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Latent Class Analysis of Syndemic Factors Associated with Sustained Viral Suppression among Ryan White HIV/AIDS Program Clients in Miami, 2017

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Abstract

The study's objective was to identify the association between sustained viral suppression (all viral load tests < 200 copies/ml per year) and patterns of co-occurring risk factors including, mental health, substance use, sexual risk behavior, and adverse social conditions for people with HIV (PWH). Latent class analysis followed by multivariable logistic regression was conducted for 6554 PWH in the Miami-Dade County Ryan White Program during 2017, and a five-class model was selected. Compared to Class 1 (no risk factors), the odds of achieving sustained viral suppression was significantly lower for Class 2 (mental health) (aOR: 0.67; 95% CI 0.54–0.83), Class 3 (substance use and multiple sexual partners) (0.60; 0.47–0.76), Class 4 (substance use, multiple sexual partners, and domestic violence) (0.71; 0.55–0.93), and Class 5 (mental health, substance use, multiple sexual partners, domestic violence, and homelessness) (0.26; 0.19–0.35). Findings indicate the need for targeted interventions that address these syndemic factors.

Keywords Latent class analysis · Syndemic factors · Sustained viral suppression · HIV/AIDS

Introduction

Sustained viral suppression, which is defined as having all viral load test results of < 200 copies/ml within a year, is critical to ensure reduced risk of human immunodeficiency virus (HIV) transmission to others and disease progression to acquired immune deficiency syndrome (AIDS) [1, 2]. In 2017, only 62.7% of people with HIV (PWH) in the United States had achieved viral suppression, when assessing their last viral load test in a year [3]. Moreover, studies have demonstrated that PWH have challenges in maintaining a consistent viral load over time [4–6]. In a study of United States HIV surveillance data from 17 states, PWH who did not have a consistently suppressed viral load on average spent 60% of a 2-year period with viral load counts of > 200 copies/ml [7].

Numerous factors play a role in achieving sustained viral suppression among PWH. The interaction of multiple adverse or syndemic factors has been shown to affect health outcomes for PWH. Compared to the presence of a single adverse risk factor, syndemic theory posits that the co-occurrence of two or more adverse risk factors contribute to an increased susceptibility to poor health outcomes [8, 9]. Syndemic theory highlights that, in addition to the affliction caused by a disease, social, behavioral, and structural factors play a significant role in a person's overall health [10]. Syndemic theory has been used to explain the HIV epidemic amongst marginalized populations by assessing the intersecting effects of mental health, substance use, violence, and other adverse conditions such as poverty and low socioeconomic status on health outcomes [9, 11, 12].

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Mental health and substance use disorders in particular have shown detrimental effects on HIV care outcomes for PWH [12]. Homelessness is another equally important adverse risk factor that has shown to have a negative impact on achieving viral suppression due to housing instability and lower rates of health care utilization [13]. Specifically, women and minority populations such as African Americans and Hispanics are predominantly affected by multiple co-occurring risk factors such as intimate partner violence, substance use, depression, and stress [11].

People living with HIV with income below the federal poverty level, those underinsured and uninsured qualify to receive HIV care from the Ryan White Program (RWP) [14]. The RWP is a federally funded program, which serves as a payer of last resort and provides comprehensive medical and social support services for underserved PWH [15]. Eligible metropolitan areas receive funding from the RWP to combat the HIV epidemic. Each year, the RWP serves more than half of the PWH in the United States, [15, 16] with approximately three-quarters of the clients served in 2017 belonging to minority populations [15].

In order to improve the health outcomes of vulnerable PWH within the RWP, it is important to assess the impact of these syndemic factors on achieving sustained viral suppression. Most syndemic studies have been conducted to assess risk of HIV acquisition, while few studies have measured syndemic factors amongst PWH. Furthermore, little is known about syndemic factors and their effect on achieving sustained viral suppression among PWH. Latent class analysis (LCA) can concurrently assess specific combinations of multiple risk factors and identify patterns of syndemic factors [17]. Therefore, the objective of this study was to identify the association between classes of patterns of mental health, substance use, sexual risk behavior, and adverse social conditions and sustained viral suppression for PWH.

Methods

Study Population and Design

This study is a cross-sectional analysis of adults 18 years and older who were enrolled in the Miami-Dade County Part A RWP from 2016–2017. Enrollment status of a client was determined by assessing whether the client received medical case management services or peer education network support from the RWP in 2017. Clients only referred to the program for ancillary services from an out-of-network provider, those with missing client health assessment forms, cases closed due to mortality, relocation, or financial ineligibility, and automatically closed due to loss to follow up in care were excluded from this analysis.

Predictor and Outcome Variables

A total of seven dichotomous (yes/no) indicator variables were utilized for the LCA. Variables were collected through questionnaires administered by case managers as part of the client's health needs assessment. These variables included substance use (Have you used alcohol in the last 12 months and Have you used drug in the last 12 months), mental health symptoms (Have you been feeling depressed/anxious and Have you been having difficulty sleeping), sexual risk behavior (Have you had more than one sexual partner in the last 12 months), and adverse social conditions (Have you ever experienced domestic violence/abuse and Are you homeless or not). Demographic variables of interest were age (18–34, 34–49, 50 + years), race (Black, other), gender (men, women), US born (yes, no; not including US territories), preferred language (English, other) and household income (< 100% federal poverty level (FPL), ≥ 100% FPL).

The outcome variable was sustained viral suppression, which was defined as having a viral load count of < 200 copies/ml in all viral load tests within a year [18]. Individuals with a viral load test of ≥ 200 copies/ml on any laboratory test result in 2017 were not considered to have sustained viral suppression. For individuals with only one suppressed viral load test in 2017 (or those who had more than one viral load test, but less than three months apart), we additionally included the last viral load test result of the prior year, consistent with the Centers for Disease Control and Prevention's definition of sustained viral suppression [18]. Individuals without a viral load test in 2017, or only one suppressed viral load test in 2017 and no viral load test in the prior year, were not included in the analysis.

Statistical Analysis

All analyses were performed using SAS Version 9.4. First, LCA was used to identify groups of individuals based on patterns of response to mental health symptoms, substance use, sexual risk behavior, and adverse social conditions. A series of models between 2 and 6 latent classes were assessed using PROC LCA in SAS. Bayesian Information Criterion (BIC) and adjusted Bayesian Information Criterion (aBIC) were used to determine the best model fit, which give an optimal LCA solution. A lower BIC and aBIC value indicate a better fit model [19]. Entropy was used to determine a better distinction between classes, with a value closer to 1 representing a better distinction [20]. Clients were placed in latent classes based on highest posterior probability of membership. Second, bivariate

analyses were conducted using Chi-square test to examine the association between latent classes and sociodemographic characteristics. Finally, multivariable logistic regression models were conducted to examine the association between latent classes and sustained viral suppression controlling for sociodemographic characteristics. Adjusted odds ratio and 95% confidence intervals were computed.

Results

Data for 6,554 PWH were analyzed, and a five-class model was selected based on the model selection criteria of BIC (489.10) and entropy (0.83). The probabilities of syndemic factors in the five-class models are presented in Table 1. Class 1 members (75.9%) had no risk factors. Class 2 (8.4%) had one risk factor of mental health symptoms (depression/anxiety and difficulty sleeping). Class 3 (6.4%) had two co-occurring risk factors of substance use (alcohol and drug use) and multiple sexual partners (> 1 sexual partner in last 12 months). Class 4 (5.5%) had three co-occurring risk factors of mental health symptoms (depression/anxiety and difficulty sleeping), domestic violence, and multiple sexual partners. Class 5 (3.6%) had all co-occurring risk factors of substance use (alcohol and drug use), mental health symptoms (depression/anxiety and difficulty sleeping), domestic violence, multiple sexual partners, and homelessness (Table 1).

Table 2 shows the results of the bivariate analyses. All sociodemographic variables were significantly associated with class memberships. Majority of the population in Class 1 were adults > 35 years old, other race, men, foreign-born, non-English preferred language, and household income ≥ 100% FPL. Class 2 also exhibited similar patterns as Class 1, except the majority had English as their preferred language. Class 3 had a similar distribution of population characteristics as Class 1, with the exception that members were more likely to be US-born, have English as a preferred language, and have a household income of < 100% FPL. Class 4 was similar to Class 3 with regards to preferred language and household income, but the majority of the population were foreign-born. Finally, Class 5 consisted of majority Black race, US-born, English as a preferred language, and a household income of < 100% FPL. The results also indicated statistically significant associations between sustained viral suppression and class memberships ($\chi^2 = 214.1$, p-value < 0.0001). Classes 1 to 4 were most likely to achieve sustained viral suppression, 83.5%, 75.5%, 69.1% and 75.1% respectively, while Class 5 was least likely to achieve sustained viral suppression (48.6%).

The results of the multivariable logistic regression model that simultaneously controlled for class membership and demographic factors are presented in Table 3. Compared to Class 1 and after controlling for sociodemographic factors, the odds of achieving sustained viral suppression were significantly lower for members in Class 2 (mental health symptoms) (adjusted odds ratio [aOR]: 0.67; 95% confidence interval [CI] 0.54–0.83), Class 3 (substance use and multiple sexual partners) (aOR:0.60; 95% CI 0.47–0.76), Class 4 (substance use, multiple sexual partners, and domestic violence) (aOR: 0.71; 95% CI 0.55–0.93), and Class 5 (mental health, substance use, multiple sexual partners, domestic violence, and homelessness) (aOR: 0.26; 95% CI 0.19–0.35). Younger individuals had a significantly lower odds of achieving sustained viral suppression (aOR: 0.79; 95% CI 0.66–0.93), while adults > 50 years old had a significantly higher odds of achieving sustained viral suppression (aOR: 1.53; 95% CI 1.31–1.78) when compared to adults

Table 1 Probability of syndemic factors by latent class membership for Miami-Dade County Ryan White Program clients, 2017

Predictor variables	Class 1	Class 2	Class 3	Class 4	Class 5
Drug use in the last 12 months	0.006	0.006	**0.475**	0.001	**0.959**
Alcohol use in the last 12 months	0.031	0.020	**0.675**	0.238	**0.597**
Feeling depressed or anxious	0.011	**0.818**	0.026	**0.853**	**0.858**
Having difficulty sleeping	0.006	**0.653**	0.017	**0.631**	**0.638**
Ever experienced domestic violence	0.012	0.079	0.101	**0.199**	**0.237**
> 1 sexual partner in the last 12 months	0.172	0.014	**0.469**	**0.352**	**0.412**
Homeless	0.035	0.049	0.119	0.081	**0.299**

Class 1: No risk factors

Class 2: One risk factor of mental health symptoms

Class 3: Two co-occurring risk factors of substance use and multiple sexual partners

Class 4: Three co-occurring risk factors of mental health symptoms, domestic violence, and multiple sexual partners

Class 5: Five co-occurring risk factors of mental health symptoms, substance use, domestic violence, multiple sexual partners, and homelessness

Bolded items show the highest response probability for each predictor variable

Table 2 Distribution of Miami-Dade County Ryan White Program client characteristics by latent class membership, 2017

Variables	Class 1 n (%)	Class 2 n (%)	Class 3 n (%)	Class 4 n (%)	Class 5 n (%)	Test statistics χ^2	P Value
Age category (years)						189.3	< 0.0001
18–34	990 (19.7)	95 (17.4)	175 (43.2)	98 (27.5)	78 (36.8)		
35–49	1952 (38.8)	204 (37.3)	136 (33.6)	158 (44.3)	75 (35.4)		
50 +	2091 (41.5)	248 (45.3)	94 (23.2)	101 (28.2)	59 (27.8)		
Race						31.9	< 0.0001
Black	1872 (37.2)	231 (42.2)	188 (46.4)	126 (35.3)	107 (50.5)		
Other	3161 (62.8)	316 (57.8)	217 (53.6)	231 (64.7)	105 (49.5)		
Gender						41.8	< 0.0001
Male	3870 (76.9)	373 (68.2)	347 (85.7)	271 (75.9)	169 (79.7)		
Female	1163 (23.1)	174 (31.8)	58 (14.3)	86 (24.1)	43 (20.3)		
US born						340.3	< 0.0001
Yes	1368 (27.2)	211 (38.6)	241 (59.5)	163 (45.7)	138 (65.1)		
No	3665 (72.8)	336 (61.4)	164 (40.5)	194 (54.3)	74 (34.9)		
Preferred language						383.6	< 0.0001
English	1833 (36.4)	278 (50.8)	288 (71.1)	210 (58.8)	168 (79.3)		
Other	3200 (63.6)	269 (49.2)	117 (28.9)	147 (41.2)	44 (20.7		
Household income in federal poverty level (FPL)						158.2	< 0.0001
< 100% FPL	1892 (37.6)	270 (49.4)	221 (54.6)	195 (54.6)	143 (67.4)		
≥ 100% FPL	3141 (62.4)	277 (50.6)	184 (45.4)	162 (45.4)	69 (32.6)		
Sustained viral suppression						214.1	< 0.0001
Yes	4203 (83.5)	413 (75.5)	280 (69.1)	268 (75.1)	103 (48.6)		
No	830 (16.5)	134 (24.5)	125 (30.9)	89 (24.9)	109 (51.4)		

Class 1: No risk factors

Class 2: One risk factor of mental health symptoms

Class 3: Two co-occurring risk factors of substance use and multiple sexual partners

Class 4: Three co-occurring risk factors of mental health symptoms, domestic violence, and multiple sexual partners

Class 5: Five co-occurring risk factors of mental health symptoms, substance use, domestic violence, multiple sexual partners, and homelessness

35–49 years of age. Black race, being a woman, and having a household income of < 100% FPL were associated with a significantly lower adjusted odds of achieving sustained viral suppression (Table 3). Whereas, those who were foreign-born had significantly higher odds of achieving sustained viral suppression compared to US-born.

Discussion

This study sought to identify patterns of syndemic factors and assess the contribution of these patterns on achieving sustained viral suppression for PWH. Results from the LCA identified five classes of PWH in the RWP, where approximately 24% of the clients had at least one co-occurring risk factor. We also found that US-born Blacks in the lowest household income category were more likely to belong to the group with the highest number of co-occurring risk factors (Class 5). These findings demonstrate that the presence of any number of co-occurring risk factors, particularly having all co-occurring risk factors of substance use, mental health symptoms, multiple sexual partners, domestic violence, and homelessness adversely affects achieving sustained viral suppression.

People with HIV in Classes 2–5 (those with at least 1 co-occurring risk factor) exhibited lower odds of achieving sustained viral suppression when compared to PWH without any risk factor. Class 2 consisted of PWH who only exhibited mental health symptoms (depression/anxiety and difficulty sleeping). A higher rate of mental health symptoms has been observed among PWH when compared to the general population [21]. Studies have found that mental health symptoms impede retention in care, medication adherence, and viral suppression [21–23]. In particular, depression has been strongly identified as a barrier for medication adherence, [22] which ultimately affects sustained viral suppression. PWH in Class 3 exhibited two co-occurring risk factors of substance use (alcohol use and drug use) and multiple sexual partners. A multitude of studies have shown that alcohol and substance use often become a barrier to timely

Table 3 Adjusted odds ratio (aOR) and 95% confidence interval (CI) for association between latent class memberships and sustained viral suppression among clients in the Miami-Dade County Ryan White Program, 2017

Variables	Sustained viral suppression		
	β	aOR and 95% CI	P value
Latent class membership			
Class 2 vs. Class 1	−0.40	**0.67 (0.54, 0.83)***	0.003
Class 3 vs. Class 1	−0.51	**0.60 (0.47, 0.76)***	< 0.001
Class 4 vs. Class 1	−0.34	**0.71 (0.55, 0.93)***	0.0110
Class 5 vs. Class 1	−1.34	**0.26 (0.19, 0.35)***	< 0.001
Age (years)			
18–34 vs. 35–49	−0.24	**0.79 (0.66, 0.93)***	0.0037
50 + vs. 35–49	0.42	**1.53 (1.31, 1.78)***	< 0.001
Race			
Black vs. Other	−0.69	**0.49 (0.43, 0.58)***	< 0.001
Gender			
Female vs. Male	−0.69	0.94 (0.81, 1.09)	0.4392
US born			
No vs. Yes	0.25	**1.28 (1.04, 1.57)***	0.0194
Preferred language			
Other vs. English	−0.11	0.89 (0.72, 1.09)	0.2773
Household income			
< 100% federal poverty level (FPL) vs. ≥ 100% FPL	−0.72	**0.48 (0.43, 0.55)***	< 0.001

β regression coefficient, *aOR* adjusted odds ratio, *CI* confidence interval

*Significance

linkage to care, retention in care and medication adherence [24–27]. Additionally, some studies have found that sexual risk behaviors such as having multiple sexual partners and engaging in unprotected sex have been associated with poor adherence to antiretroviral medications, which leads to failure to achieve viral suppression and ultimately sustained viral suppression [28]. People with HIV in Class 4 had three co-occurring risk factors of mental health symptoms (depression/anxiety and difficulty sleeping), violence and multiple sexual partners. Domestic violence, particularly among women and racial ethnic minorities, in conjunction with other syndemic factors of mental health symptoms, housing instability, and substance use have been associated with decreased antiretroviral medication adherence, [11] which affects sustained viral suppression.

An important predictor of HIV treatment outcomes is the presence of syndemic risk factors of substance use, mental health, and violence (SAVA) [29, 30]. A study has shown that classes with the highest syndemic burden of mental health and substance use had the lowest odd of achieving viral suppression and retention in care [11]. In our study, PWH in Class 5, which had the highest number of syndemic factors, had the lowest odds of achieving sustained viral suppression. Blacks were more likely to belong in this class when compared to people of other races. Discrimination faced by Blacks as well as Latinos in the United States has been associated with mental health issues, risky sexual behavior, and increased substance use [10]. Additionally, substance use and violence have also predicted poor engagement in care and medication adherence particularly for racial/ethnic minorities and low-income populations [29]. Another contributing factor to poor health outcomes is poverty, which is associated with increased risk of homelessness, substance use, violence and incarceration, especially for minority populations [10]. Similar to our findings for PWH in Class 5, studies have shown that racial/ethnic minorities experience more homelessness compared to Whites [13, 31]. Except for Class 5, the odds of achieving sustained viral suppression were similar for Classes 2–4 when compared to Class 1. In a post hoc analysis, we compared Classes 2–5 to each other and found that the odds of achieving sustained viral suppression was higher for Classes 2–4 when compared to Class 5 [Class 2: aOR: 2.56, 95% CI (1.81–3.63); Class 3: aOR 2.30, 95% CI (1.61, 3.29); Class 4: aOR: 2.73, 95% CI (1.87, 3.97)]. No other significant differences were observed between the other classes. This signifies that the presence of fewer than five syndemic factors is associated with better HIV care outcomes.

Prior literature has established that younger adults have lower rates of viral suppression while older adults have a higher rate of viral suppression, [32–34] which is consistent with the findings in this study. Blacks, women, and those with a household income < 100% FPL had lower odds of achieving sustained viral suppression. These findings are supported by other research that show Blacks compared with Hispanics and Whites [18] and women compared with men [7, 32] have lower rates of viral suppression. While men are more susceptible to homelessness and substance use problem, women experience violence and sociodemographic barriers to care, such as low education and unemployment [17]. Adverse socioeconomic risk factors such as poverty have also been indicative of poor HIV health outcomes, particularly among racial/ethnic minorities [10, 21]. Finally, our results revealed that foreign-born compared to those that are US-born had higher odds of achieving sustained viral suppression. A study conducted using Florida surveillance data found that foreign-born Hispanics had higher odds of viral suppression, while foreign-born Blacks and Whites had lower odds of viral suppression compared to US-born [34]. Further studies need to be conducted to investigate racial/ethnic difference and US birth status in assessing sustained viral suppression among RWP clients.

This study has several limitations. The first is that mental health, substance use, and violence data were collected as part of a routine case management needs assessment; the questions used by the case managers were not from previously validated research instruments. Additionally, these risk factor questions were assessed using either one or two question with a binary (yes/no) response rather than a scale or continuum. Hence, this may not accurately measure the complex nature of syndemic risk factors. Furthermore, the answers were self-reported, so there may have been underreporting of sensitive topics such as mental health symptoms, substance use problems, and violence. Secondly, the RWP only serves uninsured or underinsured individuals; hence, caution needs to be taken in generalizing these findings to other PWH populations. Moreover, this study only included RWP clients in Miami-Dade County, which has on the highest prevalence of HIV in the US and a majority Hispanic and foreign-born population. Even though these findings might not be generalizable to other geographic locations, it is important to investigate syndemic factors that affect HIV care outcomes for Miami-Dade County given its unique socio-demographic makeup. Lastly, we excluded individuals with only one suppressed viral load test from the analysis because it was not possible to classify sustained viral suppression with one measurement. This may have excluded individuals who have been consistently virally suppressed but have fewer lab test results.

Conclusion

Overall, our findings indicate that the presence of multiple co-occurring risk factors negatively affects attaining sustained viral suppression. This is especially true for PWH experiencing mental health symptoms, substance use, domestic violence, multiple sexual partners, and homelessness. Furthermore, sociodemographic factors such as younger age, Black race, women, and poverty were less likely to achieve sustained viral load even after controlling for the class membership (i.e. the co-occurring risk factors). The use of latent class analysis clarifies the synergistic and cumulative effects of multiple factors on HIV health outcomes. Identification of these patterns could inform and enhance clinical practices to address these risk factors for PWH. Targeted interventions should also be implemented to address syndemic factors that are known to contribute to poor HIV-related health outcomes, especially for marginalized populations. These include addressing structural factors that impede access to care and resources, through providing integrated care and expanding health insurance coverage to address substance use and mental health care access barriers. Additionally, criminal justice reforms are needed to avert incarceration for alcohol/drug offenses, especially among minorities. Policies that ensure affordable housing and minimizing adverse neighborhood disadvantages such as poverty, unemployment, and crime are essential to combat homelessness. Further, adoption of stronger national, regional, and local policies addressing domestic violence are critical for individuals experiencing abuse. Enhanced engagement of domestic violence centers is also essential in order to provide outreach and supports for victims of domestic violence. Finally, providing education and prevention interventions promoting safe sexual behaviors would minimize engagement in multiple sexual partners.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no competing interests. The content is solely the responsibility of the authors and does not necessarily represent the view of the National Institute of Health.

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