each of the 6 binary outcomes, with robust standard errors to account for repeated measurements of the same participants over time. Unadjusted odds ratios (OR) and adjusted odds ratios (AOR) for each outcome were estimated using a single explanatory variable as a lone predictor and as a predictor alongside covariates, respectively, in the models. For measuring the effect of additional service linkages, the number of services utilized is also included in all relevant models to adjust for confounding due to a greater likelihood of connections with a greater numbers of services utilized.

Results

Linkages of services within each participants

Linkage of services among PLWH appears to be low despite high rates of service utilization. On average, the CHAIN participants utilized 4.3 service types (range 1-9) of the selected 9 service types at any point during the study period and there were, on average, 2.0 linkages between those service types (range 0-21). The average number of linkages per service was 0.25 (range 0-3); that is, the average participant had 1 linkage for every 4 service types they utilized.

Linkages between service types among all participants

Across 4,430 observations provided by 1,012 individuals completing an average of 3-5 interviews, we documented 4,835 linkages between service categories (data summarized in Table 3). Within these 4,835 linkages, some services were more likely to be linked with others; case management and HIV primary care services are the most common services to be linked with other services; 24% of case management services and 20% of HIV primary care services are linked to at least one other service category (Table 3). The most common pairing of service linkage was between case management and housing services, consisting of 14% of all linkages (Table 3 and Figure 1).

Table 3. **Most common services to be linked and most common linkages between services.**

Service Category	% linked to other service category
Case Management	24.2%
HIV Primary Care	19.6%
Medical Practitioners	12.5%

Housing Services	11.4%
Mental Health Treatment	10.2%
Food or Meal Services	9.9%
Dental Services	5.4%
Financial Assistance	3.7%
Substance Use Treatment	3.2%

Most common pairs of service category linkages	% among all linkages
Case Management and Housing	13.7%
HIV Primary Care and Case Management	12.1%
HIV Primary Care and Medical Practitioners	10.1%
HIV Primary Care and Mental Health Treatment	7.0%
Case Management and Food/ Meal Services	6.7%

[1] A total of 4,835 linkages between service-providing agencies were documented across 4,430 observations of 1,012 individuals (reported during an average of 4.8 interviews).

Figure 1 presents the proportion of service linkages between service types, displaying the most common to the least common pairing of service types. The triangular half above or below the diagonal line represents 100%. The most frequently linked types of services are case management and housing services, and case management and HIV primary care as well as HIV primary care and other medical practitioners. .

Figure 1. Proportion of service linkages between service types

HIV Primary Care
Dental
Other Practitioner
Substance Treatment
Housing
Financial Assistance
Mental Health Treatment
Food
Case Management

HIV Primary Care
Dental
Other Practitioner
Substance Treatment
Housing
Financial Assistance
Mental Health Treatment
Food
Case Management

Color Key
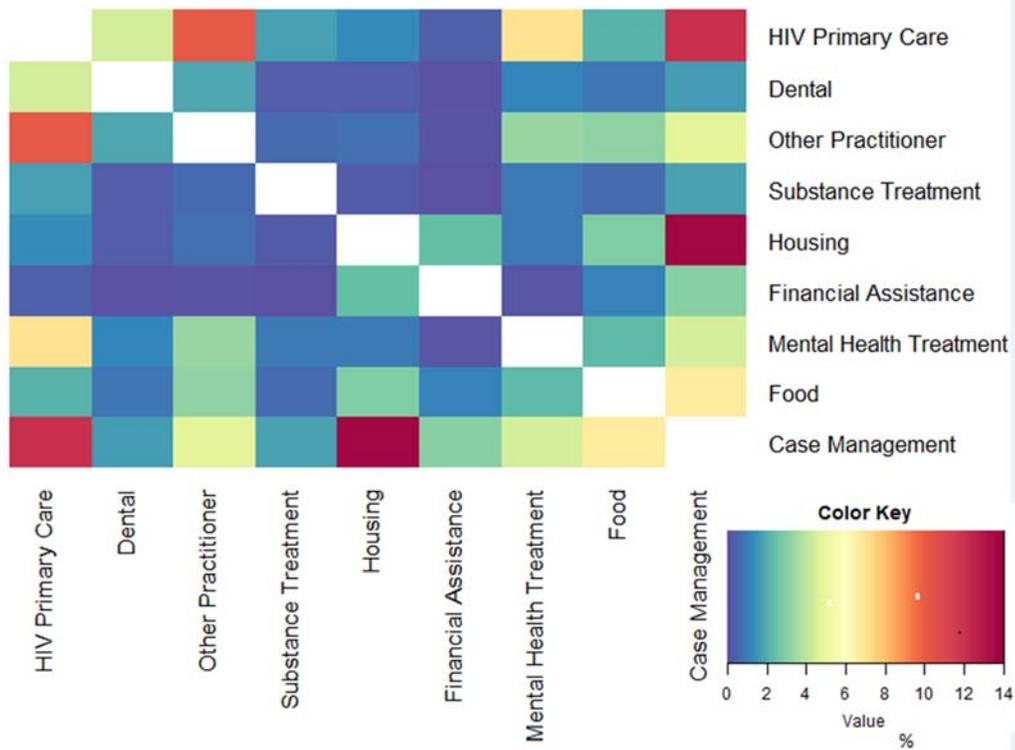
0 2 4 6 8 10 12 14
Value
%

Figure 2 presents the proportion of linkages between each type of service and other types of services. For example, examining linkages to housing services, approximately 60% of all linkages with housing services were with case management services. Each row in Figure 1 adds up to 100%.

Figure 2. Proportion of service linkages by service type (100% by row)[1]
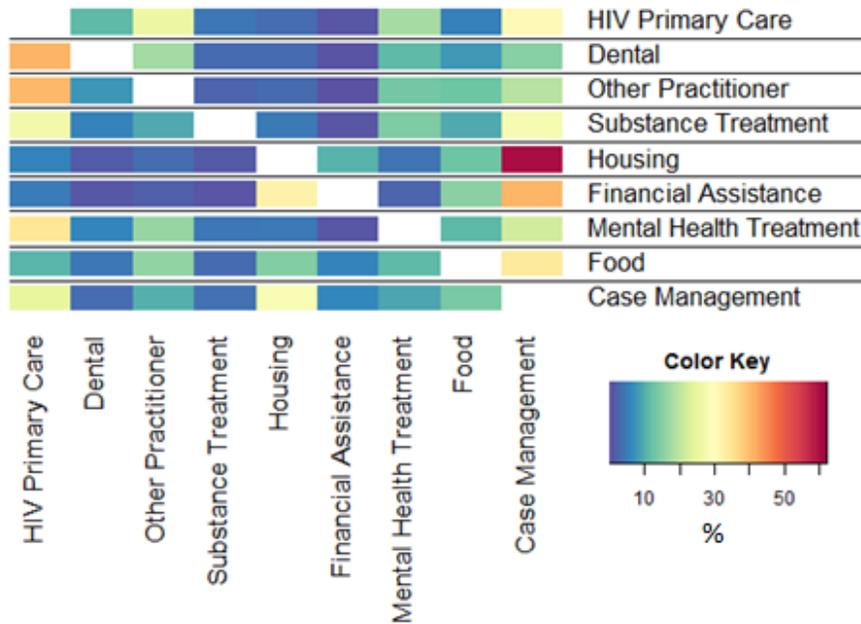
[1] The most common service linkages are represented by warmer colors; absent or less frequent connections are cooler colors. For example, examining Housing, the most common service linkage is with Case Management (red, warmest color), and the least common service linkages are with Dental Services and Substance Treatment (dark blue, coolest colors).

Overall Service Linkages and Health and Medical Care Utilization Outcomes

Table 4 presents associations between health and medical care utilization outcomes and overall service linkage. When adjusted for covariates, a greater number of service linkages were associated with suppressed viral load and reduced ER visits: for one additional service linkage, participants had a 7% greater odds of suppressed viral load (AOR: 1.07, 95% CI: [1.02, 1.13]), and a 5% decreased odds of an ER visit (AOR: 0.95, 95% CI:[0.91, 0.99]). We found no significant associations between the addition of services to an individual's service network for predicting other health and medical care utilization outcomes, when adjusted for covariates.

Table 4. Odds of Specfic Health and Service Utilization Outcomes for Each Additional Service Linkage

	OR	AOR[2]
Adherent ART Use	1.10*** [1.04, 1.15]	1.05 [0.99, 1.12]
Suppressed Viral Load	1.15*** [1.07, 1.22]	1.07** [1.02, 1.13]
Good Physical Health Functioning	0.98 [0.92, 1.03]	1.01 [0.95, 1.07]
Missed Medical Appointment	0.98 [0.94, 1.03]	1.01 [0.96, 1.06]
ER Visit	0.95* [0.91, 0.99]	0.95* [0.91, 0.99]
Hospital Admission	1.02 [0.96, 1.06]	1.01 [0.96, 1.06]

*** $p < .001$ ** $p < .01$ * $p < .05$

1. Number of links between any two services within the individual's network of services. Both the OR and AOR adjust for the number of services utilized at the time of interview.
2. Adjusted for race/ethnicity, gender, sexual orientation, poverty, problem drug use, mental health functioning, food insecurity, housing need. In addition, ART adherence is controlled for in all models except for the adherent ART use outcome.

Table 5. Odds of specfic health and service utilization outcomes associated with linkage to specific services

	Adherent ART Use		Suppressed Viral Load		Good Physical Health Functioning	
	OR	AOR[2]	OR	AOR[1]	OR	AOR[1]
Number of linkage with:[3]						
HIV Primary Care	1.28*** [1.15, 1.44]	1.10 [0.97, 1.25]	1.34*** [1.17, 1.55]	1.11 [0.98, 1.26]	0.87* [0.77, 0.99]	0.92 [0.81, 1.05]
Dental Services	1.16* [1.00, 1.34]	1.06 [0.89, 1.27]	1.28** [1.06, 1.54]	1.10 [0.92, 1.32]	1.01 [0.83, 1.23]	1.10 [0.90, 1.33]
Medical Practitioners	1.16* [1.02, 1.32]	1.06 [0.91, 1.24]	1.32** [1.09, 1.61]	1.19 [0.99, 1.42]	0.96 [0.81, 1.15]	1.04 [0.87, 1.24]
Substance Use Treatment	1.32* [1.03, 1.68]	1.26 [0.93, 1.71]	1.14 [0.91, 1.42]	1.04 [0.83, 1.29]	1.04 [0.81, 1.33]	1.16 [0.90, 1.50]
Mental Health Treatment	0.98 [0.84, 1.14]	0.96 [0.81, 1.14]	1.00 [0.82, 1.22]	0.97 [0.81, 1.17]	0.89 [0.72, 1.10]	0.98 [0.79, 1.21]
Case Management	1.23*** [1.11, 1.37]	1.06 [0.94, 1.20]	1.36*** [1.18, 1.56]	1.12 [0.99, 1.28]	0.85** [0.76, 0.96]	0.90 [0.80, 1.02]
Housing	1.32** [1.11, 1.57]	1.17 [0.96, 1.41]	1.26* [1.02, 1.55]	1.07 [0.87, 1.31]	1.04 [0.86, 1.26]	1.05 [0.86, 1.29]
Food Services	1.01 [0.83, 1.23]	1.00 [0.82, 1.21]	0.90 [0.75, 1.10]	0.97 [0.80, 1.17]	1.04 [0.90, 1.20]	0.99 [0.85, 1.18]
Financial Assistance	1.18 [0.85, 1.65]	1.14 [0.82, 1.57]	1.03 [0.72, 1.46]	1.14 [0.81, 1.61]	1.03 [0.80, 1.31]	0.95 [0.71, 1.28]

	Missed Medical Appointments		ER Visit		Hospital Admission	
	OR	AOR[1]	OR	AOR[1]	OR	AOR[1]
Number of linkage with:[3]						
HIV Primary Care	0.91 [0.81, 1.01]	0.97 [0.87, 1.08]	0.96 [0.87, 1.04]	0.96 [0.88, 1.05]	1.06 [0.95, 1.18]	1.05 [0.94, 1.16]
Dental	0.85* [0.73, 0.99]	0.88 [0.76, 1.02]	0.88 [0.77, 1.01]	0.88 [0.76, 1.00]	0.99 [0.84, 1.16]	0.98 [0.83, 1.15]
Medical Practitioners	0.99 [0.87, 1.14]	1.05 [0.92, 1.20]	0.95 [0.83, 1.08]	0.93 [0.81, 1.06]	1.11 [0.97, 1.27]	1.10 [0.96, 1.25]
Substance Use Treatment	0.89 [0.72, 1.11]	0.99 [0.80, 1.22]	0.86 [0.69, 1.05]	0.88 [0.71, 1.09]	1.03 [0.86, 1.23]	1.09 [0.91, 1.30]
Mental Health Treatment	1.04 [0.88, 1.22]	1.05 [0.90, 1.23]	1.07 [0.94, 1.22]	1.02 [0.90, 1.16]	1.17* [1.01, 1.35]	1.12 [0.96, 1.30]
Case Management	0.88* [0.79, 0.97]	0.94 [0.85, 1.04]	0.92 [0.84, 1.00]	0.93 [0.85, 1.01]	0.96 [0.86, 1.06]	0.97 [0.88, 1.08]
Housing	0.87 [0.72, 1.05]	0.92 [0.77, 1.10]	0.94 [0.80, 1.10]	0.97 [0.84, 1.13]	0.97 [0.83, 1.15]	1.03 [0.89, 1.20]
Food Assistance	1.03 [0.87, 1.22]	1.01 [0.87, 1.19]	0.97 [0.85, 1.10]	0.95 [0.84, 1.08]	1.04 [0.90, 1.20]	1.02 [0.89, 1.18]
Financial Assistance	0.97 [0.72, 1.31]	0.92 [0.70, 1.20]	0.96 [0.74, 1.26]	0.97 [0.74, 1.26]	0.85 [0.65, 1.12]	0.88 [0.68, 1.15]

*** $p < .001$ ** $p < .01$ * $p < .05$
1. Adjusted for race/ethnicity, gender, sexual orientation, poverty, problem drug use, mental health functioning, food insecurity, housing need, and ART.
2. Adjusted for race/ethnicity, gender, sexual orientation, poverty, problem drug use, mental health functioning, food insecurity, and housing need.
3. Addition of an additional service linkage of any type to each of the services listed

Service-Specific Measures of Linkage and Health and Medical Care Utilization Outcomes

Table 5 presents associations between number of linkages with a specific service type and health and medical care utilization outcomes. Linkage with particular services, mainly HIV primary care, dental care, case management, housing, and medical practitioner services, predicts positive outcomes. When unadjusted for covariates, we found that a greater odds of adherent ART use was associated with one additional linkage to HIV primary care (OR: 1.28, 95% CI: [1.15, 1.44]), dental care (OR: 1.16, 95% CI: [1.00, 1.34]), care from medical practitioners (OR: 1.16, 95% CI: [1.02, 1.32]), substance use treatment (OR: 1.32, 95% CI: [1.11, 1.57]), case management (OR: 1.23, 95% CI: [1.11, 1.37]), and housing services (OR: 1.32, 95% CI: [1.11, 1.57]). We also found a greater odds of viral suppression for one additional linkage to HIV primary care (OR: 1.34, 95% CI: [1.17, 1.55]), dental care (OR: 1.28, 95% CI: [1.06, 1.54]), care from medical practitioners (OR: 1.32, 95% CI: [1.09, 1.61]), case management (OR: 1.36, 95% CI: [1.18, 1.56]), and housing services (OR: 1.26, 95% CI: [1.02, 1.55]). Furthermore, participants with more connections to HIV primary care and case management were also likely to have poor health; we interpreted this finding with caution, as approximately 70% of individuals reported poor physical health at the baseline interview, and the effects of overall linkage measures are not significant when adjusting for other covariates. This effect appears to be especially related to socioeconomic status; we found that there was an interaction between each measure of linkage and level of education. A combination of higher education and greater service linkage was associated with better physical health (data not shown).

In terms of medical care utilization outcomes, one additional linkage to dental care (OR: 0.85, 95% CI: [0.73, 0.99] and case management (OR: 0.88, 95% CI: [0.79, 0.97]) predicted reduced odds of missing 2 or more medical appointments, and one additional linkage to mental health treatment (OR: 1.17, 95% CI: [1.01, 1.35]) predicted increased hospital admissions. After adjusting for covariates, these effects were no longer significant.

Discussion

This study documents wide variability in service linkages and provides some evidence that health and social services linkages predict better health and medical care utilization outcomes for PLWH. Overall, connections between services were relatively low despite a service rich environment and high rates of service utilization. Most linkages between services appear to link through case management, primary care, and housing, indicating the importance of these services within the overall care management of PLWH. Each additional linkage added to a participant's network of medical and social services appears to be important for achieving suppressed viral load, with greater density of service linkages associated with higher odds of positive health outcomes. Beyond overall linkage among services used, we identified specific service areas that appear to confer greater benefit with greater linkage with other services. Additional service linkages with HIV primary care, dental, medical practitioners, case management, and housing services are associated with higher odds of adherent ART use and viral suppression. These findings vary in significance when taking into account covariates such as age, race, education, mental health and substance use challenges. This may indicate that service integration effects are not homogenous

across different demographic and risk groups and may be a mechanism through which outcomes are influenced.

Our findings are consistent with the growing awareness of the benefits of service integration or care coordination to address the multiple, co-occurring medical and supportive service needs of PLWH (Sarango et al., 2018). We found that greater linkage of medical services with social services and case management is associated with greater odds of positive outcomes, especially adherent ARV use and viral suppression, controlling for a wide range of client characteristics and service needs associated with worse retention in care, adherence, and viral load outcomes. Our analytical approach has documented the positive benefits of linkages or organizational ties between services, regardless of whether or not there is any deliberate information sharing or service coordination at the organizational level. Further research would be required to assess the extent to which these network analyses correspond to actional coordination of care.

This conceptual approach to using network connectivity for measuring service linkage adds to a growing body of literature focusing on network analysis and public health. This is the first study to employ network analysis for predicting longitudinal health outcomes for PLWH. Studies examining networks of services for HIV positive populations most commonly assess agency linkages descriptively (Costenbader, Mangone, Mueller, Parker, & MacQueen, 2018; Jain et al., 2016; Khosla, Marsteller, Hsu, & Elliott, 2016; Kwait, Valente, & Celentano, 2001; Messeri, Kim, & Whetten, 2003). Predicting outcomes associated with service provider connectivity is significantly less common although there have been outcome studies focused on other health conditions or populations at risk (Provan & Sebastian,1993; Rosenheck et al.1998). A study at the aggregate level found that counties in North Carolina with greater density of linkages among providers with STD or HIV prevention initiatives had lower syphilis rates, and authors inferred that agencies working together would also improve HIV prevention (Thomas, Carter, Torrone, & Levandowski, 2008). More recently, an intervention for improving connections among service providers for PLWH in Ethiopia demonstrated that increased integration was associated with higher rates of adherent ART use (Thomas, Reynolds, Alterescu, Bevc, & Tsegaye, 2016). These findings corroborate our results, indicating the potential benefits of increased overall service linkage for promoting positive outcomes among PLWH.

There are a number of limitations to this study based on available data and the analytical approach. The causal effect of integration of services on outcomes is not directly assessed or ascertainable, as the study utilizes cohort data and is not experimental in nature. Loss to follow up in our study, though minimal, may bias the results one way or another, as some participants were no longer able to be contacted, or missed interview waves. Although there are some indication of greater attrition among participants with greater service needs, such as housing, mental health, food, and substance use services, the direction of the bias in this study is unclear as this study is based on the actual use of the services, rather than the need for such services. A further limitation is that reports of services used only during the six months prior to interviews may reduce recall bias but results in gaps in service utilization over time; thus the data may underestimate the full spectrum of service utilization and service linkages experienced by participants. Although we include covariates to control for major indicators of service need, the lack of a particular service

area in a network of services utilized by an individual may have occurred for a number of reasons, including utilization of the service outside of the 6 months prior to interview, which is our observation period.

The use of self-reported data for both service utilization and referrals to services used may be subject to presentation and recall bias. However, it is unlikely that inaccurate reporting of referrals may have influenced the strength of associations found. Questions regarding referrals were only asked for 3 of the 9 service types (primary care, mental health services, and substance use treatment). The majority of connections were documented using the linked agency-level database rather than self-reported referral information. Further, data collection via comprehensive in-person interviews by trained interviewers following protocols to use memory aids and probe for incomplete or inconsistent reports, and checks with agency generated information, strengthens our confidence in the reliability of respondent reports.

In addition, there are benefits to using patient self-report data. Our analysis of service linkages reflects actual usages of linked services which are functionally available to them (known, acceptable, and accessible by them). Benefits of organizational structures based on contracts or other mechanisms supporting service integration are beneficial to the extent that arrangements actively engage patients. Measuring the impact of integrated care based on actual usage reported by service users provides important information not accessible by measuring integration only from systems' or organizational perspectives, such as perceived coordination of care.

In addition, our network analytical approach to analyzing service linkages based on patient service encounters offers an approach to understanding 'systems' of care without an additional effort to collect information from organizational managers and program staff. Analyzing linkages among service providers by tracking client encounters with service providers as documented in administrative databases maintained by funders (e.g. state Medicaid data, Ryan White contract data) and/ or government agencies, especially analyses using integrated data sets (e.g. health, mental health, social services) holds substantial potential for understanding systems of care and individual and population outcomes associated with different service linkage patterns (Fantuzzo & Culhane, 2015). Better understanding of outcomes associated with different patterns of service integration can inform interventions targeting identified services for linkage and testing of benefits for individual patient health and quality of life as well as healthcare cost savings.

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