Title

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Journal

AIDS Care, 36(sup1)

ISSN

0954-0121

Authors

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Publication Date

2024-07-09

DOI

10.1080/09540121.2024.2308747

Peer reviewed

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Published online: 30 Jan 2024.

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Measuring health care continuum with multifaceted indicators for people who use drugs in Vietnam

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ABSTRACT

Continuum of care is a concept that has been widely applied in HIV prevention and treatment studies. However, measuring care continuum can be challenging because it involves multiple stages and multiple components or domains at each stage of care. In this study, we introduced an analytical framework to (1) estimate intervention effects overall and by domain using a multi-level modeling approach, and (2) learn possible patterns of domains over time utilizing a multi-layer heatmap visualization. Longitudinal data from an intervention study conducted among people who use drugs in Vietnam were used to construct Seek, Test, Treat, and Retain (STTR) domain and overall scores. Findings from the adjusted analysis showed that people who use drugs in the intervention exhibited a significantly greater improvement in the overall STTR score than those in the control (p-values $< .0001$). The multi-layer heatmap revealed different patterns of the individual domains over time and the inter-relationships among the individual domains. This study demonstrates the feasibility of constructing a general fulfillment score and domain specific scores to measure care continuum among people who use drugs. The analytical framework can be readily extended to evaluate service fulfillment outcomes in health services and treatment studies for other key populations.

Introduction

Care continuum is a concept involving an integrated system of care, particularly with chronic conditions or life-long diseases, over time through a comprehensive array of health services (Gardner et al., 2011; Kay et al., 2016; Martinez-Guerra et al., 2023; McNulty & Schneider, 2018; Zhou et al., 2016). For example, HIV care continuum was used to achieve viral supression or manage HIV-associated complications (Deeks et al., 2013; Hogg, 2018;), continuum of care was used for cancer surviors to stablize their physical and mental well-being (Dulaney et al., 2017), and care continuum was used for managing non-communicable diseases in low- and middle-income countries (Thapa et al., 2020). Incorporating such a concept into emerging public health issues, such as substance use, will help in understanding and reducing gaps in different stages of HIV and addiction care continuum (Korthuis & Edelman, 2018). Most studies on care continuum were cross-sectional, which is useful to assess the success of various care programs among the populations of interest. However, the investigation of longitudinal continuum might provide further insights about the performance of care programs (Jose et al., 2018).

Measuring care contiunun in medical or public health fields could face challenges because it involves multifaceted measures or indicators at each stage of care. Examples include different types of measures from health-associated survey assessments among persons who inject drug (Li et al., 2018), patient-reported outcome measures (PROMs) used in the continuum of cancer clinical care (Di Maio et al., 2022), survivorship care plan at the different stages of diseases among low-income breast cancer surviors (Maly et al., 2017). Traditionally, researchers focus on the individual measures of interest, such as intervention effects on treatment adherence over time. However, multifaceted outcomes (e.g., a domain outcome involving multiple indicators) and an overall care-continuum outcome are equally important for measuring care in specific areas and disease stages. Additional analyses on multifaceted outcomes may provide different perspectives of

care that might be directly relevant to community stakeholders.

The concept of Seek, Test, Treat and Retain (STTR) treatment cascade proposed by the National Institute on Drug Abuse, National Institute of Health, displays a continued sequence of services to effectively deliver an HIV continuum of care to diverse drug-absuing populations (Chandler et al., 2015). The STTR treatment cascade is a process that involves in reaching out to at-risk individuals who have not been tested for HIV recently (Seek), engaging these individuals in HIV testing (Test), connecting persons living with HIV (PLWH) to available treatments and services (Treat), and making uninterrupted HIV care feasible (Retain) (Chandler et al., 2017). The application of STTR treatment framework faces the same challenges described earlier since it involves multiple indicators and domains that were evaluated in different ways. Christopoulos and colleagues (2017) use the STTR framework to examine the intervention studies that utilized mobile phones and text messaging to improve engagement in HIV care for vulnerable populations in the United States. However, they did not evaluate the domains of STTR in the study. Beckwith and colleagues (2018) use the cross-sectional data from the STTR Data Harmonization Initiative to examine HIV care continuum among transgender women who were involved with the criminal justice system. Nevertheless, this study analyzed the STTR indicators separately, e.g., currently taking ART of the Treat domain seperately from the adherence to ART of the Retain domain.

In this study, we proposed an analytical framework that included two steps to measure care continuum at different stages. First, we estimated intervention effects overall and by STTR domain longitudinally using a multi-level modeling approach. Second, we demonstrated how to visualize patterns of STTR domains over time and their inter-relationships among the individual domains utilizing a multi-layer heatmap visualization. This visualization can be further used to graphically examine the patterns of domains across populations or subgroups of interest. To illustrate our approach, we used the STTR individual measures that were constructed in the efficacy assessment of an intervention in Vietnam as an example. The intervention was delivered in two consecutive steps. The first step aimed to enhance the communication skills of community health workers (CHW) in providing services to people who use drugs (PWUD). The CHWs participated in three weekly sessions, each lasting 90 min, to improve their communication skills. In the second step, the trained CHWs conducted three one-hour individual sessions with PWUD, utilizing the tools and skills they had learned. Li and colleagues

(2018) provide a more detailed description of the intervention's development and implementation.

Materials and methods

Data source

The present study used longitudinal data from an intervention study in Vietnam during 2014-2016. The clustered randomized controlled trial was conducted in two provinces of Vietnam. A total of 900 people who use drugs (PWUD) from 60 communes were enrolled and assessed in the study. Survey assessments were collected at baseline and every 3 months thereafter for one year. Study details, including sample characteristics of the participants, are described in Li et al. (2018).

Scoring procedure

The STTR framework with four domains: SEEK, TEST, TREAT, and RETAIN, is used for the present study. The SEEK domain includes five indicators: awareness of local healthcare service, health literacy, access to care, barriers in care seeking, and support in care seeking. There are two indicators available to evaluate the TEST domain: having been tested HBV/HCV/STI and having done routine HIV testing if seronegative or routine viral testing if seropositive. The TREAT domain involves five different services: community health center, mental health, substance use treatment center, prevention services for seronegative or ART for seropositive PWUD, and social service. The last domain, RETAIN domain, includes only a single indicator, substance use treatment. The STTR domains and indicators are listed in Table 1. Each indicator is given one point if it is fulfilled, e.g., one point is given

Table 1. Seek, Test, Treat, and Retain (STTR) individual items at baseline.

Domain	Item	Baseline (%)
Seek	Awareness of local healthcare service	93.9
	Health literacy	83.7
	Having regular doctor visits (access to care)	43.9
	Having any barriers in CHC care seeking	7.1
	Having support in care seeking	67.6
Test	Having done any comorbidity testing (including HBV/HCV/STI)	12.2
	Having done routine HIV testing for seronegative PWID or routine viral testing for seropositive PWID	15.3
Treat	CHC primary care visiting	42.6
	Mental health care reception	41.7
	Substance use treatment reception (e.g., MMT)	30.0
	HIV prevention services reception for HIV- PWID and ART reception for HIV+ PWID	26.0
	Social service reception	45.0
Retain	Retention in substance use treatment	27.4

if a PWUD self-reported that he or she knows any local healthcare services, such as primary care services. A domain score is defined as the sum of all the individual indicators within each domain, and an overall score is calculated by summing all the domain scores.

Data analysis

Sample characteristics by intervention condition were summarized and compared at baseline. Baseline frequency distribution of each STTR indicator was summarized. Generalized linear mixed-effects regression models with appropriate link functions (e.g., identity for continuous and logit for binary) were used to examine intervention effects on each domain score and the overall STTR fulfillment score. Each regression model included commune- and participant-level random effects that accounted for dependence within communes and correlation among repeated observations within PWUD. The intervention effect at each follow-up visit was defined as the difference in mean changes in overall STTR and domain scores from baseline between intervention conditions (a difference in difference approach) and was estimated through model contrasts. The adjusted means of overall STTR score (with standard error) over time were plotted by intervention condition. A heatmap is an efficient visualization tool commonly used in display genomic or medical data involving high dimensions to reveal patterns and relationships of clustered data matrices (Gu et al., 2016). This tool was implemented to demonstrate the inter-relationships among the STTR domain scores related to overall STTR score by intervention condition. All analyses were conducted using SAS 9.4 software (Cary, NC, SAS Institute), and the graphs were generated using the publicly available statistical software R (R Core Team, 2022).

Results

The majority of the PWUD were male; around 45% aged between 31 and 40 years (mean = 36.7). Almost 80% of them reported having 7–12 years of educations, and 73% reported an annual household income of less than 750,000 thousand VND (US $3290). All PWUD in the study were heroin users with an average of 10 years of experience. More PWUD were married in the intervention vs. control groups (77% vs. 68%, respectively; $p = 0.005$).

Application of STTR measures

Table 1 lists the domains, indicators in each domain, and the percentage of each indicator across domains at baseline. Almost all the participants in the study reported they were aware of local healthcare services (94%). The second and third highest percentages were health literacy (84%) and having support in care seeking (68%). These three STTR items were part of the SEEK domain.

Figure 1 presents the adjusted mean overall STTR score (± SE) over time for intervention and control conditions. At the 3-month follow-up, participants from both conditions showed a significantly greater improvement in the overall STTR score (mean change scores from baseline for intervention and control: 1.24 vs. 0.45, p-values < .0001), adjusting for PWUD's demographic characteristics and drug use history. The improvement from the intervention condition was significantly greater than that from the control group ($p < .0001$). As shown in Figure 1, the intervention effects on the improvement of overall STTR score remained over time, but slowly decreased at the 12-month follow-up. Participants aged 30 or younger ($p <.0001$), women ($p = 0.003$), more educated participant ($p = 0.002$), and those with longer drug use history ($p = 0.001$) were significantly associated with improvement of the overall STTR score.

Visualization of STTR domains and its inter-relationship

Figure 2 displays the multi-layer heatmap of adjusted mean STTR domain and overall scores over time by condition, controlling for baseline covariates, commune-level clustering, and repeated observations within participants. The multi-layer heatmap revealed different patterns of the individual domains over time and also the inter-relationships among the individual domains. First, the starting levels of the individual domains varied, despite the comparable overall STTR scores between the conditions (can be seen in the last column). For example, the SEEK domain started at a higher level for both groups (> 0.62, first column under each condition), whereas the RETAIN domain started at a much lower level (< 0.10, fourth column under each condition). Second, the intervention effects on domain scores varied. For example, the adjusted mean scores of the SEEK domain for the intervention participants increased steadily over time (can be seen in the first column under intervention condition), whereas those for the control participants stayed around the same level. The improvement of SEEK domain (i.e., mean change from baseline) was significantly greater for intervention than control at the 6-month follow-up ($p < .0001$) and maintained throughout the study. The mean TEST domain score for the intervention participants was significantly greater than that for the control participants at the 3-month follow-up, but did not maintained further.
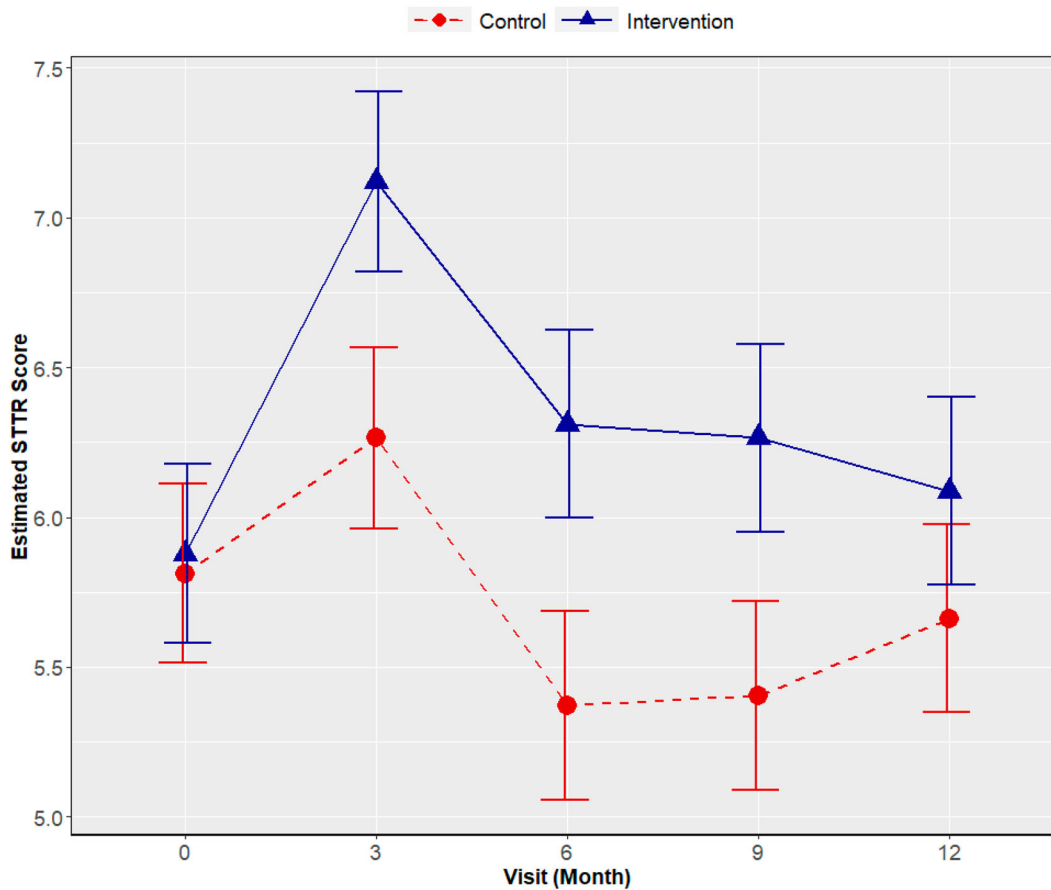
Figure 1. Adjusted* Mean STTR Score (± SE) over Time for Intervention vs. Control. Adjusted mean STTR score with standard error (SE) at each time point for each intervention condition was estimated from the adjusted model with the individual characteristics (age, gender, marital status, education, and household income).

Whereas the intervention effect on the TREAT domain occurred at the 3- month follow-up and was able to last for another 6 months (p-values < .0001). No intervention effects were observed for the RETAIN domain.

Discussion

This study demonstrated the feasibility of constructing a fulfillment score for patients' seek, test, treat, and retain (STTR) continuum of care and showed the utility of measuring the care continuum at various stages for the key population. The individual STTR indicators in this application were set equally when constructing the overall STTR and domain scores. For future studies, however, the construction can be flexibly tailored to the research questions of interest or weighted differently based on the specific domains of interest. Additionally, the associations between the STTR domain scores and the overall STTR fulfillment score provide more insight of care or services needed for various stages of medical conditions among those with long-term diseases to ensure continuum of care. The suggested analytical framework can be extended to evaluate the overall STTR fulfillment as an outcome of interest through a large integrated data set from several similar studies, with the potential to address additional research questions.

Furthermore, the framework we introduced allows researchers to observe the change in each STTR domain and its inter-relationship among other STTR domains over time. Future interventions may focus on a particular domain, for example, with specific outcome indicators. In this application for people who use drugs, we observed a higher level of SEEK domain relatively to other STTR domains for both intervention and control, suggesting that the study participants had reasonable knowledge and awareness to seek out needed care or services. However, for the TEST domain, the study participants could face additional challenges in their comorbidity tests, routine HIV testing for the seronegative participants, and routine viral testing for the seropositive participants. Those participants with lower scores of SEEK domain might be less motivated to follow-up their routine HIV or viral testing. The
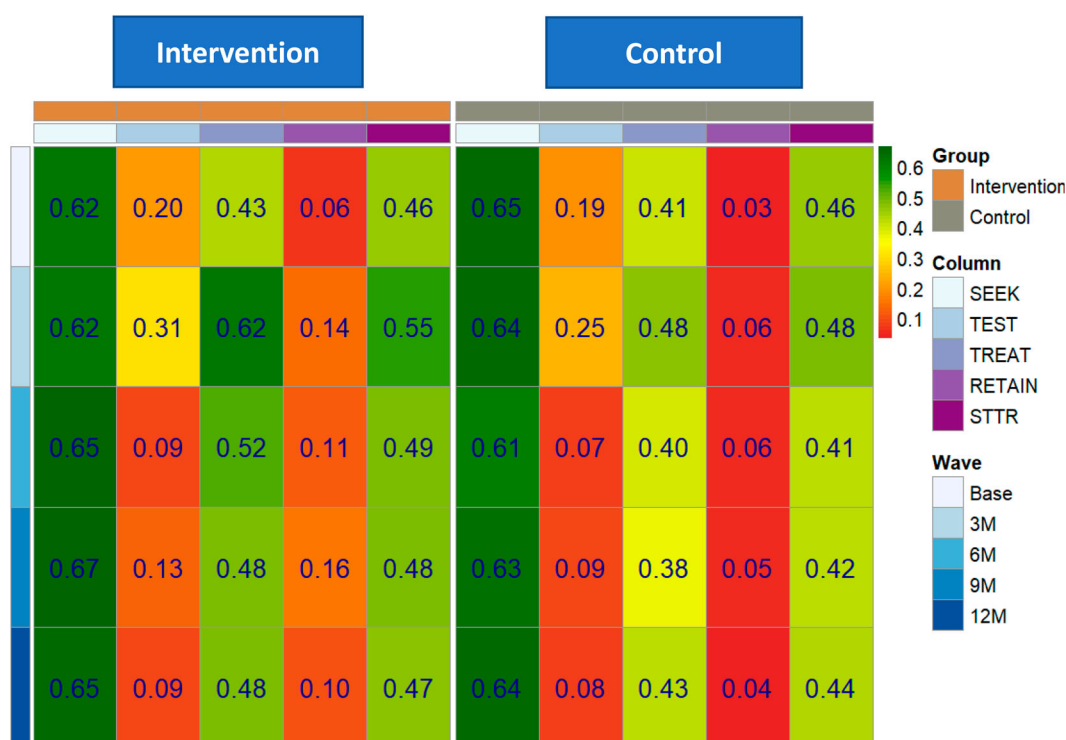
Figure 2. Multi-layer Heatmap of Adjusted STTR Domain and Overall Score over time by Intervention Condition. Adjusted domain-specific mean scores and overall mean STTR over time plotted by intervention condition. Within each group, columns 1–5 are "Seek", "Test", "Treat", "Retain" and "STTR overall score", respectively. Low score is shown in red, whereas high score is shown in green. Generalized liner mixed-effects regression model described in the data analysis section was performed separately for each column.

improvement of the TEST domain was observed at the 3-month follow-up but did not last long, suggesting that some participants may have lost their motivation of getting routine testing after the intervention was completed.

The analytical framework used in this study can be readily applied to investigate populations or subgroups of interest, e.g., patients with certain health-related conditions. The use of heatmap, in particular, provides a powerful tool for visual display of high dimensional data and has been heavily used in the various research fields, e.g., visualizing high-throughput gene expression data in the fields of bioinformatics and patterns of fatty infiltration score in the imaging studies (Gómez-Andrés et al., 2019; Gruber et al., 2022; Svanberg et al., 2022). As demonstrated in this study, this tool can be customized and exploited to measure care continuum at different stages in a few different aspects: (1) visualizing the high-dimensional data without losing information, (2) understanding patterns of multifaceted outcomes in relation with the overall fulfillment score, and (3) differentiating patterns of high-dimensional data across subgroup of interest (e.g., STTR individual components for short- vs. long-term use) or different sources of data (e.g., electronic health records

and survey assessments). Information learned from the application can be used as a precursor to inform tailored interventions targeting better health of target populations.

Our study presents a couple of limitations. First, since the original study was not designed to investigate STTR measures and application strategy, some of suggested STTR items were not included and the domains were not equally focused. Second, the individual components of each domain were based on self-reports. Despite these limitations, our proposed analytical framework provides a practical alternative approach for researchers to investigate the complex relationships among the multifaceted outcomes of care continuum over time.

Conclusion

This study demonstrates the feasibility of constructing a general fulfillment score and specific domain indicators to measure patients' condition at different stages of the care continuum. The proposed scoring method and analytical framework can be readily extended to evaluate various service fulfillment outcomes in HIV and other health service studies.

Disclosure statement

Funding

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