A Multicomponent Intervention to Reduce Readmissions Among People with HIV

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Abstract

Background: Hospital readmissions are common, costly and potentially preventable, including among people with HIV (PWH). We present the results of an evaluation of a multicomponent intervention aimed at reducing 30-day readmissions among PWH.

Methods: Demographics, socio-economic, and clinical variables were collected from the electronic health records of people with HIV or cellulitis (control group) hospitalized at an urban safety-net hospital before and after (September 2012 -December 2016) the implementation of a multidisciplinary HIV transitional care team. After October 2014, hospitalized PWH could receive a medical HIV consultation +/- a transitional care nurse intervention. The primary outcome was readmission within 30 days of discharge to any hospital. Multivariate logistic regression and propensity score analyses were conducted to compare readmissions before and after intervention implementation in PWH and cellulitis.

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Results: Overall, among PWH, 329/2049 (16.1%) readmissions occurred before and 329/2023 (16.3%) occurred after the transitional care team intervention. After including clinical and social predictors, the adjusted OR (aOR) of 30-day readmission for post-intervention PWH was 0.81 (95% CI 0.66–0.99, p= 0.04) whereas little reduction was identified for cellulitis (aOR 0.91 (95% CI 0.81–1.02, p= 0.10). A dose-response was not observed for receipt of different HIV intervention components.

Conclusions: A multicomponent intervention reduced the adjusted risk of 30-day readmissions in PWH, though no dose-response was detected. Additional efforts are needed to reduce overall hospitalizations and readmissions among PWH including increasing HIV prevention, early diagnosis and engagement in care and expanding the availability and spectrum of transitional care services.

Keywords

HIV; readmissions; multidisciplinary; multicomponent; hospitalization

Introduction

Hospital readmissions are common, costly and potentially preventable, directly impacting the patient healthcare experience.[1,2] For these reasons, unplanned rehospitalizations within 30 days of discharge continue to be a key quality metric, with financial penalties for hospitals with higher than expected readmissions.[3,4] Nearly one-fifth of Medicare beneficiaries experienced 30-day readmissions in a large national study.[1] In the US overall, the cost of readmissions is approximately $26 billion, of which $17 billion is attributed to avoidable readmissions.[1] Estimates vary as to the proportion of readmissions which are avoidable, ranging from 5%-79%.[5–8] Patients who report high satisfaction and good provider communication during hospitalization are less likely to be readmitted,[9] whereas patients who are readmitted are more likely to express dissatisfaction with physicians and staff responsiveness.[10]

For people with HIV (PWH), despite the major impact of antiretroviral therapy (ART) on reducing HIV-associated morbidity and mortality,[11] admissions and readmissions remain a common occurrence.[12] The prevalence of 30-day readmissions for PWH range from 16%-25%,[13–17] with more recent studies reporting lower readmission rates.[16,18] Multiple factors contribute to readmissions in PWH, including clinical predictors, such as AIDS-defining illnesses, low CD4 count, mental health conditions, substance use, as well as social factors, such as insurance status, homelessness and food insecurity.[14,15,18] Prior health care utilization, such as emergency room visits and hospitalizations, contributes to higher readmission risk, however, having an outpatient follow-up visit after discharge did not lower readmission risk in an observational study of PWH.[13] Protective factors may include the patient-provider relationship (e.g. consistent medical provider between admission and follow-up),[19] and increased ART uptake.[20] In contrast to many chronic illnesses associated with high readmission rates (e.g. cirrhosis, chronic obstructive pulmonary disease, congestive heart failure (CHF)), HIV can be treated with medications that not only help control disease but which also help reverse immunosuppression. Given high rates of potentially preventable readmissions among PWH (50%-55%),[6,17] especially among

individuals with AIDS or those not on ART, a unique opportunity exists for intervention to avoid readmission and improve long term clinical outcomes.

Key elements of successful multicomponent interventions for reducing readmissions in the general inpatient population include a patient needs assessment, medication reconciliation, patient education, timely outpatient post-hospitalization appointment, and post-discharge telephone follow-up[21] as described in landmark studies.[22–24] Others have successfully deployed predictive analytics, utilizing the electronic medical record to identify those at highest risk for readmission,[25] as well as disease-specific models and interventions.[26] In our prior work, we have developed and validated an EMR-enabled prediction model for readmissions among PWH,[14,18] and have also explored patient and provider perspectives on readmissions among PWH, highlighting intervention strategies to be implemented during admission, at the time of discharge and post discharge.[27] We build on this prior work to develop and implement a multicomponent intervention to reduce readmissions among PWH.

With both a high prevalence and preventability of readmissions among PWH, as well as the potential to improve clinical outcomes in this population, we aimed to evaluate the impact of a multicomponent intervention for hospitalized PWH on 30-day readmissions in an urban safety-net hospital in the South. In this paper, we (1) assess and describe the characteristics of index admissions among PWH and among patients admitted with cellulitis, who serve as a concurrent control group; (2) determine and compare the proportion of 30-day readmissions before and after implementation of the intervention; and (3) assess for evidence of a dose-response effect of this multicomponent intervention on readmissions.

Methods

This study is an interrupted time-series study of a multidisciplinary transitional care team (HIV physician specialist, transitional care nurse, and HIV care manager) targeting medical and socio-behavioral contributors to hospitalization, implemented at a large urban safety-net hospital in Dallas, TX beginning in October 2014. To evaluate the impact of this intervention, data were collected from electronic health records (EHR) of PWH hospitalized in the Parkland Health and Hospital System (PHHS) two years before and after the implementation of the transitions team. In addition, EHR data were collected for a comparison group of individuals with a diagnosis of cellulitis who were hospitalized at PHHS during the same time period (September 1, 2012- December 30, 2016). Cellulitis was chosen as a comparator group as it is a relatively common cause of readmission but there have not been disease-specific readmissions reduction efforts directed at cellulitis (unlike for congestive heart failure, acute myocardial infection and other conditions for which excess readmissions carry a financial penalty from the Center for Medicare and Medicaid Services.[4] Parkland is an 870-bed, urban, public hospital and the primary safety-net health system in Dallas, TX. This study was approved by the UT Southwestern Medical Center Institutional Review Board.

Data obtained from the EHR (Epic systems, Verona, WI) included all individuals with a diagnosis of HIV (ICD-9 codes 042, V08; ICD-10 codes B20, Z21; positive HIV test result; or an HIV viral load > 20 copies/mL); aged 18 or older; who had an inpatient

admission to PHHS between 9/1/2012 and 12/30/2016. In addition, data were also collected for individuals with an inpatient admission during the same time period at PHHS who had a diagnosis of cellulitis (ICD-9 codes 681, 682; ICD-10 code LO3) among their discharge diagnoses. If a patient had both HIV and cellulitis they were included in the HIV group.

Variables collected included: demographics (age, sex, race, ethnicity, marital status, primary language), socio-economic and behavioral variables (insurance status, homelessness, substance use, mental illness), laboratory variables (including white blood cell (WBC) count, creatinine and CD4 count/HIV viral load closest in time to admission and within 180 days for PWH), hospitalization characteristics (primary inpatient diagnoses, length of stay, discharge status) and recent healthcare utilization (number of emergency room and inpatient visits in preceding 12 months). Mental health was categorized into the following categories: depression/suicidality/mania, anxiety, schizophrenia/psychosis, other/multiple diagnoses based on ICD-9/10 classification. Substance use was determined by urine drug screen result.

In addition to the above, variables that were included in the previously published EHR risk prediction model (e-model) for 30-day readmissions among HIV patients[14] were also collected including history of AIDS-defining illness, bicarbonate (HCO_3), aspartate aminotransferase (AST), alanine aminotransferase (ALT), hematocrit (HCT), PO2 (partial pressure of oxygen), anion gap, absolute lymphocyte count and distance of residence from hospital. For cellulitis, there was no existing e-model for 30-day readmission risk, though variables cited in the literature as contributing to readmissions for cellulitis patients[28,29] were collected as part of the baseline measures including age, insurance, creatinine, WBC count, diabetes mellitus, venous insufficiency, homelessness, length of stay, prior ED visits and prior hospitalization.

For PWH, similar to previously published methods, [13,30] we determined the primary admitting diagnosis using the first listed ICD-9/ICD-10 code assigned at discharge, unless it was a code for HIV (042, B20, V08, Z21), in which case the second code was used. Clinical Classification Software (CCS) was used to assign primary ICD-9 and ICD-10 codes into one of 18 clinically meaningful categories [31] and modified as per previous studies. [13,30] We reassigned end-organ infections to the non-AIDS-related infection category and defined a separate category for AIDS-defining illnesses.[32] For the cellulitis group, the principal diagnosis for admission was defined as the first listed discharge diagnosis.

The primary outcome for this study was 30-day readmission. The first hospitalization for an individual during the study period was considered an index admission, following which a subsequent admission within 30 days of discharge was considered a 30-day readmission. Admissions occurring after 30 days were considered a new index admission. Encounters during which the patient expired or left against medical advice were not eligible to be index admissions. We identified readmissions to any hospital in North Texas utilizing information from the Dallas Fort Worth Hospital Council Foundation which has inpatient claims data from over 90 hospitals within a 100 mile radius of Dallas. All encounters labeled as elective admissions, outpatient procedures/day surgeries, or outpatient visits were excluded.

The multidisciplinary HIV transitions team, supported in part through the Center for Medicare and Medicaid Services (CMS) 1115 waiver program, was implemented with the goal of reducing 30-day hospital readmissions for hospitalized PWH and has been described elsewhere.[33] Members of the team address different aspects of patient care: medical (HIV specialists and advanced practice providers), social (transitional care nurses, TCNs) and care coordination (HIV case managers). The inpatient medical HIV team (available 7 days per week) provides diagnostic and therapeutic recommendations and post-discharge follow-up and is activated when an HIV consult is placed by the primary inpatient treatment team. The TCN (weekdays only) approaches patients within this HIV consult group who are deemed high-risk for readmission (new HIV diagnosis, prior admission, psychosocial needs) to review barriers to care, complete patient education using a teach-back method and develop an individualized transitional care plan, typically meeting with patients multiple times during hospitalization and at the time of discharge. HIV case managers provide care coordination (assist with funding, follow-up visits, referrals) for all hospitalized PWH. As part of the transitions team program, interdisciplinary rounds are conducted each weekday. Prior to October 2014, the pre-intervention time period, medical consults for HIV inpatients were performed by the general infectious diseases team without formal coordination with HIV case management, and the TCN and advanced practice provider positions did not exist. Within the post-intervention time period, PWH could be assigned to TCN plus consult, consult alone (includes those who refused TCN) or no intervention (case management alone).

Baseline characteristics for individuals with an index admission before and after October 1, 2014 were described for PWH and cellulitis using frequencies for binary and categorical variables and with means, medians, ranges and/or standard deviations for continuous variables. We constructed logistic mixed-effect models to assess the overall effect of intervention in the HIV population. The dependent variable is 30-day readmission, and independent variables include an indicator of before/after intervention, as well as various demographic, socio-economic and clinical variables. Patient random effects are included to account for observations contributed by the same patients. Missing CD4 count values were imputed and included in analyses. We adjusted for the predicted readmission risk was using our previously published HIV e-model.[14] First, univariate models were constructed to assess the association of individual covariates to 30-day readmission. Second, a stepwise variable selection procedure was employed to obtain the final multivariate model, with *a priori* inclusion of pre/post-intervention variable, and for other covariates, p=0.20 to enter the model and p=0.10 to remain in the model. Similar analyses were performed for admissions with a diagnosis of cellulitis, where predicted readmission risk was included as a covariate.

Finally, the post-intervention HIV cohort was categorized into 3 groups (TCN+ consult, consult alone, no intervention) to evaluate the dose-response effect of intervention. To account for potential confounding by indication (as sicker, more socially complicated patients were more likely to receive intervention components), propensity scores were calculated as the conditional probability of receiving any of the interventions based on a multinomial regression model. Variables included in the propensity score analysis include: sex, race/ethnicity, primary language, history of AIDS-defining illness (ADI), HIV viral load group, abnormal labs (p02), substance use (opiates, benzos), mental illness (anxiety)

and prior inpatient stay. Then propensity score weighting was employed in the logistic mixed-effect model to compare the effect of 3 interventions on 30-day readmissions.

All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

Results

During the study period, there were 4072 index admissions among PWH, with 2049 (1412 unique individuals) occurring prior to the transitions team and 2023 (1103 unique individuals) afterwards. Overall, index admissions occurred among patients who were majority male (66.4%), non-Hispanic Black (51.8%), single (76.2%) with a median age of 43.3 years. The population with index admissions before and after the transitions team was relatively similar, though when comparing admissions during the period after the transitions team was implemented to before implementation fewer had Medicaid insurance (34.5% v 40.8%), and more were self-pay (41.3% v. 35.9%). Other notable differences are that post-intervention index admissions were associated with higher proportions of mental health diagnoses, including depression, anxiety and psychotic disorders, higher rates of homelessness (14.4% v 5.8%) and higher proportions with a prior AIDS defining illness (ADI) (31.6% v. 21.0%) (Table 1). On average, length of stay was longer in the post-intervention period, with mean of 7.1 versus 5.4 days. Non-ADI infections were the leading cause of admission in both time periods, though a somewhat higher proportion had primary diagnoses of both non-ADI infections (35.5% v 31.9%) and ADI (8.7% v 6.7%) in the post- v. pre-intervention period (Table 2).

For the concurrent control group, index admissions for cellulitis, the pre- and post-intervention populations were similar to one another and were majority male (57.4%) and Hispanic (50.4%). However, similar to the HIV comparison groups, the post-intervention cellulitis admissions had higher rates of mental health diagnoses, homelessness and had a longer length of stay compared to pre-intervention (Tables 1 and 2).

With regards to receipt of the intervention in post-intervention HIV group (total N=2023), 544 (26.9%) met with the TCN and received an HIV consult, 28 (1.4%) were approached by TCN but refused, 566 (27.9%) received HIV consult only and 913 (45.1%) received no intervention (case management only).

Unadjusted thirty-day readmission rate between pre- and post-intervention time periods, in the HIV group was 329/2049 (16.1%) versus 329/2023 (16.3%) and in cellulitis group was 952/5023(18.9%) versus 943/5326 (17.7%).

Results of univariate modeling for 30-day readmissions among PWH outcome are shown in Table 3. Age, homelessness, Medicaid insurance, HIV viral load, abnormal labs (absolute lymphocytes, AST/ALT, HCT), length of stay and prior ED and inpatient visits were associated with readmissions. Multivariate modeling included a summary variable from the e-model (history of ADI, CD4 result <92, absolute lymphocyte count, AST/ALT, HCT, p02, Anion gap, Medicaid insurance, homelessness, distance from PHHS >13 miles, prior inpatient and prior ED visits), and age. The adjusted OR of 30-day readmission for the post-intervention group was 0.81 (95% CI 0.66–0.99, p= 0.04).

Similarly, univariate and multivariate analyses for 30-day readmissions among the cellulitis group were also conducted. In univariate analyses, being in the post-intervention time period was not associated with readmission (OR 0.96, 0.87–1.07, p=0.49). In multivariate analyses, after adjusting for co-morbidities (CHF, vascular insufficiency, mood disorder), lab abnormalities (creatinine, HCT, platelets), Medicaid insurance and prior healthcare utilization (inpatient and ED visits) the odds ratio for readmission in the post-intervention time period was aOR 0.91 (95% CI 0.81–1.02, p value=0.10).

To examine the dose-response of intervention to outcome, 30-day readmissions were compared within the post-intervention HIV population by TCN assignment group. Unadjusted readmission rate by treatment group was as follows: no intervention (15.9%), consult only (16.7%), approached by TCN but refused (25%) and TCN + consult (16.4%). In univariate analyses, both the TCN + consult (OR 1.37, 95% CI 0.99–1.90) and the consult only groups (OR 1.23, 95% CI 0.83–1.84, overall p value=0.15) had a higher odds of readmission than those who did not receive an intervention, though this was not statistically significant. In multivariate analyses adjusting for length of stay, healthcare utilization (inpatient and ED visits) and propensity score for assignment to treatment group (which included variables race, gender, primary language, history of AIDS, anxiety, benzodiazepine use, opiate use, viral load group, pO2, length of stay and prior inpatient visits), those in the TCN + consult (aOR 1.56, 95% CI 1.10–2.20) had a higher odds of readmission than those who did not receive an intervention whereas the consult only groups (aOR 0.93, 95% CI 0.65–1.33, overall p value 0.01), had comparable odds of readmission than those who did not receive an intervention. To assess how well the propensity score model accounts for variability in the choice of treatments received, we calculated the PDI (Polytomous Discrimination Index) as 0.58. The PDI is an extension of the widely used C statistic to the scenarios of multiple categories and can be interpreted as the probability of correctly identifying a case from a randomly selected category.

Discussion

In this interrupted time series study, we found that a multicomponent transition of care intervention for PWH reduced the adjusted odds of 30-day readmission by about 20%. There was a minimal post-intervention decline in adjusted odds of readmission in the concurrent control group with cellulitis. Though the crude prevalence of 30-day readmissions in PWH remained stable, 16% throughout, adjustment for multiple clinical, social and healthcare utilization variables identified a decreased odds of readmission in the post-intervention period, likely related to higher rates of current and prior AIDS-defining illnesses, mental illness, homelessness and lack of insurance in the post-intervention group. However, a dose-response effect was not observed among PWH, as more intensive intervention (medical consult + transitional care nurse) was not associated with decreased readmissions, though adjustment for confounders using propensity score analysis was imperfect.

Our study adds to and extends the literature on readmissions reduction interventions and contains similar core elements to those used in other studies among elderly, general internal medicine and CHF patients, though interventions, study designs and outcomes vary between published studies. Naylor et al., in an RCT of an advanced practice nurse-centered discharge

planning and home follow-up intervention for elders (>65), identified a significant difference in the proportion with a readmission within 6 months between intervention versus control groups (37% v. 20%).[22] Among patients admitted to a safety-net hospital, an RCT of an intervention resembling that in our study, including a nurse discharge advocate who helped with medication reconciliation, patient education, transmission of discharge summary to the primary doctor and post-discharge call from a pharmacist, resulted in 14.9% (intervention) v. 20.7% (control) (p=0.09) with 30-day readmissions.[24] A disease-specific intervention focused on hospitalized patients with CHF, directing an evidence-based intervention at those patients predicted to be at highest risk for readmission by an EHR model, was associated with a 27% reduction in readmissions.[26]

Limited data exist on interventions to reduce readmissions or improve clinical outcomes for hospitalized PWH. A small study (N=128) examining readmissions pre- and post-implementation of a pharmacist-led inpatient intervention, found a reduction in medication errors and 30-day readmissions (27% to 12%), as well as an increase in linkage to care after discharge, from 78% to 90%.[34] Similarly, a quasi-experimental study of antimicrobial stewardship for inpatients with HIV (N=203) resulted in reduced medication errors and improved linkage to HIV care (19% v 40%), though 30-day readmissions were not different between those who were or were not on ART.[35]

In this study, we did not find a dose response, and in fact those who received interventions had higher or similar readmissions rates to those who received case management alone. Though interventions were directed at those who were at higher risk for readmission, adjusting for confounding by indication by using a propensity score analysis did not identify a relationship between intervention receipt and reduced readmissions. This suggests either the existence of additional unmeasured confounders or that the intervention did not adequately address preventable determinants of readmission. System-level factors, such as how interventions were assigned (based on medical complexity, socio-behavioral barriers), sometimes inconsistently (depending on primary team decision to consult, TCN availability) created challenges for adequate propensity score adjustment. It is possible that certain subgroups, such as those with a new diagnosis of HIV, responded differently to the intervention. Though we did not have access to date of HIV diagnosis, future studies examining such subgroups could help tailor the intervention. In addition, we have previously identified additional predictors of readmission among PWH, such as food insecurity and readiness for substance use treatment, which are not typically measured as part of routine clinical care and could be contributing to readmission in this cohort.[18] A toolbox of readmission reduction interventions for PWH, based on qualitative interviews from 87 patients, providers and case managers, suggests various additional approaches, such as direct partnerships between the hospital and community based organizations and improving active linkage to mental health, substance use treatment and social services, which were not included in this intervention and may have further improved outcomes.[27]

Patient-level factors, such as patient activation, or a "patient's willingness and ability to take independent actions to manage their health and care"[36] has been associated with various health outcomes,[37,38] including HIV.[39] In this study, the transitional care nurse role provided an interactive and intensive intervention—patient education, assessment of

barriers, contacting patient's social support, reviewing prescriptions, confirming follow-up and contacting patient after discharge— all of which require the patient to be engaged and motivated. Especially high readmission rates (25%) among those who refused to meet with the transitional care nurse suggest that low patient activation may also have influenced results. In addition, for PWH who have very low CD4 counts, 30 days is a relatively short time to substantially improve their immune status. Thus, applying this quality metric to patients with AIDS may not reflect the longer-term progressive health trajectory seen with patients initiating or resuming ART.

Our study has several limitations. First, this is a single site study and therefore may not be generalizable to other settings, though our inpatient population of PWH reflects what has been described in other large urban centers in the southern US[16,40] many of which are also prioritized as part of the federal *EHE* initiative. We also include data from readmissions to over 90 hospitals in the greater Dallas Fort Worth area, contributing a more comprehensive assessment of readmissions across health systems. Second, this is a non-randomized pragmatic study, which limits our ability to exclude unmeasured confounders or to control who did and did not receive interventions. Third, several variables were not captured completely, including missing values for CD4 count and HIV viral load, which may be due to those being available to providers from outside medical records not recorded in the PHHS EHR, and the use of urine toxicology screens to indicate substance use, which likely underestimate this variable. Imputation of CD4 counts (which were also part of the e-model) did not cause substantial changes to results. Furthermore, parallel changes in certain variables across both cohorts, such as increases in mental illness and homelessness, may reflect a difference in how the health system captured social determinants of health over time, though this is hard to distinguish from local trends which show increases in mental health and housing needs over this time period.[41,42] Lastly, though cellulitis as a comparator group was selected due to the absence of specific readmissions reduction efforts for this diagnosis, individuals in this group may have received interventions aimed at co-morbid conditions (e.g. CHF), which were unable to adjust for and may have contributed to lower readmissions in this group.

In this trial, a hospital-based multicomponent intervention, including medical, social and care coordination elements, was effective in reducing the risk-adjusted 30-day readmissions among PWH in a safety-net hospital in the southern US, while no significant reduction was seen in a concurrent control group. However, no dose-response to the intervention was detected. Overall, admissions and readmissions among PWH in our region remain high, and substantial proportions have AIDS and AIDS-defining illnesses, highlighting the need for additional efforts to address overlapping barriers to care and social determinants of health. County-wide collaborative efforts which engage numerous diverse stakeholders have the potential to increase HIV prevention, early diagnosis and engagement in HIV care, preventing initial hospitalizations among PWH. Increased availability and breadth of transitional care services could lead to further declines in hospital readmissions.

References:

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360(14):1418–1428. [PubMed: 19339721]

2. Moy E, Chang E, Barrett M. Potentially preventable hospitalizations - United States, 2001–2009. MMWR Suppl 2013;62(3):139–143. [PubMed: 24264504]

3. Zuckerman RB, Sheingold SH, Orav EJ, et al. Readmissions, Observation, and the Hospital Readmissions Reduction Program. N Engl J Med 2016;374(16):1543–1551. [PubMed: 26910198]

4. Services CfMaM. Hospital Readmissions Reduction Program https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/HRRP/Hospital-Readmission-Reduction-Program. Accessed September 29, 2021.

5. Auerbach AD, Kripalani S, Vasilevskis EE, et al. Preventability and Causes of Readmissions in a National Cohort of General Medicine Patients. JAMA Intern Med 2016;176(4):484–493. [PubMed: 26954564]

6. Nijhawan AE, Kitchell E, Etherton SS, et al. Half of 30-Day Hospital Readmissions Among HIV-Infected Patients Are Potentially Preventable. AIDS Patient Care STDS 2015;29(9):465–473. [PubMed: 26154066]

7. Feigenbaum P, Neuwirth E, Trowbridge L, et al. Factors contributing to all-cause 30-day readmissions: a structured case series across 18 hospitals. Med Care 2012;50(7):599–605. [PubMed: 22354212]

8. van Walraven C, Bennett C, Jennings A, et al. Proportion of hospital readmissions deemed avoidable: a systematic review. Canadian Medical Association Journal 2011;183(7):E391–E402. [PubMed: 21444623]

9. Carter J, Ward C, Wexler D, et al. The association between patient experience factors and likelihood of 30-day readmission: a prospective cohort study. BMJ Qual Saf 2018;27(9):683–690.

10. Siddiqui Z, Berry S, Bertram A, et al. Does Patient Experience Predict 30-Day Readmission? A Patient-Level Analysis of HCAHPS Data. J Hosp Med 2018;13(10):681–687. [PubMed: 30261085]

11. Survival of HIV-positive patients starting antiretroviral therapy between 1996 and 2013: a collaborative analysis of cohort studies. Lancet HIV 2017;4(8):e349–e356. [PubMed: 28501495]

12. Berry SA, Fleishman JA, Moore RD, et al. Thirty-day hospital readmissions for adults with and without HIV infection. HIV Med 2016;17(3):167–177. [PubMed: 26176492]

13. Berry SA, Fleishman JA, Yehia BR, et al. Thirty-day hospital readmission rate among adults living with HIV. AIDS 2013;27(13):2059–2068. [PubMed: 23612008]

14. Nijhawan AE, Clark C, Kaplan R, et al. An electronic medical record-based model to predict 30-day risk of readmission and death among HIV-infected inpatients. J Acquir Immune Defic Syndr 2012;61(3):349–358. [PubMed: 23095935]

15. Feller DJ, Akiyama MJ, Gordon P, et al. Readmissions in HIV-Infected Inpatients: A Large Cohort Analysis. J Acquir Immune Defic Syndr 2016;71(4):407–412. [PubMed: 26505329]

16. Davy-Mendez T, Napravnik S, Wohl DA, et al. Hospitalization Rates and Outcomes Among Persons Living With Human Immunodeficiency Virus in the Southeastern United States, 1996–2016. Clin Infect Dis 2020;71(7):1616–1623. [PubMed: 31637434]

17. Hadlock GC, Moleres KA, Pineda LJ, et al. Risk factors for potentially preventable hospital readmissions among persons living with human immunodeficiency virus infection. AIDS Care 2021;33(3):306–310. [PubMed: 31893942]

18. Nijhawan AE, Metsch LR, Zhang S, et al. Clinical and Sociobehavioral Prediction Model of 30-Day Hospital Readmissions Among People With HIV and Substance Use Disorder: Beyond

Electronic Health Record Data. J Acquir Immune Defic Syndr 2019;80(3):330–341. [PubMed: 30763292]

19. Parent S, Barrios R, Nosyk B, et al. Impact of Patient-Provider Attachment on Hospital Readmissions Among People Living With HIV: A Population-Based Study. Journal of acquired immune deficiency syndromes (1999) 2018;79(5):551–558. [PubMed: 30204719]

20. Davy-Mendez T NS, Hogan BC, et al. Thirty-day hospital readmission rates among North Americans living with HIV, 2005–2015 Internal AIDS Society 2021, 11th IAS Conference on HIV Science; July 18–21, 2021; Virtual conference.

21. Kripalani S, Theobald CN, Anctil B, et al. Reducing hospital readmission rates: current strategies and future directions. Annual review of medicine 2014;65:471–485.

22. Naylor MD, Brooten D, Campbell R, et al. Comprehensive discharge planning and home follow-up of hospitalized elders: a randomized clinical trial. Jama 1999;281(7):613–620. [PubMed: 10029122]

23. Coleman EA, Smith JD, Frank JC, et al. Preparing patients and caregivers to participate in care delivered across settings: the Care Transitions Intervention. J Am Geriatr Soc 2004;52(11):1817–1825. [PubMed: 15507057]

24. Jack BW, Chetty VK, Anthony D, et al. A reengineered hospital discharge program to decrease rehospitalization: a randomized trial. Ann Intern Med 2009;150(3):178–187. [PubMed: 19189907]

25. Warchol SJ, Monestime JP, Mayer RW, et al. Strategies to Reduce Hospital Readmission Rates in a Non-Medicaid-Expansion State. Perspect Health Inf Manag 2019;16(Summer):1a–1a.

26. Amarasingham R, Patel PC, Toto K, et al. Allocating scarce resources in real-time to reduce heart failure readmissions: a prospective, controlled study. BMJ Qual Saf 2013;22(12):998–1005.

27. Nijhawan AE, Higashi RT, Marks EG, et al. Patient and Provider Perspectives on 30-Day Readmissions, Preventability, and Strategies for Improving Transitions of Care for Patients with HIV at a Safety Net Hospital. J Int Assoc Provid AIDS Care 2019;18:2325958219827615.

28. Garg A, Lavian J, Lin G, et al. Clinical Factors Associated with Readmission among Patients with Lower Limb Cellulitis. Dermatology 2017;233(1):58–63. [PubMed: 28501866]

29. Cutfield T, Walter H, Hobbs M, et al. Association of the Dundee severity classification with mortality, length of stay and readmission in adult inpatients with cellulitis. J Antimicrob Chemother 2019;74(1):200–206. [PubMed: 30295790]

30. Berry SA, Fleishman JA, Moore RD, et al. Trends in reasons for hospitalization in a multisite United States cohort of persons living with HIV, 2001–2008. J Acquir Immune Defic Syndr 2012;59(4):368–375. [PubMed: 22240460]

31. Elixhauser A SC, Palmer L. Clinical Classifications Software (CCS). US Agency for Healthcare Research and Quality 2015. http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.

32. CDC. 1993 revised classification system for HIV infection and expanded surveillance case definition for AIDS among adolescents and adults. MMWR Recomm Rep 1992;41(RR-17):1–19.

33. Nijhawan AE, Bhattatiry M, Chansard M, et al. HIV care cascade before and after hospitalization: impact of a multidisciplinary inpatient team in the US South. AIDS Care 2020;32(11):1343–1352. [PubMed: 31809594]

34. Brizzi MB, Burgos RM, Chiampas TD, et al. Impact of Pharmacist-Driven Antiretroviral Stewardship and Transitions of Care Interventions on Persons With Human Immunodeficiency Virus. Open Forum Infectious Diseases 2020;7(8).

35. Roshdy D, McCarter M, Meredith J, et al. Implementation of a comprehensive intervention focused on hospitalized patients with HIV by an existing stewardship program: successes and lessons learned. Ther Adv Infect Dis 2021;8:20499361211010590–20499361211010590.

36. Hibbard JH, Stockard J, Mahoney ER, et al. Development of the Patient Activation Measure (PAM): conceptualizing and measuring activation in patients and consumers. Health Serv Res 2004;39(4 Pt 1):1005–1026. [PubMed: 15230939]

37. Milo RB, Ramira A, Calero P, et al. Patient Activation and Glycemic Control Among Filipino Americans. Health Equity 2021;5(1):151–159. [PubMed: 33937600]

38. Wilkinson TJ, Memory K, Lightfoot CJ, et al. Determinants of patient activation and its association with cardiovascular disease risk in chronic kidney disease: A cross-sectional study. Health Expect 2021;24(3):843–852. [PubMed: 33835670]

39. Marshall R, Beach MC, Saha S, et al. Patient activation and improved outcomes in HIV-infected patients. J Gen Intern Med 2013;28(5):668–674. [PubMed: 23288378]

40. Colasanti JA, del Rio C. Declining Hospitalizations Among Persons With Human Immunodeficiency Virus: Time to Leave No Patient Behind. Clinical Infectious Diseases 2020;71(7):1624–1626. [PubMed: 31637419]

41. Dallas City Hall. State of the Homeless Address 2017; https://dallascityhall.com/departments/homeless-solutions/DCH%20Documents/2017%20State%20of%20Homelessness%20Address.pdf.

42. North Texas Community Health Collaborative. Behavioral Health Needs Assessment of 16 North Texas Counties 2018; https://www.healthyntexas.org/content/sites/dallasfortworth/BHCHNA__16_Counties_CHC.DFWHCFoundation2018.pdf.

Table 1.

Baseline Characteristics of Pre-Intervention (2012–2014) and Post-Intervention (2104–2016) Index
Admissions for HIV and Cellulitis

	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention	
	HIV Index Admissions		HIV Index Admissions		Cellulitis Index Admissions		Cellulitis Index Admissions	
	N=2049	%	N=2023	%	N=5023	%	N=5326	%
Demographics/SES								
Age, median	43.3 (18.3–85,5)		43.3 (18.1—85.0)		50.6 (17.5–92.9)		52.3 (17.7–93.4)	
Sex								
Male	1360	66.4	1382	68.3	2877	57.3	3060	57.5
Female	689	33.6	641	31.7	2146	42.7	2265	42.5
Race								
Non-Hispanic Black	1062	51.8	1102	54.5	1141	22.7	1276	24.0
Non-Hispanic White	461	22.5	399	19.7	1200	23.9	1308	24.6
Hispanic	497	24.5	479	23.7	2581	51.4	2642	49.6
Other	29	1.4	43	2.1	101	2.0	99	1.9
Marital status								
Single	1561	76.2	1541	76.2	2180	43.4	2450	46.0
Married	239	11.7	238	11.8	1498	29.8	1591	29.9
Divorced	196	9.6	181	9.0	977	19.5	919	17.3
Widowed	44	2.2	49	2.4	347	6.9	341	6.4
Other	9	0.4	14	0.7	21	0.4	24	0.5
Primary Language								
English	1738	84.8	1714	84.7	3299	65.7	3603	67.7
Spanish	275	13.4	274	13.6	1670	33.3	1658	31.2
Other	36	1.8	35	1.7	54	1.1	64	1.2
Homelessness	119	5.8	291	14.4	294	5.9	550	10.4
Insurance								
Medicaid	824	40.8	684	34.5	1667	33.6	1549	29.8
Medicare	416	20.6	422	21.3	890	17.9	1097	21.1
Private	57	2.8	59	3.0	99	2.0	162	3.1
Charity / Self-Pay	725	35.9	820	41.3	2312	46.5	2397	46.1
Comorbid conditions								
Mental Health								
Depression, Mania	247	12.1	399	19.7	304	6.1	728	13.7
Anxiety	117	5.7	169	8.4	276	5.5	376	7.1
Psychotic disorders	76	3.7	95	4.7	116	2.3	151	2.8
Other	87	4.3	107	5.3	157	3.1	188	3.5
Positive drug screen								

	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention	
	HIV Index Admissions		HIV Index Admissions		Cellulitis Index Admissions		Cellulitis Index Admissions	
	N=2049	%	N=2023	%	N=5023	%	N=5326	%
Opiate	148	7.2	117	5.8	252	5.0	243	4.6
Cocaine	108	5.3	109	5.4	108	2.2	121	2.3
Benzodiazepines	38	1.9	40	2.0	92	1.8	75	1.4
Amphetamine	26	1.3	79	3.9	35	0.7	75	1.4
Other co-morbidities								
Diabetes	363	17.7	384	19.0	3050	60.7	3298	61.9
CHF	369	18.0	375	18.5	1971	39.2	2075	39.0
Vascular Insufficiency	40	2.0	71	3.5	640	12.7	738	13.9
Clinical variables								
CD4								
< 50	299	14.6	338	16.7	NA		NA	
51 – 200	354	17.3	336	16.6	NA		NA	
201 – 500	362	17.7	375	18.6	NA		NA	
> 500	211	10.3	174	8.6	NA		NA	
Missing	823	40.2	800	39.6	NA		NA	
HIV VL (copies/mL)								
< 20	292	14.3	302	14.9	NA		NA	
21–200	155	7.6	114	5.6	NA		NA	
201–10,000	162	7.9	177	8.8	NA		NA	
> 10,000	637	31.1	686	33.9	NA		NA	
Missing	803	39.2	744	36.8	NA		NA	
History of ADI	431	21.0	639	31.6	--	--	--	--
WBC (x10 (9)/L)								
< 4.2	450	22.0	435	21.5	306	6.1	314	5.9
4.2 10.3	1207	58.9	1207	59.7	2838	56.5	2961	55.6
> 10.3	363	17.7	366	18.1	1816	36.2	2022	38.0
Missing	29	1.4	15	0.7	63	1.3	29	0.5
Creatinine (mg/dL)								
< 0.67	354	17.3	244	12.1	1095	21.8	1089	20.5
0.67 – 1.17	1044	51.0	1076	53.2	2067	41.2	2284	42.9
> 1.17	521	25.4	594	29.4	1729	34.4	1858	34.9
Missing	130	6.3	109	5.4	132	2.6	95	1.8

Abbreviations: SES= socio-economic status, CHF= congestive heart failure, VL= viral load, ADI= AIDS defining illness, WBC= white blood cells.

Table 2.

Principal Diagnoses and Prior Healthcare Utilization for HIV and Cellulitis Index Admissions in Pre-Intervention (2012–2014) and Post-Intervention (2014–2016) Time Periods

	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention	
	HIV Index Admissions		HIV Index Admissions		Cellulitis Index Admissions		Cellulitis Index Admissions	
Variable	N=2049	%	N=2023	%	N=5023	%	N=5326	%
LOS, Mean (SD)	5.4	(5.6)	7.1	(7.8)	6.1	(7.7)	7.1	(7.5)
Principal diagnoses								
AIDS-Defining Illness	138	6.7	176	8.7	--	--	--	--
Non-ADI infections	653	31.9	718	35.5	1720	34.2	1964	36.9
Neoplasms	57	2.8	52	2.6	98	2.0	91	1.7
Endocrine, nutritional, metabolic	144	7.0	97	4.8	822	16.4	792	14.9
Blood and blood-forming organs	72	3.5	55	2.7	67	1.3	53	1.0
Mental Illness	64	3.2	57	2.8	113	2.3	86	1.6
Nervous system	66	3.3	50	2.5	71	1.4	59	1.1
Circulatory system	154	7.5	170	8.4	696	13.9	799	15.0
Respiratory system	108	5.3	78	3.9	141	2.8	177	3.3
Digestive system	174	8.5	158	7.8	382	7.6	374	7.0
Genitourinary system	99	4.8	92	4.6	210	4.2	200	3.8
Pregnancy, childbirth	132	6.4	142	7.0	199	4.0	161	3.0
Skin	12	0.6	10	0.5	66	1.3	54	1.0
Musculoskeletal system	19	0.9	30	1.5	72	1.4	94	1.8
Congenital anomalies	0	0.0	1	0.1	4	0.1	1	0.0
Injury and poisoning	100	4.9	91	4.5	263	5.3	322	6.1
Misc Health Status	50	2.4	40	2.0	57	1.1	65	1.2
ED visits prior 12 mo								
0	835	40.8	837	41.4	1464	29.2	1429	26.8
1	340	16.6	306	15.1	648	12.9	781	14.7
2	133	6.5	136	6.7	355	7.1	384	7.2
3	102	5.0	104	5.1	278	5.5	327	6.1
4	58	2.8	77	3.8	174	3.5	222	4.2
5	46	2.2	47	2.3	167	3.3	208	3.9
6 or more	535	26.1	516	25.3	1937	38.6	1975	37.1
Inpt visits prior 12 mo								
0	1291	63.0	1202	59.4	2555	50.9	2294	43.1
1	358	17.5	347	17.2	943	18.8	1114	20.9
2	189	9.2	178	8.8	527	10.5	654	12.3
3	74	3.6	106	5.2	315	6.3	395	7.4

Variable	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention	
	HIV Index Admissions		HIV Index Admissions		Cellulitis Index Admissions		Cellulitis Index Admissions	
	N=2049	%	N=2023	%	N=5023	%	N=5326	%
4	46	2.2	56	2.8	197	3.9	269	5.1
5	27	1.3	41	2.0	124	2.5	181	3.4
6 or more	64	3.1	93	4.6	362	7.2	419	7.9

Abbreviations: LOS= length of stay, SD= standard deviation, Misc= miscellaneous, ED= emergency department, Inpt=inpatient, mo=months

Table 3.

Univariate Analysis of 30-day Readmissions Among People With HIV

Variable	Univariate			Multivariate		p value
	OR	95% CI	p value	aOR	95% CI	
Post-intervention	1.02	0.85–1.29	0.81	0.81	0.66–0.99	0.04
Age at admission	1.01	1.00–1.02	0.04	1.01	1.00–1.02	0.03
HIV readmission e-model[*]				1.74	1.57–1.93	<0.01
Age group			0.03			
<30	0.82	0.55–1.20				
30–39	0.71	0.49–1.04				
40–49	1.10	0.77–1.56				
50–59	0.93	0.64–1.35				
60+	Ref	--				
Female sex	0.93	0.75–1.14	0.46			
Race/ethnicity			0.53			
NH White	Ref	--				
NH Black	1.08	0.84–1.37				
Hispanic/Other	0.94	0.71–1.25				
Marital status			0.80			
Single	Ref	--				
Married	1.09	0.82–1.47				
Divorced/Widowed/Other	1.06	0.78–1.42				
Primary language			0.88			
English	Ref	--				
Spanish/Other	0.98	0.75–1.28				
Homelessness	1.66	1.23–2.26	<0.01			
Medicaid	1.55	1.28–1.87	<0.01			
Distance from PHHS	0.86	0.67–1.10	0.24			
Mental health						
Depression	1.03	0.80–1.32	0.81			
Anxiety	0.89	0.62–1.27	0.51			
Psychosis	1.30	0.85–1.99	0.22			
Other	1.08	0.72–1.64	0.69			
Positive drug screen						
Opiates	1.08	0.72–1.63	0.92			
Cocaine	1.49	0.98–2.71	1.17			

	Univariate			Multivariate		p value
Variable	OR	95% CI	p value	aOR	95% CI	
Benzodiazepines	1.24	0.65–2.35	0.73			
Methamphetamines	0.85	0.45–1.58	0.86			
CD4 <92	1.32	0.09–1.60	<0.01			
HIV viral load			<0.01			
<200	Ref	--				
>=200	0.93	0.74–1.18				
Missing	0.54	0.42–0.69				
History of ADI	1.34	0.96–1.83	0.07			
Abnormal absolute lymphocytes	4.32	1.00–18.62	0.05			
Abnormal AST/ALT	1.26	1.03–1.55	0.03			
Abnormal HCT	1.80	1.46–2.23	<0.01			
Abnormal pO2	1.10	0.74–1.62	0.64			
Abnormal Anion gap	0.93	0.77–1.13	0.48			
LOS	1.03	1.01–1.47	<0.01			
Prior ED visits	1.34	1.28–1.39	<0.01			
Prior IP visits	1.24	1.19–1.29	<0.01			

Abbreviations: OR= odds ratio; CI= confidence interval; ADI= AIDS-defining illness; AST=aspartate aminotransferase; ALT= alanine aminotransferase, HCT= hematocrit; P02= partial pressure of oxygen; LOS= length of stay; ED= emergency department; IP= inpatient

*
e-model includes the following: history of ADI, CD4 result <92, absolute lymphocyte count, AST/ALT, HCT, p02, Anion gap, Medicaid insurance, homelessness, distance from PHHS >13 miles, prior inpatient and prior ED visits