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High-Risk Sexual Behavior, Binge Drinking and Use of Stimulants are Key Experiences on the Pathway to High Perceived HIV Risk Among Men Who Have Sex with Men in Brazil

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Abstract

In Brazil, pre-exposure prophylaxis (PrEP) is currently available for gay, bisexual, and other men who have sex with men. As PrEP use depends on an individual's perceived risk, we explored pathways by which potentially modifiable behaviors lead to high perceived HIV risk. Using online surveys (N = 16,667), we conducted a path analysis on the basis of ordered sequences of multivariate logistic regressions. High perceived HIV risk was low (26.3%) compared to condomless receptive anal sex (41.4%). While younger age increased the odds of binge drinking and of condomless receptive anal sex, it was associated with decreased odds of high perceived HIV risk. In contrast, use of stimulants increased the odds of condomless receptive anal sex and of high perceived HIV risk. Our results suggest that binge drinking and use of stimulants are key points in different pathways to high-risk sexual behavior and may lead to different perceptions of HIV risk.

Keywords Perceived HIV risk · Sexual behavior · Binge drinking · Stimulant use · HIV · Gay · Bisexual and other men who have sex with men (GBM)

Resumen

En Brasil, la profilaxis previa a la exposición (PrEP) está disponible actualmente para hombres homosexuales, bisexuales y otros hombres que tienen sexo con hombres. Como el uso de PrEP depende del riesgo percibido de una persona, exploramos vías por las cuales los comportamientos potencialmente modificables conducen a un alto riesgo percibido de VIH. Utilizando datos de encuestas en línea (N = 16.667), realizamos un análisis de ruta sobre la base de secuencias ordenadas de regresiones logísticas multivariadas. El alto riesgo percibido de VIH fue bajo (26,3%) en comparación con el sexo anal receptivo sin condón (41,4%). La edad más joven aumentó las probabilidades de consumo de alcohol en exceso y del sexo anal receptivo sin condón, todavía se asoció con una menor probabilidad de alta percepción de riesgo sobre VIH. Sin embargo, el uso de estimulantes aumentó las probabilidades de tener sexo anal receptivo sin condón y de un alto riesgo percibido de VIH. Nuestros resultados sugieren que el consumo excesivo de alcohol y el uso de estimulantes son puntos clave en diferentes vías de conductas sexuales de alto riesgo y pueden llevar a diferentes percepciones del riesgo de VIH.

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Introduction

Globally, in all settings where the burden of the HIV epidemic is studied, gay, bisexual and other men who have sex with men (GBM) are disproportionally affected. In Latin America, 40% of new HIV infections among those aged 15–49 years are estimated to occur among GBM [1]. In Brazil, GBM are a key population with HIV incidence increasing among those aged 16–24 years in the past five years [2]. Also, national population-based surveys have shown that HIV prevalence among GBM increased from 14.2% in 2009 to 18.4% in 2016 [3, 4].

Brazil's response to the HIV epidemic includes provision of antiretroviral therapy since 1996 (without immunologic restrictions since 2014), and post-exposure prophylaxis since 2009. Since 2018, daily oral pre-exposure prophylaxis (PrEP) with tenofovir/emtricitabine (TDF/FTC) has been available through the Brazilian Public Health System to selected populations including eligible GBM defined as those engaging in condomless anal sex in the previous 6 months and/or having symptoms or diagnosis of sexually transmitted infections in the previous 6 months and/or reporting repeated use of post-exposure prophylaxis in the prior 12 months [5]. PrEP uptake among eligible HIV-negative GBM varied considerably during the program's first year, from a maximum of 25% in Florianopolis to a minimum of no uptake in some cities [6]. One explanation for such a discrepancy may be related to varying levels of awareness and willingness to use PrEP [7] with prior studies showing that high perceived HIV risk positively correlates with willingness to use PrEP [8, 9] as well as with PrEP acceptance [10]. Additionally, underlying differences in sociodemographic characteristics of GBM, such as race, income and education [7] which have been shown to be associated with knowledge of HIV transmission [11], may also influence PrEP uptake.

As theorized in models such as the Health Belief Model, risk perception is central to understanding what motivates people to engage in specific behaviors and may thus guide the development of interventions aimed at increasing protective behaviors [12, 13]. Similarly, the AIDS risk reduction model [14] highlights perceived risk as a necessary path to behavior change. However, risk perception itself is not a purely cognitive process of weighing the risks and benefits of actions but rather a process greatly influenced by a variety of subjective factors such as thoughts, feelings and social processes, and, in so being, risk perceptions are greatly influenced by heuristics and cognitive biases [15–17].

Most prior studies have focused on identifying factors contributing to perceived HIV risk, ignoring the sequence of factors or interconnected experiences that may lead to that perception, including one's sexual and substance use behaviors. One recent study from Thailand showed how perceived HIV risk correlates with engagement in high-risk sexual behavior and stimulant use [10]. Similarly, engagement in high-risk sexual behavior has been linked to alcohol consumption [18] and illicit drug use [19]. The aim of this study was to identify predictors of perceived HIV risk by determining potential pathways by which sexual behavior, substance use, and sociodemographic characteristics result in high perceived HIV risk in a large sample of HIV-negative GBM from multiple cities in Brazil. Specifically, we focus our attention on the pathways that occur through potentially modifiable behaviors including sexual and substance use behaviors.

Methods

Study Design

We conducted three cross-sectional web-based studies targeting GBM in Brazil from 2016 to 2018, one per year. Individuals who met eligibility criteria (age ≥ 18 years, cisgender men, and self-reported HIV-negative) and who acknowledged reading the informed consent text were directed to the online questionnaire. The first study (2016 survey) was conducted in July 2016 in 10 Brazilian state capitals, two from each Brazilian Geographical Region [20]. The second (2017 survey) [21] and third (2018 survey) [8] studies were conducted in July 2017 and March to April 2018, respectively, and were expanded to all Brazilian state capitals and two large cities in São Paulo State (Santos and Campinas). The 2016 and 2018 surveys were advertised on two geospatial networking apps for sexual encounters among GBM: Hornet and Grindr. The 2018 survey was also advertised on Facebook social media. The 2017 survey was advertised on Hornet only. No incentives were provided for answering the survey and, on average, participants took approximately ten minutes to complete it.

Survey Instrument

The survey instrument was composed of five sections (25 items) addressing: sociodemographic information, substance use, sexual behavior and history of sexually transmitted infections, and perceived HIV risk (survey instrument is available at [7]; though the instrument was not the same in the three surveys, the items used in this analysis were present in all). SurveyGizmo® was used to develop and program the online survey. Of note, in Brazil, PrEP availability was restricted to clinical trials and demonstration projects such

as PrEP Brasil [22] until December 2017 when it became available through the Brazilian Public Health System.

Main Outcome

HIV perceived risk was assessed with the question "In your opinion, what is your risk of getting HIV in the next year?" with possible response options "No risk", "Low risk", "High risk/50%", "Certain/100%" and "I don't know / prefer not to answer".

Variables

Socio-demographic

Variables were categorized as follows: age at the time of the survey (18–24 vs. 25 years or more), race (white/Asian vs. non-white), education (≤ 12 years vs. > 12 years of formal education), monthly family income (≤ 3 vs. > 3 minimum wages, Brazilian minimum wage was R$998 or US$268 in January 2019). Sexual orientation was dichotomized as gay vs. other (bisexual, heterosexual or other). Steady partnership was assessed with the question "Do you have a steady partner (male or female)?" (yes/no).

Substance Use

Using National Institute on Alcohol Abuse and Alcoholism (NIAAA)'s 2004 definition, we evaluated at least one episode of binge drinking with the question "In the last 6 months, did you drink 5 or more drinks in a couple of hours?". Use of stimulants (cocaine, poppers, crack, or amphetamines) during the previous 6 months (at least one episode) was dichotomized as yes/no.

Sexual Behavior and Sexually Transmitted Diseases

Sexual behavior was assessed with the question: "In the last 6 months, did you have condomless receptive anal sex with any partner?" with response options yes/no, a "yes" response was coded as high-risk sexual behavior in the past 6 months. Report of sexually transmitted infections (STI; syphilis, gonorrhea or rectal chlamydia, at least one episode) in the last six months was dichotomized as yes/no.

Ethical Approval

The National Instituto of Infectious Diseases (INI) Evandro Chagas, Oswaldo Cruz Foundation (FIOCRUZ) institutional review board approved this study (#CAAE 51595815.7.0000.5262 and 82021918.0.0000.5262) in accordance with all applicable regulations and all study participants digitally signed an informed consent. No identifying information on participants was collected.

Statistical Analysis

Socio-demographic characteristics, relationship status, sexual and substance use and perceived HIV risk were described. Ordered regression sequencing was used to understand the pathways to perceived risk [23, 24], which has been previously applied in a population of people living with HIV to the understanding of antiretroviral adherence [25]. We focused on the potentially modifiable behaviors leading to perceived HIV risk. The regression models were constructed based on the arrangement of variables as in Fig. 1. In this graphical representation, each block of variables to the right of a given block represents temporally antecedent and potential explanatory variables for the variables in the block. Accordingly, perceived HIV risk may be predicted by all variables listed in boxes (b)–(d) whereas binge drinking (in box (c)) may be predicted only by variables in box (d). Box (d) contains variables assumed to be purely explanatory. The criteria used to group variables into blocks were based on prior knowledge and literature considering the temporal ordering of proximal and distal drivers.

In the models, perceived HIV risk was categorized into high ("High risk/50%" and "Certain/100%", coded as 1) and low ("No risk" and "Low risk", coded as 0); participants selecting "I don't know/prefer not to answer" were considered as a missing value and were excluded from all models (N = 986, 5.9%). The first regression model used high perceived HIV risk as the outcome of interest and all other variables as potential predictors. High-risk sexual behavior was then used as an outcome of interest in the subsequent regression. Subsequently, two more models were constructed for the modifiable factors, binge drinking and stimulant use. Model coefficients were exponentiated and interpreted quantitatively as adjusted odds ratios (aOR) with 95% confidence intervals (95% CI) and qualitatively via an independence graph. Analyses were performed using R version 3.6.2 (The R project).

Results

A total of 16,667 GBM completed the survey; 26.6% of the participants were young (18–24 year), 41.9% self-reported as non-white, and 59.6% had more than 12 years of schooling (Table 1). Most participants (14,909, 89.4%) self-identified as gay, 1010 (6.0%) as bisexual, 662 (4.0%) as heterosexual or other orientation, and only 86 (0.5%) did not answer the sexual orientation question. Overall, only 23.8% of participants had a steady partner (91.7% male, 8.3% female); among those who self-identified as heterosexual or other
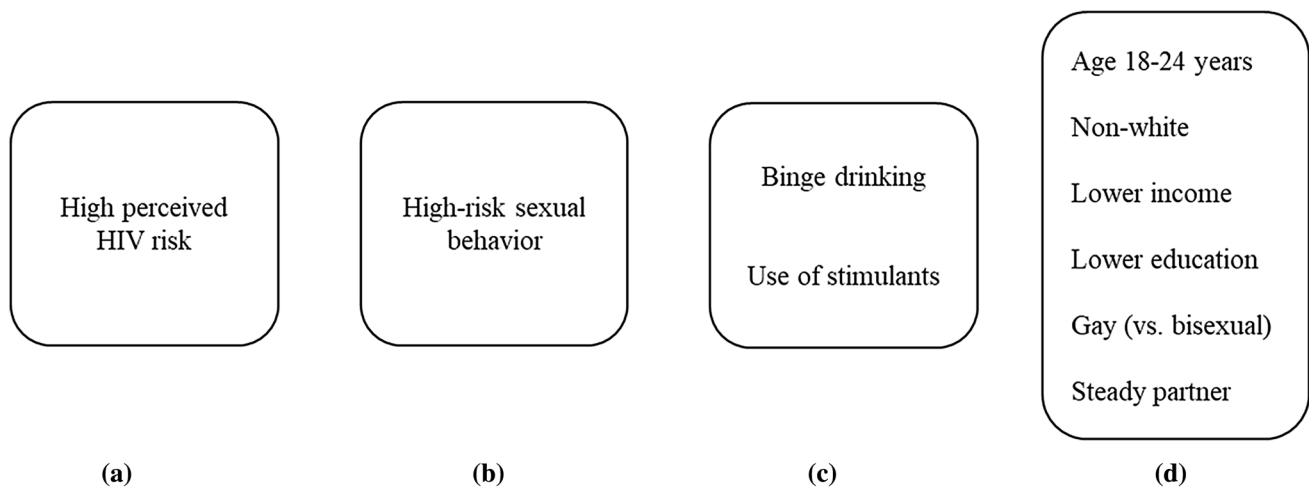
Fig. 1 Ordering of variables to guide regression model sequencing. High perceived HIV risk (box (**a**)) is the outcome of primary interest. High-risk sexual behavior (box (**b**)) is a potential explanatory variable for high perceived HIV risk, and is itself potentially explained by variables in boxes (**c**) and (**d**). Variables in box (**c**) are potentially predicted by variables in box (**d**), which are considered to be purely explanatory. By design, the variables in each box are temporally ordered: perceived HIV risk was assessed as a future risk perception (during the next year). Although variables in box (**b**) and (**c**) were measured concurrently, we hypothesize that binge drinking and use of stimulants precede and therefore influence sexual behavior

orientation (N = 662), only 87 reported no male sexual partner in the previous six months. At least one episode of binge drinking in the prior six months was frequent (70.2%) while a much smaller fraction reported use of stimulants (20.4%). Over two thousand (13.1%) participants reported an STI and 41.4% reported condomless receptive anal sex in the prior six months. PrEP use was reported by 153 (3.0%, 153/5065), 69 (2.4%, 69/2841) and 229 (2.6%, 229/8761) individuals, respectively, in the 2016, 2017, and 2018 surveys (overall 2.7%, 451/16,667). Perceived HIV risk was reported as certain, high, low or no risk by 0.4%, 25.9%, 51.8% and 16.0% of participants, respectively.

Results of the multivariate logistic regression models are shown in Table 2 and the pathways are highlighted in Fig. 2. All variables were found to be associated with high perceived HIV risk. Younger age (18–24 year) and having a steady partner were associated with decreased odds of high perceived HIV risk. Non-white race, lower income, lower education, and gay sexual orientation were positively associated with high perceived HIV risk. Additionally, binge drinking and use of stimulants increased the odds of high perceived HIV risk. The largest effect size was observed for high-risk sexual behavior, which led to a 2.5-fold increased odds of high perceived HIV risk; a similarly high increase in odds was also observed among those who reported an STI in the prior six months.

High-risk sexual behavior was positively associated with all variables (except non-white race) though the largest effect sizes were observed for GBM self-identifying as gay, having a steady partner, reporting binge drinking and use of stimulants. Predictors of binge drinking and use of stimulants were each then modeled as a function of the variables in box (d); these models suggest a different profile of user for each of the two substances, though the two behaviors were highly associated. Younger participants had increased odds of binge drinking and decreased odds of stimulant use, which was also less frequent among those of non-white race and lower income. In contrast, gay sexual orientation increased the odds of stimulant use while steady partner decreased it.

Discussion

In this study, we used ordered sequences of multivariate models to explore the pathways leading to engagement in high risk sexual behavior and to high perceived HIV risk. Engagement in high risk behavior was the strongest predictor of high perceived HIV risk, consistent with a cognitive assessment of one's behavior and its consequences. Other predictors that increased the odds of high perceived HIV risk included non-white race, lower income and education, gay sexual orientation, and substance use. We also found that engaging in high risk sexual behavior played a central role in the pathway, since all factors, with the exception of race, indirectly impacted HIV risk perception through their relationships with sexual behavior.

For younger men, our results indicate that despite their higher odds of binge drinking and of engagement in high-risk sexual behavior, they had lower perceived HIV risk. This discordance between perception and behavior suggests there may be other pathways leading to risk perception, that is, that other behaviors and types of sexual partners (casual

Table 1 Socio-demographic characteristics, sexual and substance use behavior and perceived HIV risk

	N (%)
Total	16,667 (100%)
Age (years)	
18–24	4426 (26.6)
25 or more	12,240 (73.4)
Race/skin color	
White/Asian	9579 (58.1)
Non-white	6898 (41.9)
Schooling (years)	
≤ 12	6704 (40.4)
> 12	9888 (59.6)
Income (minimum wage, per month)	
≤ 3	6683 (40.1)
> 3	9984 (59.9)
Sexual orientation: gay	14,909 (89.9)
Steady partner: yes	3955 (23.8)
Binge drinking[a]: yes	11,684 (70.2)
Stimulant use[a,b]: yes	3401 (20.4)
Sexually transmitted infection[a,c]: yes	2145 (13.1)
Condomless receptive anal sex[a]: yes	6865 (41.4)
Perceived HIV risk[d]	
I don't know	986 (5.9)
No risk	2665 (16.0)
Low risk	8629 (51.8)
High risk/50%	4324 (25.9)
Certain/100%	63 (0.4)

[a]At least one episode during the previous 6 months

[b]Cocaine, poppers, crack, or amphetamines

[c]Syphilis, gonorrhea, or rectal chlamydia

[d]In the next 12 months

vs. non-casual), as well as sociodemographic characteristics, may codetermine perception of risk. Results from a previous analysis using this study population [7], as well as other studies among GBM, suggests that approximately 40–80% of high-risk men underestimate their true risk [7, 9, 26–28]. In a prior study, GBM aged 18–24 years, reported lower perceived HIV risk compared to GBM aged 25 years or more [21]. Moreover, our finding on the misperception of HIV risk, especially among the young, supports the recent rise in HIV incidence among GBM aged 16–24 years in Brazil [29]. In a study of over 5,000 GBM in six US cities, authors reported on how misperception of HIV risk links to lower HIV testing and lack of knowledge of one's HIV-infection [30].

One plausible explanation for the misperception of risk is optimism bias, where there is a tendency to underestimate the likelihood of negative events (and overestimate the likelihood of positive events) [31]. Importantly, in a recent randomized controlled trial among high risk GBM from San Diego County, authors tested whether providing participants with an objective risk score based on their behaviors could improve risk perception and PrEP uptake. Results showed that providing a risk score did not improve perceived HIV risk or PrEP uptake [26]. Unfortunately, the absence of an effect of providing correct information about a negative consequence (i.e. likelihood of acquiring HIV) is expected given that optimism bias is "tied to a failure to update from undesirable information" [31]. An Australian study of over 2000 gay men sought to disentangle optimism bias with respect to HIV transmission and HIV disease and its impact on risk behavior [32]. Results showed that the majority of respondents agreed that "HIV is no longer a death sentence", though only HIV transmission optimism was associated with unprotected anal sex with casual partners.

Another possible explanation for the discrepancy between behavior and perception among the young is lack of knowledge of HIV transmission. In Brazil, sexual education at schools or within the families is still a taboo subject likely impacting knowledge of HIV transmission risk and prevention strategies. A recent study among GBM from multiple cities in Brazil observed overall low HIV transmission knowledge, with age 25 years or more associated with a two-fold increased odds of high knowledge compared to those aged < 25 years [11]. Though plausible, it does not seem to be sufficient that knowledge of HIV transmission leads to more accurate risk assessments, as discussed above. In a web-based survey conducted among GBM from the US, younger GBM had higher knowledge of HIV transmission risks and of prevention strategies compared to the older participants, but no differences regarding their perceived HIV risk or their HIV testing behavior [33].

Our results on the two modifiable factors, namely binge drinking and stimulant use, suggest pathways leading to engagement in high risk sexual behavior. Though both binge drinking and stimulant use increase the odds of engagement in high-risk sexual behavior and most of GBM reporting stimulant use also reported binge drinking (2946/3401, 86.6%), we found that younger age was associated with increased odds of binge drinking (and report of high risk behavior as discussed above) while older individuals, of white-race and higher income showed increased odds of stimulant use. When coupled with the reported prevalence of substance use, these results suggest two distinct pathways, one of relevance to a larger group (approximately 70% of participants overall) who engage in binge drinking and high-risk sexual behavior, and a second smaller group, of older white GBM of higher income who use stimulants and engage in high-risk behavior (and who had higher odds of high perceived HIV risk). Although both substances have been linked with high-risk sexual behavior, binge drinking seems particularly harmful in this population given its

Table 2 Odds ratio and 95% confidence intervals for the four regression sequencing models considering the outcomes: high perceived HIV risk, high-risk sexual behavior, binge drinking and stimulant use

	High perceived HIV risk (vs. low/no risk)	High-risk sexual behavior (vs. low/no risk)	Binge drinking (vs. no)	Stimulant use (vs. no)
Younger age (18–24 vs > 24 years)	**0.72 (0.66–0.79)**	**1.22 (1.13–1.33)**	**1.23 (1.13–1.35)**	**0.79 (0.71–0.88)**
Non-white race (vs. white)	**1.21 (1.12–1.31)**	0.96 (0.89–1.03)	1.05 (0.98–1.13)	**0.87 (0.80–0.95)**
Low income (vs. > 3 MW)	**1.11 (1.02–1.21)**	**1.17 (1.08–1.26)**	0.97 (0.90–1.05)	**0.63 (0.57–0.69)**
Low education (vs. > 12 years)	**1.11 (1.02–1.21)**	**1.13 (1.05–1.22)**	1.03 (0.95–1.12)	0.99 (0.90–1.09)
Gay (vs. other)	**1.28 (1.12–1.47)**	**1.93 (1.71–2.17)**	1.12 (1.00–1.25)	**1.68 (1.44–1.97)**
Steady partner (vs. no)	**0.78 (0.71–0.85)**	**1.40 (1.29–1.51)**	0.93 (0.86–1.02)	**0.88 (0.80–0.97)**
Binge drinking (vs. no)	**1.15 (1.05–1.25)**	**1.35 (1.26–1.45)**	–	**3.35 (3.01–3.74)**
Stimulant use (vs. no)	**1.51 (1.38–1.66)**	**1.57 (1.45–1.71)**	**3.35 (3.01–3.74)**	–
STI diagnosis (vs. no)	**2.40 (2.17–2.66)**	–		
High-risk sexual behavior (vs. low)	**2.54 (2.35–2.74)**	–		

Within each model, variables were adjusted concomitantly for all others

Brazilian minimum wage was R$998 or US$268 in January 2019

Entries in bold are statistically significant (*p*-value < 0.05)
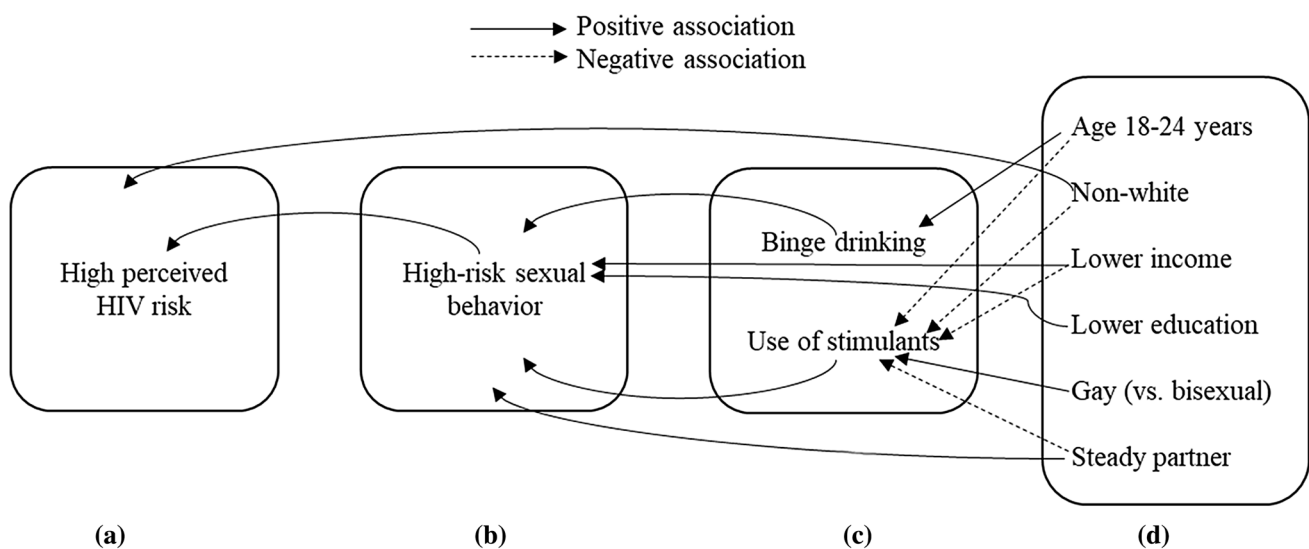
MW minimum wages

Fig. 2 Independence graph with arrows indicating statistically significant positive (normal arrow) and negative (dashed arrow) associations in the pathway leading to high perceived HIV risk. The direct associations between variables in (**d**) and (**a**) are not shown for the sake of clarity

higher likelihood of occurrence among younger men and subsequent association with high-risk behavior and low perceived HIV risk.

Experimental evidence on the effect of the level of alcohol consumption on the use of condoms indicates a consistent dose–response relationship such that the higher the blood alcohol content the lower the intention to use condoms [18]. Moreover, studies evaluating trends in alcohol use and binge drinking in the United States have shown both to have steadily increased from 2000 to 2016 with younger men having the highest reported prevalence [34]. Among

high risk GBM who decided to use PrEP in the context of the PrEP Brasil study conducted in Rio de Janeiro and Sao Paulo, binge drinking (≥ 5 drinks in a sitting) in the prior three months was reported by 59% of participants [22]. In a recent online study conducted among GBM from Rio de Janeiro, prevalence of substance use, including stimulants and alcohol, before or during sex ('chemsex') in the prior three months was high (64%), and 'chemsex' was associated with engagement in high-risk sexual behavior [19]. In a nation-wide respondent driven sampling study conducted among GBM, more than one episode per month of binge

drinking (≥ 4 drinks in a sitting) was reported by 27% of men [35]. It is likely that alcohol use is high among younger men as it is widely accepted and easily accessed in Brazil, even by minors [36, 37]. Stimulants, in contrast, are expensive and illegal; explaining our results indicating lower use among men who are young, of non-white race, or with lower education.

We found that having a steady partner was associated with increased odds of engaging in high-risk sexual behavior and hypothesize this may relate to how perceived risk has been shown to decrease as feelings of trust grow in a relationship, with the continued use of condoms being difficult to maintain [38]. In the present study, having a steady partner was associated with increased odds of engagement in high-risk behavior but decreased odds of high perceived risk for HIV. Similarly, in a US study, having a steady partner was associated with a four-fold increased odds of unprotected anal intercourse [30], while another study found that having a steady partner significantly decreased perceived HIV risk [33]. Accordingly, GBM may feel more comfortable having condomless sex with a steady partner and may perceive no or low risk with this behavior. Indeed, even in the context of a relationship where one partner is HIV-infected and the other HIV-uninfected, from the perspective of HIV transmission, the practice of condomless anal sex is entirely safe if the HIV-infected partner is on suppressive antiretroviral therapy and has undetectable HIV viral load [39–42]. We lacked information on the HIV-status of the participant's partner in this study and therefore cannot extrapolate the frequency of sero-discordant partnerships. Moreover, though approximately one third of the sample was from 2018 when PrEP was already being provided within the National Health System, the fraction of men on PrEP was very low (2.8% as per prior results that included the 2018 sample [8]). As such, we do not believe the reported high-risk behavior represents situations where condomless receptive anal sex would correctly lead to a low risk perception given overall very low PrEP use. The need to understand populational sexual mixing patterns by HIV status, antiretroviral therapy, and PrEP use cannot be understated, as recently highlighted in a study of over a thousand GBM from Montreal [43].

Although there was no association between race and engagement in high-risk sexual behavior, non-whites had an increased odds of high HIV perceived risk. This could potentially be a reflection of high rates of new HIV infections among non-white populations in Brazil. According to Brazilian surveillance data, in comparison to white males, the proportion of new HIV cases among non-white males has increased from 48 to 64% between 2007 and 2019 [44]. And although this information has been made public in reports from the Department of HIV, STDs and Hepatitis of the Ministry of Health, we believe it is unlikely that population-level statistics are informing individual-level

perceived HIV risk among non-white GBM from Brazil. Rather, we interpret these findings as resulting from the persistent effects of stigma and discrimination, pervasive in the Brazilian society [45], at the individual, interpersonal and structural levels, that create a sense of self-stigma and low self-esteem [46]. As noted in the introduction, risk perception is not a precise cognitive phenomenon but also greatly influenced by emotional content or affect, which can be positive or negative [15–17]. Stigma and discrimination have strong negative components that may influence a person's risk perception, as hypothesized in the framework of "affect heuristic", where "badness" is linked with "more risk" [47, 48]. GBM populations face different forms of stigma, including internalized, perceived, experienced and layered stigmas [49]. In a national sample of GBM from 10 cities in Brazil, conducted in 2008–9, authors reported that 16% of the participants experienced lifetime sexual violence, with more than half also reporting recent sexual violence, and, importantly, that the strongest determinant of sexual violence was homophobic discrimination [50]. In a study conducted in Belo Horizonte, black individuals had over 50% higher odds of experiencing discrimination than whites, even after controlling for income, education, social status, and health problems [51]. A systematic review showed a higher prevalence of mental health disorders in non-white Brazilians compared to their white counterparts [52], and this could be attributed to a negative psychological stress response [53]. Studies addressing intersectional stigma ("the convergence of multiple stigmatized identities" [54]) are required as is the need to include black/mixed-black race individuals in the conception and delivery of educational campaigns.

This study has limitations. First, web-based studies are not probabilistic sampling strategies, precluding the generalization of our findings to all Brazilian GBM. That said, the comparison of indicators such as HIV prevalence, high-risk sexual behavior and substance use between these participants and other studies from Brazil [3, 55] reveal similar patterns. Moreover, our findings are restricted to GBM who have access to computer or cellphones with internet and who use GSN apps or social media, also limiting generalizability to all GBM in Brazil. Recent data, however, suggests that 76% of the Brazilian population has access to internet connection and 83% has a cellphone [56]. Although the cross-sectional nature of the data precludes asserting any causality or direction for identified associations, perceived HIV risk was assessed with a question regarding future risk, such that its temporal relationship with the other variables was inherently suggested. We measured perceived HIV risk with a single item, however, studies show that risk perception is a multi-dimensional construct [15, 57]. Future studies should use validated instruments that can assess multiple dimensions of perceived HIV risk such as the Perceived Risk of HIV scale [58]. As for sexual behavior and substance use, as

discussed above, a body of literature supports the temporal relationship of substance use affecting sexual behavior. All collected data were self-reported by participants and may be subject to recall and information biases. However, compared to face-to-face interviews, individuals tend to be more open and honest through web-based surveys, thereby reducing social desirability bias [59]. Our assessment of substance use addresses at least one episode in the prior six months and therefore cannot inform the frequency of the behavior during the recall period. Lastly, although a screening survey question asked if a participant had already responded to the survey and if so, to not continue, we cannot rule out the duplicate records. The fact that no incentive was offered to complete the survey makes repeat participation less likely.

Conclusions

Our results show, through the use of ordered sequences of multivariate models, that the pathways to perceived HIV risk likely include a direct assessment of one's sexual behavior, as well as other pathways which may be linked to the use of mood-altering substances such as alcohol and stimulants. In a study among GBM in Montreal, event-level factors such as attractiveness of the partner and substance use were important determinants of engaging in high risk behavior [60]. Similarly, our results suggest that binge drinking and use of stimulants are key points in different pathways to engagement in high-risk sexual behavior. The modified social ecological model proposes inter-related layers of risk for HIV acquisition, from the individual to the social/network, the community and public policy, all of which depend on the epidemic stage that is unique to time and place [61]. The HIV epidemic stage in Brazil reflects an increased infection rate among younger GBM [35]. Our finding that younger aged men had increased odds of high-risk sexual behavior and binge drinking, but had decreased odds of high perceived HIV risk, calls attention to the vulnerability of this subgroup to HIV infection. The need to focus prevention efforts among younger GBM is urgent.

Author Contributions TST, LM, VGV and BG conceived and implemented the surveys. TST, CCAB, JC, EEMM and PML conceived this study. TST and PML analyzed the data and generated the tables and figures. CCAB, JC, and EEMM provided guidance on statistical analyses and results interpretation. TST and PML reviewed the literature and drafted the manuscript. All authors critically revised the manuscript for important intellectual content and approved the final version of the manuscript.

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