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Impact of HIV risk perception on both pre-exposure prophylaxis and condom use

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Abstract

Risk perception is one of the several important factors impacting sexual health behaviours. This study investigated the evolution of HIV risk perception on pre-exposure prophylaxis adherence and condom use in men who have sex with men at high risk of HIV and associated factors. Group-based trajectory modelling helped in identifying patterns of risk perception, pre-exposure prophylaxis adherence and condom use over time. The association between the former and the latter two dimensions was then investigated. An estimated 61 per cent ($p < 0.001$) of participants perceiving low risk and 100 per cent ($p < 0.001$) of those perceiving high risk had systematic pre-exposure prophylaxis adherence, while an estimated 49 per cent ($p < 0.001$) and 99.8 per cent ($p < 0.001$), respectively, reported low-level condom use.

Keywords

condom use, HIV, men who have sex with men, pre-exposure prophylaxis adherence, risk perception, trajectories

Introduction

Although the efficacy of pre-exposure prophylaxis (PrEP) as a preventive strategy for HIV has been demonstrated in several clinical trials (Grant et al., 2010; McCormack et al., 2016; Molina et al., 2017), a high level of adherence is crucial to its success (Molina et al., 2015, 2017). One of the psychosocial determinants

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influencing PrEP adherence is the level of self-perceived risk of HIV infection (Koenig et al., 2013). Indeed, higher PrEP adherence has been found in several clinical trials in individuals perceiving high HIV risk (Koenig et al., 2013). This suggests that differences in PrEP efficacy observed in trials to date reflect, at least to some extent, participants' risk perception levels. Koenig et al. (2013) also pointed out that poor PrEP adherence may result from incorrect risk assessment by trial participants. Moreover, in the FEM-PrEP trial, which exclusively included women, HIV incidence was only 6 per cent lower in those provided PrEP (versus those not), with 70 per cent of the participants having a low self-perceived risk (Corneli et al., 2014). Furthermore, participants perceiving high risk had good adherence to PrEP in that study. (Corneli et al., 2014). In the context of on-demand (i.e. based on sexual activity) PrEP, one study showed that participants who perceived high risk were more likely to adhere to PrEP (Sagaon-Teyssier et al., 2018).

All these results are in line with health behavioural models which consider risk perception to be one of the main determinants of health behaviours (Ajzen, 1991; Catania et al., 1994; Janz and Becker, 1984; Paicheler, 1997; Rogers, 1983). However, the relationship between HIV risk perception and sexual behaviour is complex. Perceived high risk does not always predict safe sexual behaviours (Akwara et al., 2003). This complex association has been highlighted in several studies, especially concerning the relationship between condom use and risk perception. Condomless sex has been reported in HIV-positive men who have sex with men (MSM) and in HIV-negative heterosexual men with a perceived low risk of HIV transmission (Brooks et al., 2009; Kalichman et al., 2016). However, in a study by Woodward et al. (2014), perceived high risk was not associated with safer sexual behaviours in male or female refugees, irrespective of HIV serostatus. This counter-intuitive effect of risk perception on sexual behaviours highlights the complexity of this link and suggests the importance of taking into account study context and conditions.

Risk perception is often considered a purely individual process, whereby interactions with and the influence of other people (i.e. sharing emotions, beliefs, knowledge, actions and norms) are not considered (Paicheler, 1997). HIV risk perception should be studied as a process where interactions with sexual partners and the social context surrounding the sexual encounter play a crucial role. From the methodological point of view, risk perception is often studied using cross-sectional data. Little is known about its evolution, especially in relation to health-related behaviours (Ogden, 2011).

In France, both daily and on-demand PrEP protocols are currently available in real-world situations. The latter comprises the protocol used in the ANRS-IPERGAY trial which ended in 2016 (Haute Autorité de Santé, 2017). In that trial, on-demand PrEP was based on sexual activity. The treatment schedule involved taking PrEP before and after risky sex. Anticipating sexual risk is crucial in this context, and risk perception may constitute a key element for PrEP adherence.

One longitudinal study from the ANRS-IPERGAY trial pointed out the positive association between risk perception and PrEP adherence in the on-demand context (Sagaon-Teyssier et al., 2018). However, risk perception was used only as an explanatory variable and was not explored over time. The present analysis aimed to investigate whether different HIV risk perception trajectories exist and their possible relationship to PrEP adherence and condom use. This study used self-reported data from the open-label extension (OLE) phase of the ANRS-IPERGAY trial, which offered a more realistic setting than the trial's initial double-blind phase to study behavioural aspects related to risk.

Methods

Design of the ANRS-IPERGAY trial

The ANRS-IPERGAY trial, conducted in France and Canada, provided sexual activity–based antiretroviral prophylaxis for HIV prevention to

high-risk MSM (Molina et al., 2015). The trial included HIV-negative males or transgender women who had sex with men, were aged ⩾18 years and were at high risk of HIV acquisition. High risk was defined as reporting condomless anal sex with at least two different partners during the previous 6 months. During follow-up visits (every 2 months), participants benefitted from individual, tailored risk-reduction counselling by community-based coaches. They were also provided with condoms and lubricants and were tested for HIV and other sexually transmitted infections (STIs) (Molina et al., 2015).

The double-blind randomization trial started in February 2012, and thanks to the drug's effectiveness in terms of HIV incidence reduction, the placebo arm was discontinued in November 2014. The trial then continued as an OLE study until June 2016 (Molina et al., 2017). Public health authorities and ethics committees in France (*Comité de Protection des Personnes, Paris, Ile de France IV*) and Canada (*Comité d'éthique de la recherche, Montreal, QC*) approved the amendment to the initial protocol in order to implement the OLE phase.

The on-demand PrEP treatment schedule was as follows: two pills 2–24 hours before sex, followed by a third and fourth pill 24 and 48 hours after the first dose. For participants with multiple consecutive sexual intercourses, the schedule was one pill per day for each day sexual intercourse occurred and one pill 24 and 48 hours after the most recent intercourse (Molina et al., 2015).

Participants and questionnaires

The present analyses were performed on 361 participants in the OLE phase, accounting for 5277 analysable questionnaires.

During follow-up, from M0 to M18 of the OLE phase, participants completed an online questionnaire every 2 months. The questionnaire covered sociodemographic characteristics, alcohol and recreational drugs use, sexual behaviours, HIV risk perception, condom use and PrEP adherence during their most recent sexual intercourse.

Outcomes

The present analyses were performed using three outcomes: (1) Risk perception of HIV infection was self-assessed by participants using a scale from 1 to 10, that is, from low- to high-risk perception; (2) Self-reported PrEP adherence was classified into two categories: correct PrEP use (i.e. at least one pill taken within 24 hours before sex and one pill taken within 24 hours after sex) and suboptimal PrEP use (any other use) versus no use (no pills taken within 48 hours before or after sex); and (3) condom use was classified in two categories: condom use versus no condom use.

The three outcomes were measured with regard to the most recent sexual intercourse and computed for each point-time during follow-up.

Statistical analysis

First, group-based trajectory modelling with censored normal specification was implemented to identify different trajectories concerning HIV risk perception levels. The same model was then used again, but this time with logistic specification, to identify trajectories of PrEP adherence and condom use. All models were implemented for the whole follow-up of the OLE phase (Jones et al., 2001). Group-based trajectory modelling identifies similar behavioural patterns among individuals to determine distinctive trajectories and to characterize individuals within each trajectory (Jones and Nagin, 2007). One of its main advantages is that it can be used even with missing values (Nagin and Odgers, 2010a). In our study, participants could be included, provided they completed questionnaires for at least two time-points over the follow-up (Jones et al., 2001). The optimal number of trajectories determined by the model was identified using the Bayesian Information Criterion (BIC). The factors associated with the probability of membership of each trajectory estimated through the specification of the fixed explanatory variables (Jones and Nagin, 2007; Nagin and Tremblay, 2001). In addition, time-varying factors (the number of sexual partners,

location, sexual positioning and recreational drug use during the most recent sexual intercourse) were evaluated to estimate their effects on each trajectory evolution over time.

Joint group-based trajectory modelling was implemented to separately investigate the links between HIV risk perception and both PrEP adherence and condom use. (Nagin and Odgers, 2010a, 2010b; Nagin and Tremblay, 2001).

All statistical analyses were performed using SAS software (version 9.4).

Fixed explanatory variables. Sociodemographic characteristics and sexual behaviours according to HIV risk perception trajectories were assessed at baseline of the ANRS-IPERGAY trial and included the following: educational level (>high school/≤high school), active employment (yes/no), housing comfort (comfortable/uncomfortable), main partner (yes/no), quality of environment of life (socially deprived/not socially deprived neighbourhood), anxiolytic use (yes/no), antidepressant use (yes/no) and mean number of sexual partners during the previous 2 months and sexual intercourses during the previous 4 weeks. Furthermore, the following variables related to the most recent sexual intercourse were assessed at baseline: located in a public location (yes/no), recreational drug use (yes/no), cannabis use (yes/no), alcohol use (yes/no) and receptive anal intercourse (yes/no).

Time-varying explanatory variables. Receptive anal intercourse (versus insertive or both) and recreational drug consumption (alcohol, cannabis and other drugs) were classified into two categories: yes/no.

Sexual intercourse location was classified into two categories: (1) private locations, including one's home, the partner's home or other private space (e.g. hotel) and (2) public locations, including sex clubs, backrooms, parks or other public spaces.

All these time-varying variables were measured for the most recent sexual intercourse at each time-point over follow-up.

The number of sexual partners during the previous 2 months was also recorded.

Data for all these variables were collected in each follow-up questionnaire.

Results

Concerning the main characteristics of the 361 participants (Table I of the Supplementary Material), the median (interquartile range (IQR)) age was 37 (30–44) years. At baseline, 91.3 per cent of participants declared having an education level higher than high school and 83.1 per cent reported they were in active employment. Less than half of the respondents (41.4%) had a main partner. Recreational drug use in the previous 12 months was reported by 44.1 per cent of the participants. Furthermore, 26.4 per cent used anxiolytics and 14.8 per cent, antidepressants. The median (IQR) number of sexual intercourses in the previous 4 weeks was 9.5 (5–15) and the median (IQR) number of sexual partners during the previous 2 months was 7 (3–15).

Trajectories of risk perception

From the group-based trajectory model, three distinct trajectories were found for HIV risk perception (Figure 1): 'low-risk perception' (62.3% of the 361 participants) with an estimated mean score of 2.2, 'medium-risk perception' (30.5% of the 361 participants) with an estimated mean score of 4.6 and 'high-risk perception' (7.2% of the 361 participants) with an estimated mean score of 7.5.

The post-estimation characteristics for each trajectory of risk perception (Table II of the Supplementary Material) showed that no difference existed between trajectories in terms of sociodemographic characteristics. With regard to behavioural characteristics, a significant difference was observed in terms of the number of sexual partners in the previous 2 months ($p = 0.004$) and recreational drug use during the previous 12 months ($p = 0.02$). More specifically, participants perceiving high risk

declared more sexual partners (17.2) than their medium-risk counterparts (15.1). In turn, the latter declared more partners than those perceiving low risk (9.5). Recreational drug use in the previous 12 months was reported more frequently by participants perceiving high (50%) and medium (54.1%) risk than those perceiving low (38.5%) risk. Furthermore, those perceiving low risk tended to declare having a main partner more often than the other two trajectories (45.3% versus 37.9% and 23.1% for medium and high risk, respectively; $p = 0.06$). Furthermore, those perceiving high and medium risk tended to use recreational drugs more frequently during their most recent sexual intercourse than their low-risk counterparts (38.5%, 47.3% and 33.8%, respectively; $p = 0.06$).

Factors affecting the shapes of the risk perception trajectories

Multivariate analysis showed the effect of time-varying factors on the evolution of risk perception within each risk perception trajectory (Table 1).

The number of sexual partners was positively associated with HIV risk perception in all three trajectories. This effect was stronger in those perceiving high risk, with an average increase of 0.18 ($p < 0.001$) per each additional sexual partner, compared with 0.01 and 0.04 ($p < 0.001$) for those perceiving low and medium risk, respectively. Receptive anal sex was positively associated with an HIV risk perception level. A stronger association was seen in those perceiving high risk (1.55, $p < 0.012$ versus 0.32, $p < 0.009$ and 1.00, $p < 0.001$ for perceived low and medium risk, respectively).

Sexual intercourse in a public location was positively associated with an HIV risk perception level (0.66, $p < 0.001$ and 1.58, $p < 0.032$, for those perceiving low and high risk, respectively). Alcohol use linked to sex was also positively associated with risk perception (0.42, $p < 0.032$ for low risk). Recreational drug use linked to sex was positively associated with higher HIV risk perception in those perceiving low and medium risk (0.77, $p < 0.001$ and 0.99, $p < 0.001$, respectively). However, it was negatively associated with the high-risk trajectory (−2.37, $p < 0.001$).

Table 1. Time-varying factors affecting the pattern of risk perception trajectories (OLE phase of the ANRS-IPERGAY trial, $n = 351$[a]).

	Low-level risk perception (64.4%), Coeff. (*p* value)	Medium-level risk perception (30.8%), Coeff. (*p* value)	High-level risk perception (4.8%), Coeff. (*p* value)
Time-varying covariates			
Intercept	1.63 (<0.001)	3.39 (<0.001)	5.20 (<0.001)
Linear			0.03 (0.530)
Number of sexual partners, previous 2 months	0.01 (<0.001)	0.04 (<0.001)	0,18 (<0.001)
Most recent sexual intercourse			
Receptive anal intercourse (ref. no)	0.32 (0.009)	1.00 (<0.001)	1.55 (0.012)
Outdoor locations (ref. no)	0.66 (<0.001)	0.46 (0.058)	1.58 (0.032)
Cannabis use (ref. no)	–0.22 (0.284)	0.37 (0.190)	–0,22 (0.829)
Alcohol consumption (ref. no)	0.42 (0.032)	–0,06 (0.845)	0,25 (0.714)
Other recreational drugs (ref. no)[b]	0.77 (<0.001)	0,99 (<0.001)	–2,37 (<0.001)

(Continued)

Table 1. (Continued).

	Low-level risk perception (64.4%), Coeff. (*p* value)	Medium-level risk perception (30.8%), Coeff. (*p* value)	High-level risk perception (4.8%), Coeff. (*p* value)
		OR 95% CI (IQR)	OR 95% CI (IQR)
Factors affecting the probability of group membership			
Constant		1.16 (0.28–4.77)	0.08 (0.01–1.19)
Age	Ref.	0.99 (0.96–1.01)	1.01 (0.96–1.07)
Educational level higher than high school (ref. no)	Ref.	0.62 (0.24–1.60)	0.55 (0.10–3.01)
Anxiolytics (ref. no)	Ref.	2.03 (1.12–3.68)*	2.44 (0.79–7.61)
	BIC = −6208.37 (*N* = 2724) BIC = −6175.88 (*N* = 335) AIC = −6116.76		

OLE: open-label extension; OR: odds ratio; CI: confidence interval; IQR: interquartile range; BIC: Bayesian Information Criterion; AIC : Akaike Information Criterion.
[a]Ten missing values.
[b]Ecstasy, cocaine, poppers, GHB/GBL, ketamine, Viagra.
*$p < 0.05$.

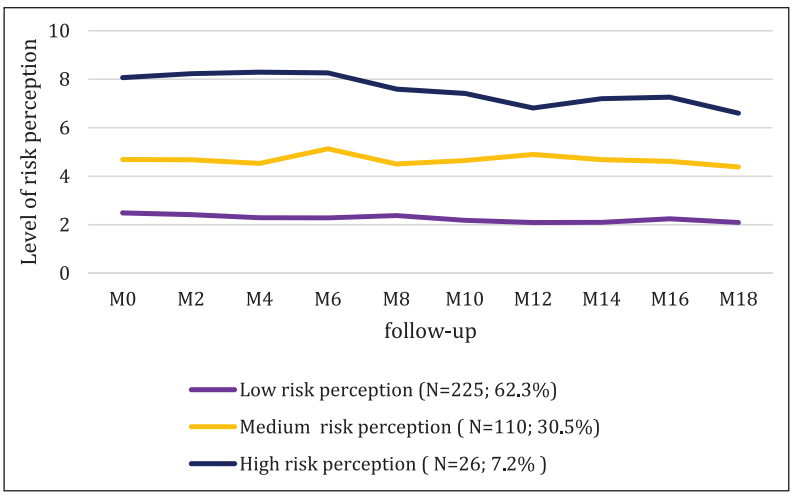

Figure 1. Evolution of risk perception trajectories during the OLE phase of the ANRS-IPERGAY trial[a] (*n* = 361).
[a]The average posterior probability of a participant belonging to one of these trajectories ranged between 0.88 for medium-level risk perception and 0.92 for both low- and high-level risk perception.

Group-based trajectories of condom use and PrEP adherence

With regard to PrEP adherence, two trajectories were identified by the model (Figure I of the Supplementary Material): 'systematically adherent to PrEP' (which included correct and suboptimal PrEP use, 69.2%), with a mean probability of PrEP adherence of approximately 0.9, and 'unsystematically adherent to PrEP' (30.8%), with a probability of PrEP adherence between 0.2 and 0.5.

With regard to condom use, two distinct trajectories were identified by the model (Figure II of the Supplementary Material): 'low-level condom use', with a probability between 0.1 and

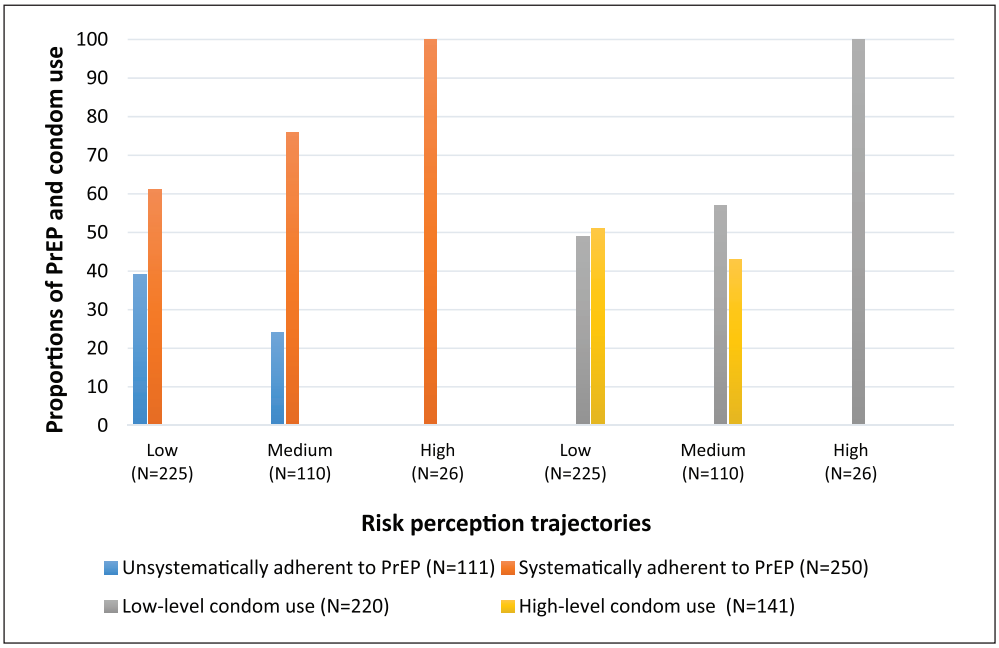

Figure 2. Proportions of condom use and PrEP adherence according to risk perception trajectories during the OLE phase of the ANRS-IPERGAY trial ($n = 361$).

0.2, and 'high-level condom use', with a probability between 0.4 and 0.6. They covered 60.9 and 39.1 per cent of participants, respectively.

Relationship between risk perception trajectories and PrEP adherence and condom use trajectories

Joint group-based trajectory modelling enabled us to estimate the proportions of each PrEP adherence and condom use trajectory according to each risk perception trajectory. Figure 2 shows that 61, 76 and 100 per cent of participants perceiving low, medium and high risk, respectively, belonged to the 'systematically adherent to PrEP' trajectory.

With regard to the two condom use trajectories, 51 and 43 per cent of participants perceiving low and medium risk, respectively, belonged to the 'high-level condom use' trajectory. In contrast, 100 per cent of participants perceiving high risk belonged to the 'low-level condom use' trajectory (Figure 2).

Therefore, unlike PrEP, condom use decreased with increasing risk perception. The group-based trajectory model highlighted that among the high-risk perception trajectory, not using condoms was compensated for by systematic adherence to PrEP.

Discussion

Our results showed three different risk perception trajectories among MSM with risky sexual behaviours participating in the OLE phase of the ANRS-IPERGAY trial. A large majority of participants perceived a low level of HIV risk. One possible explanation for this is that this study was conducted during the OLE phase, after the publication of the efficacy of the on-demand PrEP protocol (Molina et al., 2015). This efficacy, in addition to the condoms provided during follow-up visits, may have reassured participants about the risk of HIV infection (Storholm et al., 2017).

Our results also showed that risk perception is more strongly associated with behavioural and psychosocial characteristics than with sociodemographic characteristics. In certain trajectories, the number of sexual partners, type of location for sexual intercourse, receptive sexual positioning, consumption of alcohol and recreational drug use all affected the level of risk perception over time. More specifically, within each risk perception trajectories, participants reporting receptive anal sex and those having a high number of sexual partners perceived a higher level of HIV risk. Furthermore, within the low perceived risk trajectory, alcohol consumption linked to sex was associated with increased risk perception. Sexual intercourse in private locations was perceived to be less risky than in public locations for participants in the low and high perceived risk trajectories. This hypothesis is consistent with that of a previous study, which showed that individual prevention strategies are influenced by the sociocultural factors associated with the sexual encounters (Apostolidis, 2000).

Given the level of risk perception was associated with the level of PrEP adherence in our study, this might have led to decreased PrEP adherence in these participants.

Recreational drug use linked to sex had contrasting associations with HIV risk perception. Those using recreational drugs in the low and medium perceived risk trajectories had a higher perceived risk, while this risk was lower in those belonging to the high perceived risk trajectory. For the latter, one possible explanation is that recreational drug use may reflect a coping strategy (Semple et al., 2004). More specifically, recreational drug may be a tool for reducing stress during sexual encounters (Semple et al., 2004).

Risk perception was strongly associated with PrEP adherence, with participants from the high-risk perception trajectory being 100 per cent adherent. On the contrary, condom use decreased with increased risk perception. MSM perceiving a high risk of HIV infection seemed to prefer PrEP to condoms. This result echoes findings in the literature concerning the link between HIV risk perception and condom use (Bryan et al., 1996; Gerrard et al., 1996).

The theories of reasoned action and planned behaviour might partly explain our results (Albarracín et al., 2001). More specifically, Albarracín et al. pointed out that factors other than risk perception can predict condom use. Indeed, they found that condom use is influenced by intention to use, attitudes and subjective norms towards condoms and to a lesser degree by associated perceived behavioural control. The latter two elements are particularly important because condom use involves the agreement of one's sexual partner. Moreover, attitudes and intentions regarding condom use might be negatively impacted if a loss of pleasure is anticipated (Calabrese et al., 2012; Crosby et al., 2005; Golub et al., 2012; Greene et al., 2014; Sanders et al., 2012). That can lead to unsystematic condom use.

Few data exist in the literature concerning the determinants of PrEP adherence. Some barriers, such as the cost of PrEP (Auerbach et al., 2015; Eisingerich et al., 2012; Holt et al., 2013; Wheelock et al., 2013), distrust in the medical system (Auerbach et al., 2015) and stigma (Auerbach et al., 2015; Eisingerich et al., 2012), have been identified. In the ANRS-IPERGAY trial, participants had free access to PrEP and consulted physicians who volunteered to participate. Moreover, participants were recruited by a national community-based non-governmental organization (AIDES). This context may have decreased some of the barriers associated with PrEP adherence. Unlike condom use, PrEP adherence does not involve the partner's agreement. For the MSM who perceive a loss of pleasure with condoms, PrEP may improve sexual health through increased sexual pleasure (Underhill, 2015).

Furthermore, a meta-analysis of the effects of risk appraisal – including dimensions such as risk perception, anticipatory emotions (e.g. fear and worry), anticipated emotions (e.g. regret and guilt) and perceived severity – on intention and behavioural changes showed the complexity of risk assessment (Sheeran et al., 2014). Specifically, this meta-analysis indicated that

the impact of risk appraisal on behaviour and intention was greater when these various dimensions were taken into account.

Our study has limitations. First, the data were collected within the context of a clinical trial with a strict follow-up, involving highly motivated participants at very high risk of HIV acquisition. As a result, we cannot generalize our findings. Second, we did not use qualitative data, which could have helped to explain in greater detail why and how certain factors influenced HIV risk perception. As a consequence, our interpretations were based on hypotheses that need to be confirmed. Third, the relationship between risk perception and sexual behaviour was studied in one direction only (i.e. how risk perception impacted behaviours), whereas these behaviours may also impact risk perception (Huebner et al., 2011). Fourth, we were not able to study the different dimensions of risk perception described by Sheeran et al. (2014). Studying these dimensions may have provided us with more precise results.

Despite these limitations, our study highlights that PrEP helps achieve both the goals of HIV prevention and sexual pleasure. This could explain the greater adhesion to PrEP by the study's participants. Risk perception was positively related to PrEP adherence, which underlines the need for interventions to improve the evaluation of risk perception. However, such interventions should also focus on HIV risk assessment in terms of context, and not only sexual practices. Indeed, most counselling interventions concentrate on risk reduction strategies related to high-risk practices (e.g. the number of sexual partners and condomless receptive anal encounters) (Herbst et al., 2005) but few look at context. One example is location. In our study, perceived sexual risk was lower for encounters in private locations. Counselling interventions should incorporate this issue.

Overall, counselling interventions should serve to deconstruct social representations associated with the sexual context and the sexual partner (Morin and Apostolidis, 2002; Roberts et al., 2005; Sibthorpe, 1992). Counselling interventions for context-based perceptions could be provided by community-based counsellors as their specific knowledge of the various lifestyles of the MSM population means they are better equipped to discuss representations and HIV risk.

Our results also highlight drug consumption–related issues. High-risk perception participants who used recreational drugs during sex perceived a lower HIV risk. In order to reduce HIV-related stress and potentially reduce the need to consume, we recommend interventions that explain the effectiveness and functioning of available prevention methods and how to combine them.

Conclusion

This study highlights that HIV risk perception was more influenced by contextual and behavioural factors than by sociodemographic characteristics in MSM enrolled in the ANRS-IPERGAY trial. Furthermore, a high level of perceived risk predicted high PrEP adherence but not systematic condom use. To improve the ability of MSM to assess risk, HIV programmes should provide preventive interventions which aim to reduce the risk of substance use. These programmes should also focus on context-based factors related to risk, something which could be tackled in community-based counselling. Finally, our study confirms that MSM consider PrEP to be an appropriate preventive tool in the context of high-risk HIV infection. Nevertheless, future qualitative studies are needed to explore the sociocognitive processes underlying the assessment of HIV risk perception in greater detail.

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Author contributions

M.D.C. implemented this work under the supervision of L.S.-T. and B.S. M.D.C., M.M. and L.S.-T. led the analysis. The manuscript was written collaboratively between M.D.C., L.S.-T., M.S.-M., C.P. and B.S., with input from D.R.C., L.M., M.P. and J.M.M. G.P. and C.P. provided ongoing support to design and perform data collection throughout the cohort study. All authors approved the final manuscript.

Declaration of Conflicting Interests

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Supplemental material

Supplemental material for this article is available online.

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