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ORIGINAL PAPER

PrEP in the Context of Other HIV Risk Reduction Strategies Among Men Who Have Sex with Men: Results from the Flash! PrEP in Europe Survey

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Abstract

Combination HIV prevention covers a range of biomedical, behavioral, and socio-structural interventions. Despite the growing availability of pre-exposure prophylaxis (PrEP), it is not always accessible in European Centre for Disease Prevention and Control reporting countries and may not meet the needs of all at-risk populations. Based on the Flash! PrEP in Europe data, multiple correspondence analysis and hierarchical clustering were used to identify patterns in HIV prevention strategies among 9980 men who have sex with men (MSM). PrEP interest was evaluated among four identified clusters: (A) "high condom use, sometimes Treatment as Prevention (TasP)"; (B) "mix of methods, infrequent condom use"; (C) "high condom use, tendency to choose partners based on serological status" and (D) "moderate use of condoms mixed with other prevention strategies". Clusters B and D had higher PrEP interest. These results suggest that MSM use a range of behavioral and biomedical risk reduction strategies that are often combined. On-demand PrEP may meet the needs of MSM who infrequently use condoms and other prevention methods.

Keywords MSM · HIV prevention · Europe · Community-based research · PrEP · Sexual orientation

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Introduction

Sixty-two percent of new adult HIV infections worldwide occur among men who have sex with men (MSM), people who inject drugs, sex workers, and transgender people, as well as their sexual partners and clients of sex workers (UNAIDS, 2020). MSM are significantly affected by HIV, representing 23% of new infections in the world, according to 2019 data (UNAIDS, 2020). More specifically, in Western Europe, HIV transmission through sex between men accounted for 37% of the new diagnoses in 2020 (ECDC & WHO, 2021).

HIV prevention has evolved over the last decade toward a combination prevention (CP) approach (UNAIDS, 2007). As opposed to focusing on a single prevention method, CP refers to the use of biomedical, behavioral, and socio-structural interventions which respond to individual and community needs and are implemented at multiple levels for a higher and more sustainable impact (UNAIDS, 2007). CP integrates various preventive options which can be used before, during or after sex (UNAIDS, 2007). At the individual level, CP is based on behavioral and biomedical prevention strategies. Behavioral risk reduction strategies include: anal sex with a HIV-negative partner (without condoms) or a steady partner (with an agreement that anal intercourse outside the couple must be protected), withdrawal before ejaculation, avoiding a receptive position (strategic positioning), and serosorting (choosing partners and sexual practices according to the HIV status of their partners) without necessarily taking into account the viral load of sexual partners living with HIV (Chan et al., 2008; Elford, 2006; Halkitis et al., 2008; Jin et al., 2009; Kennedy et al., 2013; Philip et al., 2010; Vallabhaneni et al., 2012; van de Ven et al., 1997, 2002).

While these behavioral prevention strategies may reduce the risk of HIV infection, they are comparably less effective than biomedical interventions (Jin et al., 2009). In the past few decades, a movement toward a broader use of biomedical prevention approaches has emerged due to an increase in availability and use of HIV prevention tools based on antiretroviral therapy (ART) (Nguyen et al., 2011; Velter et al., 2015). In addition to condoms, biomedical prevention tools include Treatment as Prevention (TasP), Post-Exposure Prophylaxis (PEP), and Pre-Exposure Prophylaxis (PrEP) (NMAC, 2018). TasP refers to the non-transmissibility of HIV by people living with HIV who are on effective antiretroviral treatment and who have an undetectable viral load (Vernazza et al., 2008). PEP can prevent HIV infection if taken as soon as possible and no later than 3 days after a potential HIV exposure (Durojaiye & Freedman, 2013; Roland et al., 2005; Weber et al., 2010). PrEP, the most recent biomedical HIV prevention tool, has shown an 86% reduction of HIV infection (with daily or on-demand regimens) in two different European clinical trials among MSM (McCormack et al., 2016; Molina et al., 2015).

Regarding the availability and use of these biomedical strategies, PEP has been used widely to reduce the risk of HIV transmission in Europe since 2012 (European Centre for Disease Prevention & Control, 2012) and most European countries had a policy on ART initiation regardless of CD4 count since 2016 (European Centre for Disease Prevention & Control, 2017). PrEP has been recommended by the World Health Organization for HIV prevention among MSM since 2014 and was authorized by the European Medicines Agency in 2016.

Behavioral and biomedical prevention strategies may be combined at the individual level and used in combination with condoms for higher effectiveness (Coates et al., 2008). However, most of the studies exploring the use of HIV prevention strategies among MSM have focused on condom use, and more recently, on condom and PrEP use, leaving out other prevention strategies (Grant et al., 2014; McCormack et al., 2016; Molina et al., 2015). Behavioral strategies (such as reducing the number of sexual partners, choosing partners according to their HIV status or non-transmissibility, or adapting sexual practices) are often included as explanatory variables or descriptive information rather than investigated as a study outcome. Similarly, studies on PrEP cohorts in real-world settings focus on PrEP adherence, condom use, and STI infection, whereas behavioral HIV prevention is typically not examined (Nguyen et al., 2018; Oldenburg et al., 2018; Streeck et al., 2019; Volk et al., 2015).

PrEP has been widely regarded as a "game-changer" in HIV prevention; however, its availability, accessibility and uptake is variable across Europe. PrEP is formally available in only 16 out of 53 European Centre for Disease Prevention and Control (ECDC) reporting countries in Europe. Thus, the proportion of PrEP users is far lower than the estimated number of MSM who have high exposure to HIV. According to a recent estimate of the "PrEP gap" in Europe, around 500,000 MSM cannot access PrEP. In France, where PrEP is available and fully reimbursed, the number of people initiating PrEP has consistently been inferior to the projected number of eligible MSM (Epi-phare, 2020; Velter et al., 2013) and the same is true in the US (Smith et al., 2018; Sullivan et al., 2018).Moreover, a recent European survey showed that individual and structural barriers might hinder PrEP access in France (Annequin et al., 2020). Therefore, current European data suggest that PrEP is not always accessible and it may not meet the needs of all populations with high-risk exposure to HIV who may prefer other prevention methods. Finally, there is also emerging evidence that access and uptake of PrEP, in addition to sexual behavior, have been impacted by the current COVID-19 health crisis (Epi-phare, 2020; Hyndman et al., 2021).

A better understanding of how HIV prevention strategies are used among MSM may help identify specific groups that could benefit from other prevention methods (potentially including, but not limited to, PrEP) and inform the development of adapted communication strategies. This information could also be relevant to inform the development of counseling protocols or tailored medical programs which are based on current sexual practices and HIV prevention needs. A previous study had identified patterns in condom use and other biomedical and behavioral strategies used among gay, bisexual, and other MSM who were tested for HIV at a community-based testing site in Montreal, Canada (Otis et al., 2016). This study showed the use of a range of risk reduction strategies, sometimes in combination with condoms. The study also highlighted that personalized risk reduction strategies were likely to be influenced by contextual factors, in addition to the HIV status of the sexual partner, and sexual needs and preferences (Otis et al., 2016). Information is currently limited regarding the use of available prevention methods among MSM in Europe, particularly in the context of wider availability of PrEP. The present study used data from the Flash! PrEP in Europe (FPIE) study and aimed to (1) identify and characterize groups of MSM based upon their risk reduction strategies and to (2) evaluate PrEP interest and identify particular groups that could potentially benefit from PrEP.

Method

Participants and Procedure

FPIE was a community-based research study conducted online (June–July 2016), in partnership with two universities and 15 non-governmental organizations (NGOs), aiming to assess knowledge and interest in using PrEP across 12 European countries (Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Romania, Spain, Switzerland, and the UK). French community-based organizations AIDES and Coalition PLUS coordinated FPIE in partnership with the Universities of Amsterdam and Maastricht. Information on risk behaviors, prevention strategies used, and knowledge and interest in using PrEP was collected. Respondents were ≥ 18 years old and self-declared HIV negative or unaware of their serological status. All participants gave written informed consent. At the time of the FPIE study, PrEP was only officially available and reimbursed in France.

Convenience sampling was used, targeting key and vulnerable populations on the European and national level: MSM, migrants, transgender people, sex workers, HIV-negative individuals in serodiscordant relationships, and people who inject drugs. The survey was promoted via geolocalized dating applications, community-based organizations (CBO) and organization websites implicated in the study and email listings, social media, printed material bearing a QR code, and at CBO outreach activities. All partners and organizations were key to the survey's deployment, providing their time and resources without any funding coming from the study. They were also involved in the conception, validation, translation of the survey, and in the discussion and analysis of the results.

The responses to the survey were recorded using Qualtrics® software. This survey obtained prior approval from the Ethics Committee of the Psychology Department of the University of Amsterdam (2016-SP-7030).

Measures

Through the survey, the respondents provided information regarding sociodemographic characteristics, sexual behaviors, currently used prevention strategies, self-reported HIV status, access to sexual health care, drug consumption behavior, history of PEP use and knowledge, interest, intention, and current or past use of PrEP. Detailed information about the study survey and its promotion has been previously published (Delabre et al., 2021).

The questionnaire assessed the use and frequency of four primary risk reduction strategies in the previous six months with the question “In the past six months, excluding your main partner (if you have one), how often have you used the following methods with these partners to reduce the risk of HIV infection?" using the following affirmations (1) “I use a condom for anal sex;” (2) “I choose partners who say they are HIV-negative;” (3) “I adapt the sex I have depending on my partner's HIV-status;” and (4) “I have sex with HIV-positive partners who say their viral load is undetectable.” For each of the four risk reduction strategies, the frequency was evaluated using a five-point Likert scale (“Never,” “Rarely,” “From time to time,” “Nearly always,” “Always”). A “not applicable” modality was also available for each question for participants who did not consider the risk reduction strategy.

A brief description of PrEP was provided at the start of the survey before the respondents were asked if they knew of PrEP (“Do you already know what PrEP is?”). Among respondents who declared prior PrEP knowledge, the level of PrEP knowledge (accuracy) was evaluated using the question “What, from your point of view, is the best description of PrEP?” Respondents were asked to choose one or two definitions of PrEP among five choices, two of which were correct. Respondents were classified as having “correct” knowledge (at least one correct answer and no incorrect answers), “partially correct” (at least one correct and one incorrect answer), or “incorrect” (only incorrect answers were chosen). A brief description of PrEP was then provided to all respondents.

PrEP interest was evaluated using the question “Are you interested in using PrEP?” using a 5-point Likert scale

("No definitely not"/"No, probably not"/"Maybe"/"Yes, probably"/"Yes, definitely").

The analysis of this study was restricted to MSM who had occasional partners (partner(s) other than their main sex partner) in the previous six months and replied to at least one of the four key questions that assessed the use and frequency of the risk reduction strategies.

Romanian MSM respondents ($n = 110$) were excluded from the analysis due to a translation error.

Statistical Analysis

Multiple correspondence analysis (MCA) and hierarchical clustering were used. MCA is an exploratory technique that helps to understand data in a global way and the relationships between a high number of categorical variables (Greenacre, 1992). Hierarchical cluster analysis (Ward, 1963) was used to identify clusters of participants with similar patterns in HIV risk reduction strategies.

Chi-square and ANOVA F tests were used to compare the clusters in terms of socioeconomic and behavioral characteristics. A univariate analysis was performed to explore the relationship between the clusters and PrEP interest. Regarding PrEP interest, respondents who replied "No, definitely not," "No, probably not," and "Maybe" were compared to respondents who replied "Yes, probably" or "Yes, definitely". This analysis was conducted among those answering the question regarding PrEP interest and excluding those taking PrEP at the time of the survey ($n = 458$; at the time of the survey implementation, PrEP was officially authorized in France but it was possible to obtain PrEP informally in other countries). All tests are 2-sided, with a significance level fixed at $\alpha = 0.05$.

Among respondents, 70.4% ($n = 7024$) reported residence in Germany. To account for potential bias, we conducted an analysis with and without German respondents. The results closely resembled in both analyses, thus justifying a global analysis which is presented here.

Statistical analyses were performed using SPSS (version 20.0.0) and Stata (version 12.1).

Results

Study Sample

A total of 9975 MSM were included in this analysis. Most of the respondents reported living in Germany (70.4%), France (5.1%) and the Netherlands (4.1%).

The median age was 37 years [IQR 29—46], 53.5% of respondents lived in a very large or large city (i.e., a population of more than half a million), 93.1% reported a "fair/good" financial situation, and 58.1% were single or dating (versus in a relationship or an open relationship; Table 1).

Table 1 Description of the study sample ($n = 9\,975$)

	n% or median[IQR]
Age (in years)	37[29–46]
City of residence (population size)	
Very large (1 million or more)	3 646 (36.5)
Large (500 000 to 1 million)	1 695 (17.0)
Medium (100 000 to 500 000)	1 860 (18.7)
Small (10 000 to 100 000)	1 667 (16.7)
Town (under 10 000)	1 107 (11.1)
Financial situation	
Bad	689 (6.9)
Fair/good	9 286 (93.1)
Current relationship status	
Single	3 583 (35.9)
Dating	2 215 (22.2)
In a relationship	1 907 (19.1)
In an open relationship	2 270 (22.8)
Sexual practices	
Sex with men	8 870 (88.9)
Sex with men and women	1 105 (11.1)
Ever been tested for HIV	
Yes, in the past 12 months	6 260 (62.7)
Yes, more than 12 months	2 599 (26.1)
No, never	1 116 (11.2)
Ever been diagnosed with a STI (except HIV)	
Yes, in the past 12 months	1 525 (15.3)
Yes, more than 12 months	3 245 (32.6)
No, never	4 973 (49.9)
Don't know	224 (2.2)
Received money, goods or drugs in exchange for sex	
Yes, in the past 12 months	548 (5.5)
Yes, more than 12 months	892 (9.0)
No, never	8 518 (85.5)
Injectable drugs use	
Yes, in the past 12 months	152 (1.5)
Yes, more than 12 months	126 (1.3)
No, never	9 697 (97.2)
Injected drugs used in a sexual context	
Yes	196 (2.0)
No	9 778 (98.0)
Ever take other drugs	
Yes, in the past 12 months	3 038 (30.5)
Yes, more than 12 months	1 729 (17.3)
No, never	5 208 (52.2)
Drug use in a sexual context	
Yes	1 885 (18.9)
No	8 086 (81.1)
Ever had sex against your will	
Yes	922 (10.0)
No	8 966 (90.0)

Table 1 (continued)

	n% or median[IQR]
Self-perceived risk of becoming infected with HIV	
Low	2 276 (22.8)
Rather low	3 164 (31.7)
Average	3 021 (30.3)
Rather high	1 204 (12.1)
High	310 (3.1)
Self-perceived risk of becoming infected with an STI	
Low	1 135 (11.4)
Rather low	2 232 (22.4)
Average	3 936 (39.4)
Rather high	2 015 (20.2)
High	657 (6.6)
Ever used PEP	
Yes, more than once during past year	79 (0.8)
Yes, once during past year	287 (2.9)
Yes, more than a year ago	618 (6.2)
No, never	8 971 (90.1)
Prior knowledge of PrEP	
Yes	5 329 (53.4)
No	4 646 (46.6)
PrEP knowledge (accuracy)	
Correct	4 302 (81.1)
Partially correct	516 (9.7)
Incorrect	486 (9.2)
PrEP meet respondent's HIV prevention needs	
Yes, definitively	1 644 (17.3)
Yes, probably	3 334 (35.0)
Maybe	2 556 (26.9)
No, probably not	1 280 (13.4)
No, definitively not	705 (7.4)
Interested in using PrEP	
Yes, definitively	2 280 (24.0)
Yes, probably	2 766 (29.1)
Maybe	2 544 (26.7)
No, probably not	1 228 (12.9)
No, definitively not	699 (7.3)

Regarding sexual practices, 88.9% reported sex with men and 11.1% reported sex with men and women in the previous six months. Recent HIV testing (in the 12 months before the survey) was reported by 62.7%, and recent STI diagnosis was reported by 15.3%. History of transactional sex was reported by 14.5%, history of injection drug use by 2.8%, injection drug use in a sexual context by 2.0%, history of other drug use by 47.8% and drug use in a sexual context by 18.9%. Ten percent reported a history of sexual abuse (sex against their will because of verbal, physical or any other form of pressure). More than half (54.5%) reported a "low" or "rather low" self-perceived HIV risk, and 33.8% reported "low" or "rather low" self-perceived STI risk. Concerning biomedical prevention, 90.1% of respondents had never used PEP, 53.4% reported prior knowledge of PrEP, and when tested on their knowledge, 81.1% had correct knowledge. More than half (52.3%) felt that PrEP could "probably" or "definitely" meet their HIV prevention needs and 53.1% were "probably" or "definitely" interested in using PrEP.

Hierarchical Cluster Analysis

The hierarchical cluster analysis identified four distinct patterns of HIV prevention strategies among our sample (Table 2): (A) "High use of condoms, sometimes TasP"; (B) "Mixed prevention methods with infrequent condom use"; (C) "High use of condoms with a tendency to choose HIV negative partners," and (D) "Moderate use of condoms mixed with other prevention strategies except TasP."

Cluster A ("High use of condoms, sometimes TasP") included 2097 participants (21.0% of the sample). Among them, 73.6% reported using condoms "Nearly always" or "Always," 64.0% reported "Never" choosing HIV negative partners, 74.6% reported "Never" adapting sex by the partner's HIV status, and 9.6% reported "Always" having sex with HIV-positive partners with undetectable viral load (UVL).

Cluster B ("Mixed prevention methods with infrequent condom use") regrouped 2232 participants (22.4% of the sample). Among them, 43.0% reported using condoms "Rarely" or "From time to time," 54.0% reported "From time to time" or "Nearly always" choosing HIV negative partners, 55.2% reported "From time to time" or "Nearly always" adapting sex to the partner's HIV status and 44.3% reported having sex with HIV-positive partners with UVL "From time to time."

Cluster C ("High use of condoms with a tendency to choose HIV negative partners") regrouped 1848 participants (18.5% of the sample). Among them, 83.2% reported using condoms "Nearly always" or "Always," 24.9% reported "Always" choosing HIV negative partners (however, 67.5% answered "Not applicable"). Adapting sex to the partner's HIV status and choosing HIV positive partners with UVL were not strategies considered by this group ("not applicable": 94.4% and 85.6%, respectively).

Cluster D ("Moderate use of condoms mixed with other prevention strategies except TasP") regrouped 3798 participants (38.1% of the sample). Among them, 44.6% reported using condoms "From time to time" or "Nearly always"; 65.7% reported "Always" choosing HIV negative partners, and 53.2% reported "Always" adapting sex to the partner's

Table 2 Clusters of HIV prevention strategies identified by the hierarchical cluster analysis ($n = 9975$)

	A	B	C	D	Total
	2 097 (21.0)	2 232 (22.4)	1 848 (18.5)	3 798 (38.1)	9 975 (100)
Clusters *n* (%)					
Use a condom for anal sex					
Not applicable	51 (2.4)	21 (0.9)	45 (2.4)	57 (1.5)	174 (1.8)
Never	296 (14.1)	151 (6.8)	59 (3.2)	83 (2.2)	589 (5.9)
Rarely	91 (4.4)	392 (17.6)	87 (4.7)	272 (7.2)	842 (8.5)
From time to time	116 (5.5)	566 (25.4)	120 (6.5)	418 (11.0)	1 220 (12.2)
Nearly always	339 (16.2)	744 (33.3)	476 (25.8)	1 278 (33.6)	2 837 (28.4)
Always	1 204 (57.4)	358 (16.0)	1 061 (57.4)	1 690 (44.5)	4 313 (43.2)
Choose HIV-negative partners					
Not applicable	386 (18.4)	364 (16.3)	1 247 (67.5)	118 (3.1)	2 115 (21.2)
Never	1 343 (64.0)	210 (9.4)	0 (0.0)	102 (2.7)	1 655 (16.6)
Rarely	81 (3.9)	383 (17.2)	24 (1.3)	67 (1.7)	555 (5.6)
From time to time	114 (5.5)	719 (32.2)	0 (0.0)	33 (0.9)	866 (8.7)
Nearly always	61 (2.9)	487 (21.8)	116 (6.3)	1 982 (25.9)	1 646 (16.5)
Always	112 (5.3)	69 (3.1)	461 (24.9)	2 496 (65.7)	3 138 (31.4)
Adapt sex depending on partner's HIV status					
Not applicable	241 (11.5)	216 (9.7)	1 745 (94.4)	805 (21.2)	3 007 (30.1)
Never	1 565 (74.6)	78 (3.5)	0 (0.0)	514 (13.5)	2 157 (21.6)
Rarely	80 (3.8)	443 (19.9)	0 (0.0)	110 (2.9)	633 (6.4)
From time to time	36 (1.7)	559 (25.0)	0 (0.0)	39 (1.0)	634 (6.4)
Nearly always	23 (1.1)	675 (30.2)	0 (0.0)	310 (8.2)	1 008 (10.1)
Always	152 (7.3)	261 (11.7)	103 (5.6)	2 029 (53.2)	2 536 (25.4)
Choose HIV-positive partners with UVL					
Not applicable	447 (21.3)	251 (11.2)	1 583 (85.6)	254 (6.7)	2 535 (25.4)
Never	900 (42.9)	201 (9.0)	220 (11.9)	2 652 (69.8)	3 973 (39.8)
Rarely	120 (5.7)	295 (13.2)	40 (2.2)	632 (16.6)	1 087 (10.9)
From time to time	366 (17.5)	988 (44.3)	0 (0.0)	112 (3.0)	1 466 (14.7)
Nearly always	62 (3.0)	365 (16.4)	0 (0.0)	23 (0.6)	464 (4.5)
Always	202 (9.6)	132 (5.9)	5 (0.3)	125 (3.3)	464 (4.7)
Total [*n* (%)]	2 097 (21.0)	2 232 (22.4)	1 848 (18.5)	3 798 (38.1)	9 975 (100)

HIV status. Choosing HIV positive partners with UVL was "Never" used by 69.8%.

In brief, Cluster A had a pattern of high systematic use of condoms, with lower reliance on serosorting or seropositioning and sometimes used TasP. Cluster B infrequently used condoms but used a mix of the other HIV prevention methods. Cluster C had a pattern of high systematic use of condoms and a tendency to serosorting. Cluster D was characterized by moderate condom use, and a mix of other behavioral strategies.

Comparison of Clusters

Table 3 presents a comparison of the four identified clusters based on selected sociodemographic and behavioral variables.

Participants belonging to cluster A ("High use of condoms, sometimes TasP") were mostly between 30 and 49 years old (58.6%) and lived in a very large or large city (56.0%). Only 18.6% were in a relationship. They were more likely to be in an open relationship than participants belonging to clusters C and D ($p < 0.001$). This cluster was most likely to indicate that PrEP did not meet their HIV prevention needs and had a lower interest in PrEP than the other clusters ($p < 0.001$).

Almost two-thirds (61.8%) of cluster B ("Mixed prevention methods with infrequent condom use") participants were between 30 and 49 years old and were more likely to live in a very large or large city than participants belonging to other clusters ($p < 0.001$). They were less likely to be in a relationship. Cluster B regrouped a higher proportion of participants who reported sex with other men in the past 6 months than in other clusters ($p < 0.001$). More participants belonging to cluster B were more likely to report recent HIV testing and

Table 3 Comparison between clusters in term of sociodemographic and behavioral characteristics ($n = 9\,975$)

	A 2 197 (21.0)	B 2 232 (22.4)	C 1 848 (18.5)	D 3 798 (38.1)	Total 9 975 (100)	*p*–value
Clusters *n* (%)						
Age						< 0.001
18–29	511 (24.4)	440 (19.7)	488 (26.5)	1 246 (32.9)	2 685 (27.0)	
30–39	645 (30.8)	717 (32.2)	526 (28.6)	1 201 (31.7)	3 089 (31.0)	
40–49	582 (27.8)	659 (29.6)	488 (26.5)	801 (21.1)	2 530 (25.4)	
50–59	299 (14.3)	332 (14.9)	282 (15.4)	426 (11.2)	1 339 (13.5)	
60 or older	56 (2.7)	80 (3.6)	55 (3.0)	115 (3.1)	306 (3.1)	
Age median[IQR]	38[30–46]	39[31–47]	38[29–47]	35[27–44]	37[29–46]	< 0.001
City of residence (population size)						< 0.001
Very large (1 million or more)	829 (39.5)	1 004 (45.0)	579 (31.3)	1 234 (32.5)	3 646 (36.6)	
Large (500 000–1 million)	345 (16.5)	381 (17.1)	315 (17.1)	654 (17.2)	1 695 (17.0)	
Medium (100,000–500,000)	378 (18.0)	381 (17.1)	357 (19.3)	744 (19.6)	1 860 (18.6)	
Small (10 000 to 100 000)	341 (16.3)	282 (12.6)	336 (18.2)	708 (18.6)	1 667 (16.7)	
Town (under 10,000)	204 (9.7)	184 (8.2)	261 (14.1)	458 (12.1)	1 107 (11.1)	
Financial situation						
Bad	157 (7.5)	184 (8.2)	97 (5.2)	251 (6.6)	689 (6.9)	0.001
Fair/good	1 940 (92.5)	2 048 (91.8)	1 751 (94.8)	3 547 (93.4)	9 286 (93.1)	
Current relationship status						< 0.001
Single	752 (35.8)	841 (37.7)	640 (34.6)	1 350 (35.5)	3583 (35.9)	
Dating	381 (18.2)	460 (20.6)	434 (23.5)	940 (24.8)	2 215 (22.2)	
In a relationship	390 (18.6)	322 (14.4)	412 (22.3)	783 (20.6)	1 907 (19.1)	
In an open relationship	574 (27.4)	609 (27.3)	362 (19.6)	725 (19.1)	2 270 (22.8)	
Sexual practices						< 0.001
Sex with men	1 905 (90.8)	2 069 (92.7)	1 618 (87.6)	3 278 (86.3)	8 870 (88.9)	
Sex with men and women	192 (9.2)	163 (7.3)	230 (12.4)	520 (13.7)	1 105 (11.1)	
Ever been tested for HIV						< 0.001
Yes, in the past 12 months	1 365 (65.1)	1 616 (72.4)	1 025 (55.5)	2 254 (59.3)	6 260 (62.8)	
Yes, more than 12 months	542 (25.8)	470 (21.1)	551 (29.8)	1 036 (27.3)	2 599 (26.0)	
No, never	190 (9.1)	146 (6.5)	272 (14.7)	508 (13.4)	1 116 (11.2)	
Ever been diagnosed with a STI (except HIV)						< 0.001
Yes, in the past 12 months	322 (15.4)	540 (24.2)	205 (11.1)	458 (12.1)	1 525 (15.3)	
Yes, more than 12 months	766 (36.6)	885 (39.7)	547 (29.6)	1 047 (27.6)	3 245 (32.6)	
No, never	961 (45.9)	774 (34.7)	1 044 (56.5)	2 194 (57.8)	4 973 (49.9)	
Don't know	45 (2.1)	31 (1.4)	51 (2.8)	97 (2.5)	224 (2.2)	
Received money, goods, or drugs in exchange for sex						< 0.001
Yes, in the past 12 months	120 (5.7)	165 (7.4)	70 (3.8)	193 (5.1)	548 (5.5)	
Yes, more than 12 months	187 (9.0)	263 (11.8)	136 (7.4)	306 (8.1)	892 (9.0)	
No, never	1 783 (85.3)	1 799 (80.8)	1 641 (88.8)	3 295 (86.8)	8 518 (85.5)	
Injectable drugs use						< 0.001
Yes, in the past 12 months	36 (1.7)	81 (3.6)	7 (0.4)	28 (0.7)	152 (1.5)	
Yes, more than 12 months	28 (1.3)	57 (2.6)	12 (0.6)	29 (0.8)	126 (1.3)	
No, never	2 033 (97.0)	2 094 (93.8)	1 829 (99.0)	3 741 (98.5)	9 697 (97.2)	
Injected drugs used in a sexual context						< 0.001
Yes	46 (2.2)	109 (4.9)	9 (0.5)	32 (0.8)	196 (2.0)	
No	2 051 (97.8)	2 122 (95.1)	1 839 (99.5)	3 766 (99.2)	9 778 (98.0)	
Ever take other drugs						< 0.001
Yes, in the past 12 months	695 (33.1)	926 (41.5)	456 (24.7)	961 (25.3)	3 038 (30.5)	
Yes, more than 12 months	389 (18.6)	382 (17.1)	332 (18.0)	626 (16.5)	1 729 (17.3)	
No, never	1 013 (48.3)	924 (41.4)	1 060 (57.3)	2 211 (58.2)	5 208 (52.2)	

Table 3 (continued)

	A 2 197 (21.0)	B 2 232 (22.4)	C 1 848 (18.5)	D 3 798 (38.1)	Total 9 975 (100)	*p*–value
Ever had sex against your will because of others pressure						< 0.001
Yes	223 (10.6)	263 (11.8)	150 (8.1)	356 (9.4)	992 (10.0)	
No	1 873 (89.4)	1 965 (88.2)	1 697 (91.9)	3 431 (90.6)	8 966 (90.0)	
Ever used PEP						< 0.001
Yes, more than once during past year	12 (0.6)	44 (2.0)	8 (0.4)	15 (0.4)	79 (0.8)	
Yes, once during past year	65 (3.1)	111 (5.0)	37 (2.0)	74 (2.0)	287 (2.9)	
Yes, more than a year ago	165 (7.9)	218 (9.8)	85 (4.6)	150 (4.6)	618 (6.2)	
No, never	1 850 (88.4)	1 854 (83.2)	1 715 (93.0)	3 552 (93.0)	8 976 (90.1)	
Self–perceived risk of becoming infected with HIV						< 0.001
Low	610 (29.1)	296 (13.3)	541 (29.3)	829 (21.8)	2 276 (22.8)	
Rather low	704 (33.6)	547 (24.5)	627 (33.9)	1 286 (33.9)	3 164 (31.7)	
Average	470 (22.4)	827 (37.1)	493 (26.7)	1 231 (32.4)	3 021 (30.3)	
Rather high	208 (9.9)	463 (20.7)	157 (8.5)	376 (9.9)	1 204 (12.1)	
High	105 (5.0)	99 (4.4)	30 (1.6)	76 (2.0)	310 (3.1)	
Self–perceived risk of becoming infected with an STI						< 0.001
Low	241 (11.5)	110 (5.0)	282 (15.3)	502 (13.2)	1 135 (11.4)	
Rather low	465 (22.2)	313 (14.0)	493 (26.7)	961 (25.3)	2 232 (22.4)	
Average	783 (37.3)	900 (40.3)	725 (39.2)	1 528 (40.2)	3 936 (39.4)	
Rather high	418 (19.9)	672 (30.1)	281 (15.2)	644 (17.0)	2 015 (20.2)	
High	190 (9.1)	237 (10.6)	67 (3.6)	163 (4.3)	657 (6.6)	
Prior PrEP knowledge						< 0.001
Yes	1 306 (62.3)	1 488 (66.7)	826 (44.7)	1 709 (45.0)	5 329 (53.4)	
No	791 (37.7)	744 (33.3)	1 022 (55.3)	2 089 (55.0)	4 646 (46.6)	
PrEP knowledge (accuracy)						< 0.001
Correct	1 103 (84.8)	1 253 (84.4)	644 (78.6)	1 302 (76.6)	4 302 (81.1)	
Partially correct	108 (8.3)	122 (8.2)	75 (9.2)	211 (12.4)	516 (9.7)	
Incorrect	90 (6.9)	110 (7.4)	100 (12.2)	186 (11.0)	486 (9.2)	
PrEP meet respondent's HIV prevention needs						< 0.001
Yes, definitively	328 (16.4)	544 (27.5)	221 (12.2)	551 (14.8)	1 644 (17.3)	
Yes, probably	613 (30.7)	787 (39.7)	576 (31.7)	1 358 (36.4)	3 334 (35.0)	
Maybe	494 (24.8)	422 (21.3)	547 (30.1)	1 093 (29.3)	2 556 (26.9)	
No, probably not	330 (16.6)	160 (8.1)	315 (17.3)	475 (12.8)	1 280 (13.4)	
No, definitively not	229 (11.5)	68 (3.4)	159 (8.7)	249 (6.7)	705 (7.4)	
Interested in using PrEP						< 0.001
Yes, definitively	435 (21.8)	723 (36.5)	314 (17.2)	808 (21.7)	2 280 (24.0)	
Yes, probably	481 (24.2)	610 (30.8)	500 (27.5)	1 175 (31.5)	2 766 (29.1)	
Maybe	504 (25.3)	417 (21.1)	540 (29.7)	1 083 (29.1)	2 544 (26.7)	
No, probably not	329 (16.5)	155 (7.8)	306 (16.8)	438 (11.8)	1 228 (12.9)	
No, definitively not	244 (12.2)	75 (3.8)	160 (8.8)	220 (5.9)	699 (7.3)	
Use of PrEP in a study in which it is provided						< 0.001
Yes	70 (3.3)	144 (6.5)	24 (1.3)	59 (1.6)	297 (3.0)	
No	2 024 (96.7)	2 085 (93.5)	1 818 (98.7)	3 736 (98.4)	9 663 (97.0)	

* "Not applicable" answers were not considered for the calculation of the percentages

recent sexually transmitted infection (STI) diagnosis than participants of other clusters ($p < 0.001$). They were more likely to have a history of transactional sex, inject drugs, including in a sexual context, and take other drugs compared to other participants ($p < 0.001$). Participants of cluster B had a higher self-perceived risk of becoming infected with HIV and STI ($p < 0.001$). Additionally, cluster B pooled the highest proportion of participants who had ever used

PEP, had knowledge about PrEP, and had interest in using it ($p < 0.001$). PrEP more often met the HIV prevention needs of the participants belonging to this cluster compared to the others ($p < 0.001$).

More than half (55.1%) of the participants in cluster C ("High use of condoms with a tendency to choose HIV negative partners") were between 30 and 49 years old. They were more likely to live in a small city or town and to be in a relationship than other clusters. Participants belonging to cluster C were less likely to have a history of sexual abuse than other participants ($p < 0.001$) and had a lower self-perceived risk of becoming infected by HIV and STI compared to other clusters ($p < 0.001$). Cluster C regrouped the highest proportion of participants who had incorrect knowledge about PrEP ($p < 0.001$).

Participants belonging to cluster D ("Moderate use of condoms mixed with other prevention strategies except TasP") were younger (64.6% were between 18 and 39 years old), 38.2% lived in a small or medium city, and 20.6% were in a relationship. Participants belonging to cluster D pooled the highest proportion of participants who reported sex with men and women in the six previous months ($p < 0.001$). Similar to cluster C, participants in cluster D were more likely to report never taking PEP and no prior knowledge of PrEP. 60.6% of participants in cluster D were "maybe" or "yes, probably" interested in PrEP.

PrEP Interest

The univariate analysis was conducted among the 9517 respondents (95.4%) who responded to the question on PrEP interest. Respondents who were taking PrEP were excluded ($n = 458$). The results showed that clusters B ("Mixed prevention methods with infrequent condom use") and D ("Moderate use of condoms mixed with other prevention strategies except TasP") were more likely to be interested in using PrEP (Odds Ratio (OR) [95% CI], 2.42 [2.13–2.76] and 1.34 [1.20–1.49], respectively), using cluster A ("High use of condoms, sometimes TasP") as the reference group (Table 4). Cluster C ("High use of condoms with a tendency to choose HIV negative partners") was not significantly associated with PrEP interest (0.95 [0.84–1.08]).

Analysis without German Respondents

A supplementary analysis was performed without German MSM as this population represented 70.4% of the overall study sample. The results were nearly similar in both analyses with German ($N = 9975$) and without German respondents ($N = 2951$). Minor differences were found: cluster D represented a higher use of condoms, no difference was observed between clusters and financial situation and cluster C was more likely to be interested in PrEP.

Discussion

The present cluster analysis provides a global view of the use of HIV risk reduction strategies among HIV negative (or unknown serostatus) MSM respondents to a large community-based European survey. Four different groups were characterized, each with a different pattern concerning HIV risk reduction strategies: use of condoms, serosorting (sex with an HIV negative partner), seropositioning (adapting sex according to partner's HIV status) and TasP (using ART to reduce HIV transmission). In sum, our results showed that: participants belonging to the cluster A had a high systematic use of condoms, with lower reliance on serosorting or seropositioning and sometimes used TasP; participants of cluster B infrequently used condoms but used a mix of the other HIV prevention methods; participants belonging to the cluster C had a high systematic use of condoms and a tendency to use serosorting; and participants of cluster D moderately used condoms and chose a mix of other behavioral strategies. In accordance with the Montréal study on patterns in risk reduction strategies among MSM in a community-based setting (Otis et al., 2016), our study also showed that MSM in Europe use an array of prevention strategies which are not limited to biomedical tools such as condoms. Behavioral prevention strategies are also relevant to take into account when evaluating HIV-related risk behaviors among this group. Furthermore, biomedical and behavioral prevention strategies were often combined.

When taking into consideration the use of behavioral risk reduction strategies, our results highlighted that inconsistent condom use did not systematically lead to higher HIV

Table 4 Clusters more likely to be interested in PrEP ($n = 9\,517$)

Clusters	OR [CI 95%][1]	p value
A: High use of condoms, sometimes TasP	Reference	
B: Mixed prevention methods with infrequent condom use	2.42 [2.13–2.76]	< 0.001
C: High use of condoms with a tendency to choose HIV negative partners	0.95 [0.84–1.08]	0.444
D: Moderate use of condoms mixed with other prevention strategies except TasP	1.34 [1.20–1.49]	< 0.001

[1]Odds ratio [confidence interval 95%]

exposure. Indeed, just under half of the participants belonging to the cluster D reported condom use from time to time or nearly always but 66% declared always having sex with HIV-negative partners and 53% always adapted sex to the partner's HIV status. Although these behavioral strategies may lead to an incorrect risk evaluation (e.g., in the event of inaccurate knowledge about a partner's HIV status), they highlighted an initiative to reduce the risk of HIV exposure.

The prevention strategies employed by respondents of this survey show a combination of lay and scientific HIV knowledge (lay knowledge refers to the social perception and evaluation of prevention tools which may differ from scientific evidence and recommendations (Morin & Apostolidis, 2002)) and condom-based prevention. While a large majority of respondents (71.6%) reported using condoms "nearly always" or "always", the "juggling" of behavioral and biomedical methods with or without condom use reflected a coexistence of lay and scientific knowledge among MSM. Managing sexual risk by taking into account the serology of their partner(s) would seem consistent with a rationale based on lay knowledge of perceived low (e.g., intercourse with an HIV negative partner) or high (intercourse with partners who are seropositive or whose serology is unknown) "risky" sexual activity (even if sexual intercourse with a HIV positive partner with UVL represents no risk of HIV transmission (Vernazza et al., 2008)). Similar results were found in the ANRS-IPERGAY trial (Di Ciaccio et al., 2020).

It is important to note, however, that there are issues associated with behavioral strategies. Choosing to have sex with self-reported HIV-negative partners raises the issue of HIV testing in MSM with potentially high exposure to HIV. Although European guidelines recommend that MSM should be tested at least annually(ECDC, 2010), and more specifically quarterly according to French and the UK recommendations (Haute Autorité de Santé, 2017; National Institute for Health and Care Excellence, 2016), studies have shown a lack of regular HIV testing among MSM (Carvalho et al., 2013; Coenen et al., 2008; Deblonde et al., 2010; Haute Autorité de Santé, 2017; Marty et al., 2018). While a large majority of the participants in each identified cluster reported recent HIV testing, the proportion of respondents who have never been tested for HIV ranged from 6.5% (Cluster B) to 14.7% (Cluster C).

Regarding other biomedical strategies, TasP was the least used HIV prevention strategy in our study among the four HIV prevention methods studied; only 9.2% of respondents "nearly always" or "always" used TasP and 14.7% "from time to time". This suggests a role of lay-perception of the partner and of HIV prevention tools in HIV risk management. Despite the strong scientific evidence regarding TasP efficacy to prevent HIV transmission, this prevention strategy is not socially integrated (or rather not yet fully integrated in lay knowledge) as an HIV prevention tool. Other studies have shown a skepticism toward TasP among MSM and barriers to implementing this strategy (Siegel & Meunier, 2019; Young et al., 2015). An online survey among MSM in New York showed that only 39.1% of respondents considered TasP completely protective against HIV (Siegel & Meunier, 2019) and another study showed that only 14% of HIV negative MSM had a complete understanding of TasP (Carter et al., 2015). Recent U = U campaigns (undetectable = untransmittable) may improve TasP knowledge and confidence. Physicians, health counselors or community health workers have an important role in communicating information regarding the use of TasP as a viable prevention strategy (Persson, 2015). It is important to note however, that only MSM reporting occasional partners were included in this analysis. It is possible that confidence in TasP would be higher among serodifferent MSM couples who had participated in FPIE study.

HIV prevention interventions should consider the coexistence of various forms of knowledge (scientific and lay) on which HIV prevention behaviors are based by studying social representations of HIV prevention within targeted groups before HIV prevention program implementation. Social representations refer to a form of common-sense knowledge which impacts behaviors (Apostolidis & Dany, 2012a, 2012b). From this theory, people mobilize social representations to give sense to what is happening and then adapt their behaviors (Morin & Apostolidis, 2002; Morin et al., 2012). Therefore, studying social representations before conducting a HIV program may provide an opportunity to take into account this preexistent knowledge and to adapt the prevention program accordingly. This approach has already been used in HIV and in community-based research (Apostolidis & Dany, 2012c; Morin & Apostolidis, 2002; Morin et al., 2012).

Regarding PrEP interest, clusters A and C, which relied primarily on condoms, had a low interest in using PrEP (71.3% and 74.4%, respectively), while clusters B and D, which used a mix of prevention methods, had a higher interest. Other studies have shown that PrEP interest was dependent on condom use or attitudes toward condoms (Gredig et al., 2016; Nideröst et al., 2018). PrEP use could therefore be particularly relevant for cluster B participants who had sub-optimal use of all prevention methods studied and a high or rather high self-perception of HIV risk and other risk factors, including a history of transactional sex and recent STI diagnosis. PrEP could also be an interesting complement to the prevention strategies used by participants belonging to the cluster D. According to a modeling study that explored HIV transmission and impacts of concomitant prevention strategies among MSM in the US, PrEP uptake at a level of 25% among MSM highly exposed to HIV resulted in the reduction of 30% of HIV infections if no additional prevention strategies are employed. PrEP additionally decreases the risk of transmission if PrEP is used in conjunction with

TasP, condoms, and seroadaptive behaviors by 5.1% (LeVasseur et al., 2018). Taking into account PrEP interest among cluster B and D and their HIV risk exposure, future interventions among these profiles of MSM should focus on PrEP initiation. Community-based interventions may be suitable to reach these groups and explain how to integrate PrEP use in their HIV prevention practices. Future studies could then assess PrEP adherence and how PrEP is used in conjunction with behavioral strategies. Concerning individuals in clusters A and C, on-demand PrEP may meet their HIV prevention needs. These clusters often used condoms but when it is not the case, the HIV risk associated with prevalence in the MSM community potentially exposes them to HIV transmission. On-demand PrEP could therefore be relevant for them in conjunction with their other behavioral prevention strategies. Communication regarding on-demand PrEP as a prevention tool is important and relevant for MSM who have lower or intermittent risk exposure (Antoni et al., 2017, 2020). In addition to promoting on-demand PrEP for MSM belonging to clusters A and C, trying to increase PrEP interest through community-based HIV-counseling, self-testing can also be an interesting tool to promote. MSM belonging to clusters A and C had a high use of condoms. HIV self-testing can therefore complete their HIV prevention strategies for the rare cases where condoms are not used. Research could then assess the acceptability and the use of on-demand PrEP and HIV self-testing in HIV prevention strategies among these MSM.

The increasing use of biomedical HIV prevention has led to new forms of rationality in MSM communities through the emergence of new practices such as "biomed matching" or "PrEP sorting" according to recent study among MSM (Grov et al., 2018; Martinez & Jonas, 2019). Similar to serosorting, these behaviors refer to the selection of and the sexual intercourse between partners using the same biomedical HIV prevention tools (TasP or PrEP) (Grov et al., 2018; Martinez & Jonas, 2019). How individual risk reduction strategies change in the context of new prevention practices such as PrEP sorting or biomed matching, and greater availability and uptake of PrEP merits to be explored in future studies.

This study has limitations: FPIE was a cross-sectional study, the possible evolution and changes of risk strategies through time and partners cannot be assessed (Goldenberg et al., 2018). Additionally, information regarding risk strategies was only collected among those who have had sex with individuals other than their main partner (if they had one) in the previous six months. Although it has been estimated that as much as 68% of HIV infections are transmitted by the main partner of MSM couples (Sullivan et al., 2009), it was not possible to study the dynamics of these couples in terms of risk prevention strategies used and the possible differences between the main and the occasional partners (Malone et al., 2018). Although efforts were made to target individuals outside those in contact with CBOs, the respondents might not represent the general MSM European population. Although respondents residing in Germany were overrepresented in this study sample, the cluster profiles were the same when the data were analyzed separately from the rest of the countries (data not shown). Finally, this study was conducted in 2016 before PrEP was widely available in Europe. These results remain relevant however, as recent studies indicate that PrEP remains inaccessible in the majority of countries reporting to the ECDC. Additionally, uptake remains low even among MSM and in locations or countries where access to PrEP may have been impacted by the current Covid-19 health crisis (Epi-phare, 2020; Hayes et al., 2019). Furthermore, even if the HIV prevention landscape has evolved regarding PrEP implementation since 2016, it is unlikely that the psychosocial mechanisms linked to an individual's prevention strategies have fundamentally changed.

Conclusion

This study showed that MSM respondents to a large community-based research study in Europe use a range of behavioral and biomedical HIV risk reduction strategies that are often combined. Those who have a less-than-systematic use of condoms are not necessarily taking fewer precautions, but may instead be combining or replacing condoms with other HIV risk reduction methods. However, the effectiveness of these other risk reduction methods are not necessarily sufficient to prevent HIV. Successful combination of biomedical and behavioral risk reduction methods is dependent on accurate HIV risk perception and the effectiveness of the combined risk reduction methods in the given context. This study showed there is a place for PrEP as another risk reduction strategy for MSM in Europe, especially for those who infrequently use condoms and other prevention methods. However, this study also showed that PrEP did not interest all MSM. Therefore, diversification of HIV prevention tools remains a major factor in HIV prevention promotion so that all MSM may identify, in collaboration with their health care providers, the best way to protect themselves and reduce HIV transmission.

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Declarations

Conflict of interest ARS is a former employee of Wyeth and Pfizer laboratories, and holds Pfizer stock. J.G. reports personal fees from Merck, grants and personal fees from ViiV Healthcare, grants and personal fees from Gilead Sciences, personal fees from Roche, personal fees from AstraZeneca, personal fees from Janssen, outside the submitted work. The other authors do not declare any conflicts of interest.

Compliance with Ethical Standards FPIE study has obtained prior approval from the Ethics Committee of the Psychology Department of the University of Amsterdam (2016-SP-7030).

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