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A longitudinal study of persistent smoking among HIV-positive gay and bisexual men in primary relationships

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Abstract

Introduction—We examined the stability of smoking behaviors, and factors associated with persistent smoking in a longitudinal study of HIV-positive gay and bisexual men in primary relationships.

Methods—A sample of 377 HIV-positive men on antiretroviral therapy and their same-sex partners completed five assessments over two years. Participants completed semi-structured interviews which assessed smoking status, sociodemographic factors, relationship dynamics, and HIV-related disease characteristics. Latent transition analysis estimated the amount of transition in smoking over time. Latent class analysis examined factors associated with smoking status across the study period.

Results—At baseline, 28.1% (n = 106) of participants reported current smoking. Over 90% of the HIV-positive men remained in the same smoking category over time (68.4% persistent non-smokers; 24.1% persistent smokers). Men whose partners smoked and men with lower income had higher odds of being persistent smokers, whereas older men and men who identified as Latino race/ethnicity had lower odds of being persistent smokers compared to non-smokers.

Conclusions—Despite efforts to reduce smoking among people living with HIV (PLWH), a substantial subset of men continued to smoke during their two years in the study. Findings suggest that primary partners who also smoke and low income were the strongest predictors of sustained smoking behaviors among HIV-positive men. Additional research is needed to better understand how to increase motivation and support for smoking cessation among PLWH and their primary partners, while attending to how socioeconomic status may inhibit access to and the sustained impact of existing smoking cessation programs.

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1. Introduction

Tobacco use continues to be one of the leading causes of preventable morbidity and premature mortality in the United States and is a well-recognized risk factor for chronic diseases including cardiovascular disease, pulmonary disease, and cancer (Centers for Disease Control and Prevention, 2015). Among people living with HIV (PLWH) and in particular, HIV-positive gay, bisexual and other men who have sex with men (MSM), smoking is a highly prevalent behavior (Friis-Moller et al., 2003; Gritz, Vidrine, Lazev, Amick, & Arduino, 2004; Lifson et al., 2010; Mamary, Bahrs, & Martinez, 2002; Mdodo et al., 2015; O'Cleirigh, Dale, et al., 2015; O'Cleirigh, Valentine, et al., 2015; Vittecoq et al., 2003). Among HIV-positive individuals, smoking has been linked to an increased likelihood of HIV-related medical complications (Humfleet, Hall, Delucchi, & Dilley, 2013), and has been shown to negatively impact immune and virologic response (O'Cleirigh et al., 2014).

Despite advances in smoking cessation interventions, available data on smoking cessation interventions among PLWH indicate that cessation rates are low (Humfleet et al., 2013). In fact, fewer than 8% of HIV-positive smokers are actively engaged in any type of smoking-cessation program (Cioe, Crawford, & Stein, 2014), and engagement is even lower among HIV-positive gay and bisexual men (Webb, Vanable, Carey, & Blair, 2007). Thus, PLWH and in particular HIV-positive gay and bisexual men have been cited as a high-priority group for smoking cessation interventions; however, additional research is needed to better understand the relative stability of smoking over time among HIV-positive gay and bisexual men outside of the context of a controlled, intervention study, as well as which risk factors are associated with persistent smoking in order to develop better smoking prevention and cessation interventions.

Prior research has shown a range of factors associated with smoking behaviors among PLWH. With few exceptions (Pacek, Latkin, Crum, Stuart, & Knowlton, 2014), studies have largely focused on individual-level characteristics such as younger age, as well as comorbid depression and alcohol use which decreases the probability of successful smoking cessation (Gritz et al., 2004). Additionally, HIV-positive gay and bisexual men may also cope with unique minority stressors such as internalization of negative messages about one's sexual identity or expression, which can lead to maladaptive coping responses such as substance use (Meyer, 2003); these unique minority stressors have been associated with tobacco use among gay and bisexual men (Gamarel, Neilands, Dilworth, Taylor, & Johnson, 2015; Pachankis, Hatzenbuehler, & Starks, 2014). Moreover, recent evidence suggests that living with another smoker is an increased risk factor for sexual minority men specifically (Gamarel et al., 2016).

Close relationships are consistently linked to better health outcomes across a number of conditions (Lewis et al., 2006) and within couples affected by HIV, primary partners play a positive role in HIV-related health outcomes (Johnson et al., 2012). The mutual influence of partners on each other's health—or dyadic interdependence—can have positive and negative effects on health behaviors, such as smoking (Lewis et al., 2006). For example, individuals who are partnered with smokers are more likely to smoke themselves (Sutton, 1993), and less likely to quit if their partner also smokes (Chandola, Head, & Bartley, 2004; Cobb et al.,

2004; Holahan et al., 2012; Homish & Leonard, 2005; McBride et al., 1998). Conversely, positive influences related to relationship commitment and provision of partner encouragement to engage in healthy behaviors may contribute to health-enhancing behaviors such as quitting smoking to protect the longevity of one's relationship (Weiselquist, Rusbult, Foster, & Agnew, 1999). Thus, it is likely that relationship factors – such as commitment level and partner encouragement– may strongly influence smoking behaviors over time among HIV-positive men in same-sex relationships, given the previously observed associations with smoking behaviors among the general population.

Despite effective public health campaigns, public policy initiatives, and improvements in smoking cessation treatment programs, PLWH continue to be a group which warrants future study. To date, few studies have conducted longitudinal analyses to understand factors associated with smoking behaviors over time among HIV-positive men in same-sex relationships. Using data from a longitudinal study of HIV-positive gay and bisexual men and their same-sex primary partners, we explored the following questions: a) what is the stability of smoking status over a two-year period?, and b) to what extent is partner smoking status and relationship factors associated with smoking compared to non-smoking across a two-year period over and above existing individual and social factors? Based on existing literature showing low smoking cessation rates among PLWH in the context of intervention studies and unique minority stressors experienced by gay and bisexual men, we hypothesized that smoking status would be relatively stable across participants' two years in the study. Secondly, we hypothesized that partner smoking status and perceptions of partner encouragement would be robust predictors of smoking status over time, such that partners who also smoked and those who perceived their partners were a negative influence on their health would have greater odds of persistent smoking over time. Additionally, we hypothesized that relationship commitment would be protective such that higher levels of commitment would be predictive of non-smoking behaviors over time.

2. Methods

The data derive from the Duo Project, a longitudinal study of 266 same-sex male couples in which at least one partner was HIV-positive. While the primary purpose of the Duo Project was to examine relationship dynamics and ART adherence over time, we also collected one item on tobacco use. Details of the study procedures have been described elsewhere (Conroy, Gamarel, Neilands et al., 2016; Johnson et al., 2012). In total, 532 men participated in the baseline assessment, of which 377 were HIV-positive men on ART. Couples were enrolled for a two-year period and data collection began in January 2009 and ended in September 2014. Participants were recruited from the San Francisco Bay Area in the United States (U.S.) using passive recruitment strategies, and participant and provider referrals. Flyers were posted in clinics, community bulletin boards, AIDS service organizations, and at other community-based organizations. Media ads were placed online and in print publications targeting HIV-positive and gay/bisexual men. Interested individuals contacted study staff for more information on the study. Men were eligible for the study if they met the following criteria: (1) in a primary relationship, which was defined as "currently (for at least 3 months) in a relationship with someone you feel committed to above anyone else and with whom you have had a sexual relationship," which is the definition used in many couples-

based HIV prevention studies (Beougher et al., 2015; Mitchell & Sullivan, 2015); (2) at least one partner in the relationship is HIV-positive and on an acknowledged ART regimen for at least 30 days; (3) at least 18 years old; (4) born male and currently identify as male; (5) English-speaking; and (6) able and willing to provide informed consent.

Partners were screened separately over the phone to assess eligibility and if both partners were eligible, couples were scheduled for an in-person interview at the study research center. Both partners were required to attend the assessment appointments together, but were separated during data collection. Data were collected using a combination of Computer Assisted Personal Interviewing (CAPI) and Audio Computer Assisted Self Interviewing (ACASI) methods, which optimize data integrity through the reduction of data entry errors while minimizing the effects of social desirability bias (Turner, Ku, Rogers et al., 1998). Couples were assessed at baseline and every six months thereafter for a total of five assessment waves. All HIV-positive participants had blood drawn for viral load tests at their baseline, 12-month, and 24-month visits.

Of the 377 HIV-positive participants on ART, 21% were lost during the course of the study to relationship breakup, 4% to relocation or travel, 2% to the death of a partner, and 6% withdrew or were withdrawn from the study due to inability to follow study protocols.

Ethical approval was obtained from the Committee on Human Research at the University of California, San Francisco. Written informed consent was obtained from all participants. Each partner of the couple was paid US $50 for each survey completed and HIV-positive participants were paid an additional $10 for each blood sample.

2.1. Measures

Smoking Status—At each assessment, participants were asked “Do you currently smoke cigarettes?” Answers to this question were used to classify participants as nonsmokers (reported not smoking at that time point) or current smokers (reported smoking at that time point). Smoking status at each time point was coded as smoking (1) versus non-smoking (0). Participants were also asked on average how many cigarettes they smoked per day during the past three months.

Partner Smoking Status—Partner smoking status was assessed by a variable indicating whether the partner was currently a smoker (yes/no).

Relationship Factors—We assessed relationship factors which may impact smoking persistence. First relationship commitment was assessed with a 4-item scale consisting of statements such as “I am committed to maintaining my relationship with my partner” (Kurdek, 1995). Response options ranged from 1 (not at all true) to 9 (extremely true) (α = 0.95). Second, a lack of partner health behavior encouragement t was assessed with one item that asked participants to endorse how much their partners contributed to their health (i.e., “How often does your partner encourage you to engage in healthy behaviors (e.g. exercising, eating healthier)”Response options ranged from 1 (always encourages) to 5 (never encourages) with higher numbers indicating less support.

Sociodemographic Characteristics—Participants reported their age, race and ethnicity, education level, and income level. In our analyses race/ethnicity was represented as a series of indicator variables for Black, Latino, and other non-White race/ethnicity with White as the reference group. Because only 22 participants reported less than a GED or High School degree, education was coded as achieving high school graduation or equivalent (1) vs. less than high school education (0). This cutoff was also chosen given evidence that smokers with 12 years of schooling or less have the highest odds of persistent smoking as compared to smokers who completed college (Breslau, Johnson, Hiripi, & Kessler, 2001). Similarly, evidence indicates that low annual income levels are associated with persistent smoking (Slopen et al., 2013); thus, income level was dichotomized as less than $20,000 (1) versus $20,000 or more (0). This cut off was chosen given the small number of participants who reported earning less than $10,000 annually (21.8%) and evidence that earning less than $20,000 in San Francisco is considered low income. Participants also reported their relationship duration (in years, averaged across the couple) and HIV-positive partners reported the length of time since initiating ART (in years).

Depressive symptoms—The 20-item Center for Epidemiologic Studies Depression Scale (CES-D) was administered to measure depressed mood in the past week (Radloff, 1977). The CES-D consists of 20 items (e.g., “could not get going”). Participants responded on a 4-point scale ranging from 0 = “rarely or none of the time” to 3 = “most or all of the time.” After reverse scoring items 4, 8, 12, and 16, individual items were summed such that higher scores indicate greater depressive symptoms. Total possible scores range from 0 to 60. Internal consistency was acceptable within our sample ($\alpha = 0.91$).

Alcohol Use—Alcohol use was assessed with the 10-item Alcohol Use Disorders Identification Test (AUDIT) (Saunders, Aasland, Baber, De la Fuente, & Grant, 1993), which has been validiated in samples of PLWH (Strauss & Rindskopf, 2009). The AUDIT contains three questions which assess alcohol use and seven items on alcohol problems/ alcohol dependence and subsequent problems. Each question has five responses which are scored from 0 to 4. Total scores ranged from 0 to 40. For analyses, we used a continuous variable such that higher values indicated greater alcohol use and potential problems.

Internalized Heterosexism—Internalized heterosexism, which is the extent to which individuals internalize negative societal attitudes about their sexual identity, was assessed via four items used in prior studies with HIV-positive gay and bisexual men ($\alpha = 0.75$) (Johnson, Carrico, Chesney, & Morin, 2008; Nungesser, 1983). Example items include: “I wish I were heterosexual,” “Whenever I think a lot about being gay, I feel critical about myself.” Each question has six responses which are scored from 0 to 5 and higher scores indicate greater internalized heterosexism.

HIV Medication Adherence and Disease Characteristics—For HIV-positive men, ART adherence was assessed using the Visual Analog Scale (VAS), which measures the proportion of ART medications taken in the past 30 days (Walsh, Mandalia, & Gazzard, 2002). The majority of participants in this sample self-reported nearly perfect ART adherence (M = 94.27, Mdn = 98.00, SD = 11.61); therefore, prior studies using these data

(Gamarel, Neilands, Dilworth, Taylor, & Johnson, 2015; Johnson et al., 2012) have dichotomized medication adherence as 100% adherence (1) versus less than 100% adherence (0). This cut off was also chosen to reflect the distinction between those who meet the public health goal of 100% medication adherence versus those who do not. HIV viral load assays were performed to detect HIV RNA at or above 20 copies/mL (Roche Molecular Systems, Inc.). Viral load was dichotomized as detectable (1) versus undetectable (0). Couple HIV serostatus was dichotomized as concordant HIV-positive (1) versus HIV-discordant (0).

2.2. Statistical Analyses

One-way frequency tables were computed for all analysis variables and measures of central tendency and variability were computed for continuous variables. Our primary data analyses were constructed to address our two primary research questions: 1) whether smoking status remained stable over time and 2) which of the pre-specified baseline variables of substantive interest described previously were predictive of smoking status over the study's follow-up period. To examine whether smoking status changed over time, latent transition analysis (LTA) with a first-order hidden Markov model was used to estimate transition probabilities from one wave to the next. The likelihood ratio test statistic (LRT) was computed to assess LTA model fit and nested LRTs were computed to compare nested LTA models. Because the LTA revealed that more than 90% of the participants maintained their original smoking status over all five assessment waves, latent class analysis (LCA) was used to examine associations between persistent smoking and baseline covariates. Due to the lack of complete smoking data across all assessment waves, persistent smoking was conceptualized as a latent variable measured by the available observed data so that cases with partial data could be included in the analysis along with cases with complete data. One-, two-, and three-class solutions were examined and compared using the Lo-Mendell-Rubin adjusted likelihood ratio test statistic to determine the optimal number of classes for the latent variable of persistent smoking (Nylund, Asparouhov, & Muthén, 2007). In addition, for all LTAs and LCAs containing two or more classes, the entropy statistic, a measure of classification quality, was computed. Entropy values range from 0 to 1, with larger values indicating better classification quality. M*plus* 7.4 was used for all LTA and LCA analyses.

Based on prior literature, we were particularly interested in the extent to which relationship factors were associated with persistent smoking, after accounting for individual-level covariates. Baseline covariates included in the LCA were age, high school graduation, Black race, Latino race, other non-White race, relationship duration, low income, CES-D score, AUDIT score, internalized heterosexism, length of time since initiating ART, 100% HIV medication adherence, detectable baseline viral load, and couple HIV-serostatus. Latent smoking status was regressed onto the baseline covariates using logistic regression. For age, high school graduation, race/ethnicity, low income, CES-D, AUDIT, internalized heterosexism, relationship commitment, and lack of health support, both actor and partner effects were included in line with methods developed in the dyadic research literature to elucidate partner influences on behavior after controlling for actors' own influences using the Actor-Partner Interdependence Model (APIM) approach (Kenny, Kashy, & Cook, 2006).

All inferential analyses employed a cluster-adjusted robust variance estimator (M*plus* MLR estimator) to adjust inferences for nesting of participants within couples.

Following descriptive analyses to characterize the sample, our subsequent LTA and LCA analyses proceeded sequentially such that the LCA was informed by the results of the LTA. Specifically, first LTA addressed our research question assessing the stability of smoking status over time. Our second research question sought to examine which relationship dynamics are associated with persistent smoking, which was investigated using LCA once we established that latent smoking status did not change over the two years of the study in the initial LTA.

3. Results

Table 1 presents the baseline sample characteristics of the HIV-positive men on ART. Participants ranged in age from 22 to 69 years old (M = 46.15 years, SD = 9.93). The majority of the sample (95.8%) had earned a high school degree or higher, and over half earned less than $20,000 annually. The majority of the men (91.5%) identified as gay, and slightly more than half (55.2%) identified as white race/ethnicity. Relationship duration averaged 6.52 years (SD = 4.94) and about two-thirds of the sample (68.7%) were in HIV-positive seroconcordant relationships. HIV-positive participants on ART had been diagnosed an average of 13.45 years (SD = 8.04), had been taking ART for 9.85 (SD = 7.04) years on average, and nearly half (44.8%) had a detectable HIV viral load. At baseline, over one-quarter of the 377 participants (n = 106, 28.1%) reported currently smoking cigarettes, with a range of 1 to 90 cigarettes smoked per day (M = 11.70, SD = 13.61) and remained fairly stable over time with a slight decrease to 22.1% at two years. Attrition was moderate: 8% at 6 months, 17% at 12 months, 27% at 18 months, and 32% at 24 months.

Latent Transition Analysis (LTA)

An initial LTA model was fitted, which allowed the transition probabilities to vary across comparisons of waves. The fit of the LTA model to the data was satisfactory (χ^2 (20) = 26.80, p = .14). As shown in Table 2, transition probabilities indicated that greater than 90% of the participants remained in the same class from one assessment visit to the next. The entropy for the model was .943, indicating very good classification quality. Due to the similarities in transition probabilities across time, a second, more restricted LTA, was estimated in which the transition matrices were held equal across time. The fit of this model to the data was also satisfactory (χ^2 (26) = 30.16, p = .26). The entropy for this model was . 945, indicating similar or equivalent classification quality of the more parsimonious LTA. A nested likelihood ratio chi-square test indicated the simplified LTA with the equivalent transition probabilities fit the data equally as well as the LTA model which allowed the transition probabilities to differ across time (χ^2 (6) = 3.15, p = .79). In other words, there were no significant differences in the transition probabilities across the four transition points, implying that participants were equally likely to remain in or move out of the persistent smokers class into the persistent non-smokers class across the four transition points. The final estimated proportion of persistent non-smokers was 68.4% and the final estimated proportion of persistent smokers was 24.1%, resulting in 92.5% of participants exhibiting

persistent status. Based on these results, we proposed a two-class latent class analysis containing a persistent smoker class and a persistent non-smoker class.

Latent Class Analysis (LCA)

A series of initial unconditional LCAs were fitted to evaluate support for the hypothesized two-class model. These analyses considered models with one, two, and three latent classes, respectively. LCAs with k classes were compared with corresponding LCAs with k-1 classes using the Lo-Mendell-Rubin adjusted likelihood ratio test. Results indicated that the two-class LCA fit the data no worse than the three-class LCA (χ^2 (6) = 40.54, p = .07), but the two-class LCA was strongly preferred to the one-class LCA (χ^2(6) = 815.12, p < .0001). The entropy for the two-class model was .985 whereas the entropy for the three-class model was .889, indicating that the two-class model had better classification quality. Therefore, we fit a conditional two-class LCA including all covariates. Four participants were missing viral load assay information, yielding an analysis N of 373. The entropy for this model was .951. Results of the logistic regression of latent class membership onto the pre-specified baseline covariates appear in Table 3. Participants with older age and Latino race/ethnicity had lower odds of being a persistent smoker compared to being a persistent non-smoker. However, low-income participants and those whose partners also smoked had higher odds of being persistent smokers compared to being a persistent non-smoker. There were no significant differences in commitment level and partner support.

4. Discussion

In this study, over one-quarter of HIV-positive men reported current smoking at the baseline assessment, with 92.5% of participants estimated to remain in the same smoking category across the two years of study, and 24.1% of the participants estimated to be persistent smokers. While the smoking prevalence was lower than other samples of HIV-positive adults (Cioe et al., 2016; Lifson et al., 2010; O'Cleirigh et al., 2015), these findings are consistent with prior research illustrating that people living with HIV are significantly less likely to quit smoking, despite the availability of pharmacologic and behavioral smoking cessation aids. Prior studies have reported relatively high motivation to quit smoking among people living with HIV and high rates of quit attempts (Benard et al., 2007); however, this readiness may not appear to translate into successful smoking cessation, as demonstrated in this study and others (Mdodo et al., 2015). Several smoking cessation trials to evaluate intensive counseling and cell phone interventions with PLWH suggest that these interventions can be efficacious, but studies were limited by short follow-up or a non-randomized design (Cioe, 2013). Another study demonstrated increased smoking cessation rates following the implementation of a training program for HIV clinicians (Huber et al., 2012). However, the limited success of smoking cessation interventions necessitates moving beyond individual-level factors to identify important interpersonal and structural barriers to uptake and sustained use of smoking cessation programs for PLWH that can be readily applied within current care models.

Consistent with previous findings among non-HIV-positive samples (Brath, Grabovac, Schalk, Degen, & Dorner, 2016; Reynolds, Neidig, & Wewers, 2014), we found that having

a partner who smoked was a robust predictor of persistent smoking compared to persistent non-smoking among HIV-positive men. Partners who also smoke have been cited as a significant barrier to cessation (Christakis & Fowler, 2008), and couples in which both members smoke have significantly lower quit rates and higher relapse rates (Ferguson, Bauld, Chesterman, & Judge, 2005; Garvey, Bliss, Hitchcock, Heinold, & Rosner, 1992; Palmer, Baucom, & McBride, 2000). Thus, health care providers should assess and address the smoking status of the partner when conducting smoking cessation programs to identify and help patients resolve barriers to cessation. For example, health care providers who invite and teach partners how to support their partners in quitting has been shown to be an effective strategy to promote smoking cessation (McBride et al. 2004).

Notably, we did not find that relationship factors such as commitment level and the provision of partner encouragement for engaging in healthy behaviors to be associated with persistent smoking. Longitudinal studies have provided evidence that higher support is related to less smoking in general but these studies have not specifically examined persistent smoking as an outcome (Mermelstein, Cohen, Lichtenstein, Baer, & Kamarck, 1986). Our lack of an association with partner encouragement is somewhat consistent with the disappointing results of other intervention studies using partner support to increase smoking cessation (Cohen et al., 1989; Lichtenstein, Glasgow, Lando, Ossip-Klein, & Boles, 1996; Park, Tudiver, & Campbell, 2012). Future research is warranted to better understand each partner's motivations for and barriers to smoking cessation to guide smoking cessation interventions with couples.

Socioeconomic disadvantage as measured by low income was associated with greater odds of persistent smoking compared to persistent non-smoking across the two years of the study. While some evidence suggests that the proportion of low-income smokers who want to quit is equivalent to the general population (Lebrun-Harris, Fiore, Tomoyasu, & Ngo-Metzger, 2015), other studies illustrate that few low-income smokers attempt to quit (Burkhalter, Springer, Chhabra, Ostroff, & Rapkin, 2005; Caleyachetty, Lewis, McNeill, & Leonardi-Bee, 2012; Reid, Hammond, Boudreau, Fong, & Siahpush M., 2010). Additionally, when low-income smokers do try to quit, they are less likely to be successful than other smokers (Caleyachetty et al., 2012; Hiscock, Judge, & Bauld, 2011; Levy, Romano, & Mumford, 2005), which may be a result of limited insurance coverage, financial constraints and reduced access to quality healthcare (DeNavas-Walt, Proctor, & Smith, 2009; Hiscock R., Bauld, Amos, Fidler, & Munafò M., 2012). There is also evidence that low income neighborhoods and those with higher rates of same-sex couples have a higher density of tobacco retailers (Cantrell et al., 2015; Lee, Pan, Henriksen, Goldstein, & Ribisl, 2016). Thus, HIV-positive gay and bisexual men in lower socioeconomic positions may be more likely to share social environments with other smokers, such as romantic partners, which has been associated with smoking initiation, continued smoking, and relapse after quitting (Hiscock,. et al., 2012). These findings highlight the need for smoking cessation programs to account for the socioeconomic constraints that may impede access to and sustained use of evidence-based treatments. Evidence suggests that incorporating tobacco treatment within community agencies may be particularly helpful for lower SES smokers (Christiansen, Reeder, TerBeek, Fiore, & Baker, 2015). Specifically, brief motivational interviewing interventions for unmotivated smoker delivered by community health workers have showed

particular promise (Christiansen et al., 2015). Furthermore, a lack of social support is a common reason for why lower SES smokers fail to quit smoking and other research suggests that having access to non-smokers in one's social network can be a powerful aid to quitting (Hiscock et al., 2012). Thus, future research may include the development and testing of social network interventions designed to provide peer support and enhance motivation, which could be adapted from effective interventions with HIV-positive drug-using adults of lower socioeconomic status (Latkin, Sherman, & Knowlton 2003).

Internalized stigma, poor mental health, and alcohol use have been shown to increase the risk of smoking among PLWH (Gamarel et al., 2015; Gritz et al., 2004; Pacek et al., 2014). In previous cross-sectional analyses of the Duo Project, internalized heterosexism was positively associated with smoking (Gamarel et al., 2015). However, in this study, internalized heterosexism was not associated with persistent smoking across the two years of the study. Additional research is needed to better understand the associations between stigma, mental health, substance use, and smoking behaviors over time among PLWH.

4.1. Limitations

Our study has several limitations. Our sample of HIV-positive gay and bisexual men on ART in San Francisco may be less diverse than other communities heavily impacted by HIV in the United States, which limits generalizability. For example, our sample was predominately white, linked to HIV care, self-reported high ART adherence, and in a committed relationship, which may explain the lower smoker rates in this study compared to others with PLWH. Second, this was a longitudinal study and therefore participant attrition could be a concern if those who completed the study were different from those who did not. For example, the results could be biased by the greater participation of high-functioning couples who stayed together over the study period, which has been noted as a limitation in other couples studies (Conroy et al., 2016). However, by conceptualizing persistent smoking status as a latent variable, our modeling approach was able to include all participants, including those who dropped out, rather than only those who completed all five assessment waves, thereby broadening the generalizability beyond the population who completed all assessments. Another limitation was our reliance on self-reported smoking status; however, self-report has been established as a fairly reliable indicator of smoking status (Vartiainen, Seppälä, Lillsunde, & Puska, 2002). Finally, the data analyzed here were collected as part of a larger study of relationship dynamics and ART adherence among same-sex male couples. Although tobacco use behaviors were assessed, these measures did not include standardized measures of smoking history, nicotine dependency, interest and self-efficacy for quitting, and factors maintaining smoking behaviors. Additionally, we were unable to examine differences between non-daily and daily smokers. While evidence suggests that non-daily smokers have increased health risks (Lindson-Hawley et al. 2016; Shane, Ling, & Glantz, 2010), non-daily smokers tend to be social or weekend smokers and are less likely to consider themselves “smokers” compared to daily smokers (Shiffman et al. 2012). Thus, future studies should include a more extensive measurement of tobacco use behaviors, including couple-level motivators and barriers to smoking cessation.

4.2. Conclusions

This study is among the first to examine whether partner smoking status and relationship factors are associated with smoking behaviors over time among PLWH. Study findings provide valuable information about the need to attend to relationship and structural barriers to smoking cessation. Specifically, partners' smoking behaviors and low income appear to negatively influence the likelihood of changes in smoking behaviors and should be monitored routinely in primary care settings. Findings from this study also emphasize that members of an individual's social network, particularly primary partners, may strongly influence one's smoking behaviors. Thus, smoking cessation efforts in dual-smoker couples may need to address both partners' smoking at the same time in order to change behavior.

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Table 1

Sample Characteristics of HIV-positive men on ART (N = 377)

Demographics	Mean (SD), N (%)
Age (years) (mean, SD)	46.15 (9.93)
Education Level, (N, %)	
Less than High school	16 (4.2)
High school or higher	361 (95.8)
Annual Income (N, %)	
Less than $20,000	197 (52.3)
$20,000 or higher	180 (47.4)
Couple HIV status (N, %)	
Serodiscordant	118 (31.3)
Seroconcordant	259 (68.7)
Sexual Identity (N, %)	
Gay	345 (91.5)
Bisexual	28 (7.4)
Other	4 (1.1)
Race/ethnicity (N, %)	
Black	62 (16.4)
White	208 (55.2)
Latino	73 (19.4)
Other	34 (9.0)
Time living with HIV, years (mean, SD)	13.45 (8.04)
Relationship Characteristics	
Relationship duration, years (mean, SD)	6.52 (4.94)
Commitment (mean, SD)	32.49 (5.92)
Partner health support (mean, SD)	1.91 (1.16)
Health Status	
Depressive Symptoms (mean, SD)	15.02 (10.42)
100% Adherence to ART (N, %)	297 (78.8)
Viral Suppression (N=373, %)	169 (44.8)
Substance Use	
Alcohol Use (mean, SD)	3.92 (5.67)
Current Smoker: Baseline (Wave 1) (N, %)	106 (28.12)
Current Smoker: 6 months (Wave 2) (N=346, %)	100 (28.90)
Current Smoker: 12 months (Wave 3) (N=313, %)	83 (26.52)
Current Smoker: 18 months (Wave 4) (N=277, %)	68 (24.55)
Current Smoker: 24 months (Wave 5) (N =258, %)	57 (22.09)

Table 2

Latent Transition Analysis: Transition Probabilities (N = 377)

	Latent Class 1	Latent Class 2
Model 1		
Wave 1 vs. Wave 2		
Latent Class 1	.988	.012
Latent Class 2	.020	.980
Wave 2 vs. Wave 3		
Latent Class 1	.919	.081
Latent Class 2	.004	.996
Wave 3 vs. Wave 4		
Latent Class 1	.961	.039
Latent Class 2	.005	.995
Wave 4 vs. Wave 5		
Latent Class 1	.938	.062
Latent Class 2	.010	.990
Model 2		
Latent Class 1	.993	.007
Latent Class 2	.050	.950

Notes: Latent transition analyses were performed using M*plus* 7.4. Model 1 and Model 2 both feature hidden Markov first-order latent transitions assuming measurement invariance over time. Model 1 allows differing transition matrices over time whereas Model 2 assumes a single transition matrix across all time points.

Table 3

Latent Class Analysis: Logistic Regression Odds Ratios (OR) and 95% Confidence Intervals (CIs) for the Regressions of Persistent Smoking onto Baseline Covariates (N = 373).

Covariate	OR	95% CI	*p*
Actor Age (years)	**0.934**	**0.875, 0.998**	**.044**
Partner Age (years)	1.023	0.985, 1.063	.238
Actor High School Education	0.256	0.044, 1.491	.130
Partner High School Education	0.769	0.161, 3.670	.742
Actor Black Race	1.129	0,452, 2.825	.795
Actor Latino Ethnicity	**0.200**	**0.069, 0.575**	**.003**
Actor Other Non-White Race	0.831	0.295, 2.340	.725
Partner Black Race	1.541	0.569, 4.168	.395
Partner Latino Ethnicity	0.915	0.341, 2.459	.861
Partner Other Non-White Race	1.874	0.601, 5.839	.279
Relationship Length (years)	0.994	0.917, 1.077	.879
Actor Low Income	**3.895**	**1.866, 8.130**	**<.001**
Partner Low Income	1.606	0.797, 3.238	.185
Actor Depression (CES-D)	0.992	0.961, 1.024	.609
Partner Depression (CES-D)	0.976	0.944, 1.009	.147
Actor Alcohol Use (AUDIT)	1.023	0.960, 1.090	.485
Partner Alcohol Use (AUDIT)	1.015	0.962, 1.071	.586
Actor Internalized Heterosexism	1.018	0.931, 1.114	.694
Partner Internalized Heterosexism	1.048	0.968, 1.135	.248
Actor Relationship Commitment	0.998	0.920, 1.082	.957
Partner Relationship Commitment	0.953	0.889, 1.021	.171
Actor Perception of Health Support	1.170	0.865, 1.582	.308
Partner Perception of Health Support	1.064	0.791, 1.432	.681
Actor Time Living with HIV	1.000	0.995, 1.005	.910
Actor Detectable Viral Load	0.418	0.172, 1.018	.055
Actor100% HIV Medication Adherence	0.556	0.186, 1.664	.294
Couple Concordant HIV-positive	1.405	0.563, 3.509	.466
Partner is a Current Smoker (Baseline)	**12.857**	**5.196, 31.814**	**<.001**