

Estimating HIV pre-exposure prophylaxis (PrEP) use and analysis of HIV PrEP needs among men who have sex with men in Germany

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Abstract

Data on PrEP use in Germany is not collected systematically. We aim to estimate the number of PrEP users among men having sex with men (MSM) and describe PrEP use in Germany from 2017 through 2020. Moreover, we analyse whether PrEP needs expressed in 2017 could have been met by the expansion of PrEP until 2020. We estimated the number of PrEP users using drug prescription data, information on on-demand/intermittent PrEP use from online surveys, and number of online profiles indicating PrEP use, based on varying assumptions about the proportion of on-demand/intermittent and daily PrEP users and on the average number of PrEP pills used. Factors associated with intention to use PrEP were identified by a multivariable logistic regression analysis among respondents to an online survey. We estimated the number of MSM in need for PrEP in 2017 based on four groups defined among the survey respondents, combining respondents intending to use PrEP and respondents indicating substantial sexual risks. We used data and assumptions on self-selection biases to estimate a range for the absolute size of these groups among gay men in Germany. Depending on assumptions, we estimated a total of 15,600 to 21,600 PrEP users in Germany by the end of June 2020, which corresponds to between 40 and 55% of men with the intention to use PrEP in 2017. Distributions of PrEP users from different data sources and PrEP prescriptions by federal state in Germany were highly correlated, except for major deviations for Berlin with a higher proportion of prescriptions in Berlin compared to the proportion of survey participants using PrEP. A correlation between the regional distribution of intention to use PrEP in 11/2017 and actual PrEP use by 06/2020 suggested an unequal regional distribution of unsatisfied needs. The number of men with unmet PrEP needs ranged between 27,500 and 93,000 in 06/2020. PrEP use in Germany has increased considerably between 10/2017 and 06/2020, but large regional inequalities persist. Results suggested that PrEP is not fully accessible and that there is a need to expand services and encourage demand.

Introduction

Legal HIV pre-exposure prophylaxis (PrEP) use started in Germany in 2016 when the European Medicines Agency (EMA) approved the use of tenofovir-emtricitabine for HIV-PrEP (1). With official approval of this two-drug combination for HIV-PrEP, any physician in Germany was allowed to prescribe these drugs for PrEP use. Yet accessibility remained severely restricted due to prohibitive costs (approximately € 800/month) in the absence of affordable generics in Germany and no legal alternatives to obtain and import cheaper generics from outside the European Union (2).

PrEP activists had discovered and promoted a loophole for accessing affordable generics from abroad that relied mainly on a regulation specific for the United Kingdom (UK) allowing import of generics from outside of the European Union (EU) for personal use. This allowed importing the drugs into the UK and forwarding them by mail from UK to Germany without customs control. However, the number of people in Germany who used this channel or used other informal sources to obtain drugs for use as PrEP remained limited. After the patent for tenofovir-emtricitabine had expired, in October 2017 a pharmacist from Cologne exploited a rarely used clause of the German regulatory framework and made a cheap generic version of tenofovir-emtricitabine accessible as monthly supply packaged for individual clients for approximately €50 per month, the so-called "blister PrEP". The blister PrEP became available through a network of HIV-specialized pharmacies (3). The price for this generic version was cut to less than one tenth of the usual pharmacy price for the originator and the already approved generics in Germany. Shortly after the launch of this blister PrEP another pharmaceutical company cut the price of their generic version to about €70 per month, later followed by other generics, which then became available across pharmacies in Germany on private prescription (4).

PrEP drugs and laboratory tests associated with PrEP initiation and follow-up were not covered by statutory health insurance up to this point. A new law that contained a right to access PrEP including counselling and testing covered by statutory health insurance (5, 6) came into effect in September 2019. Coverage within the framework of the statutory health insurance system is now granted provided that PrEP is prescribed by a physician licensed to prescribe PrEP. Such license requires continuing medical education and documented case management of people living with HIV and/or of PrEP provision, and is thus feasible mainly for HIV specialists (7).

To summarize, by end of October 2017 PrEP drugs were available by informal sources (mainly direct or indirect import from countries outside of the EU), as blister PrEP on private prescription (since October 1), or through PrEP-trials in Germany. Availability of a cheap generic version on private prescription in general pharmacies was limited at this point of time. By 2018 until August 2019, PrEP drugs were available mainly as blister PrEP and other generic versions on private prescription, and still by informal sources. Before September 2019 some health insurances already voluntarily covered the drug costs. By 2020, all statutory health insurance companies in Germany covered the costs of PrEP when prescribed by authorized PrEP prescribers.

The number of people accessing PrEP in Germany is not available since no centralized source collects data on PrEP use in Germany. For this analysis we aim to use different sources to estimate the number of PrEP users and describe PrEP use in Germany between 2017 and

2020. Since all available information suggest a marginal use of HIV-PrEP by people other than men having sex with men (MSM), our estimates are restricted to PrEP use among MSM.

A second aim of this analysis is to estimate the PrEP need among MSM in Germany, the extent to which needs expressed in 2017 might have been met by the expansion of PrEP access until 2020, and whether access to physicians able to prescribe health insurance-covered PrEP might still be a barrier for accessing PrEP after financial barriers have been removed by coverage of drugs and tests by statutory health insurance.

Methods

Study design and outcomes

1. Estimate the number of PrEP users in Germany between 2017 and 2020

Data sources for the estimate of PrEP users

a) Drug prescription data

There is no tracking system for private prescriptions in Germany with the exception of controlled substances. For the time period between October 2017 and August 2019 we obtained data on blister PrEP prescriptions at specified time points from the company that repackaged and distributed blister PrEP (Kölsche Blister GmbH). These time points were synchronized with the dates when online surveys provided additional information on PrEP access and mode of PrEP use among participating PrEP users.

For the time period since September 2019 data on antiretroviral drugs prescribed on statutory health insurance included drugs prescribed for PrEP. We have been using antiretroviral prescription data provided by “Insight Health” (company providing drug prescription data from pharmacies) on a regular base to determine the number of people treated for HIV in Germany. The method to determine the number of people receiving antiretroviral treatment based on drug prescription data is described in detail elsewhere (8). Tenofovir disoproxil and emtricitabine (TDF/FTC) is used for PrEP and in HIV treatment with no possibility to distinguish in the prescription data. To determine the number of defined daily doses (DDD) used for PrEP, we set as baseline the number of DDD prescribed for HIV treatment during the first two quarters of 2019 and designated excess prescriptions as PrEP use from the third quarter 2019 onwards, when PrEP could be prescribed under statutory health insurance rules.

b) Online surveys addressing PrEP use among MSM

The European MSM Internet Survey 2017 (EMIS-2017) addressed PrEP use in all participating European countries. Methods for this low-threshold online survey have been described in detail elsewhere (9). In Germany, data for this online survey were mainly collected between early November 2017 and mid-January 2018, with most data collected during early November.

An online survey to specifically address PrEP use among MSM in Germany was designed by the Robert Koch-Institute in early 2018 (PrApp study). Three rounds of this repeated survey have been launched since; the first round collected data from July to September 2018, the second round from April to mid-June 2019, and the third round from March to early May 2020. Methods for this survey have been described elsewhere (10). In this survey, data on place of residence (not collected in round 1), mode of PrEP access, type of PrEP use (daily vs. on-demand) and source of PrEP (informal sources, Blister PrEP, other self-paid generic, health insurance-covered PrEP) were collected.

c) Online profiles indicating PrEP use

PlanetRomeo is a worldwide operating gay dating app and website which is widely used in Germany by MSM (11). According to Planet Romeo there were 643,000 active user profiles in Germany by June 2020. Upon request in June 2020, PlanetRomeo provided the number and regional distribution (by federal state) of user profiles from Germany in which “PrEP use” or “PrEP and condom use” were stated as “safer sex” choices.

Statistical methods to estimate the number of PrEP users

To estimate the absolute number of PrEP users we took the data on prescribed monthly doses for daily PrEP use and multiplied this with a factor that results in the number of monthly PrEP users, based on assumptions about 1) the proportions of daily and on-demand/intermittent PrEP use, and 2) the number of on-demand/intermittent PrEP users based on a monthly supply of a daily PrEP dose. Information on 1) and 2) was collected in the online surveys. However, we did not obtain data on how long and often on

demand/intermittent PrEP users were taking PrEP. Thus, 2) could not be defined based on data and we had to use plausible assumptions for the calculation of the average number of PrEP pills per month used by intermittent and on-demand users.

To test the plausibility of these assumptions, we compared our estimate of PrEP users with the number of PrEP users from a widely used dating app in Germany, PlanetRomeo. We took the number of users who indicated PrEP use on their PlanetRomeo dating profile and multiplied them by 1.4 based on the proportion of PrEP users from the PrApp surveys indicating that they did not state their PrEP use in their online profile (30%). We chose parameters such as the average number of PrEP pills used by on-demand/intermittent users and the proportion of on-demand/intermittent users to get close to this number while remaining consistent with the number of PrEP prescriptions derived from the drug prescription data.

Because of discrepancies particularly regarding the regional distribution between estimates based on different data sources we used (survey data, drug prescription data, PlanetRomeo PrEP profiles), we performed sensitivity analyses to test the impact of different assumptions on 1) and 2) within plausible ranges for these variables since assumptions on 1) could be biased by self-selection effects on survey participation.

2. Identifying factors associated with intention to use PrEP and estimating the number of MSM in need for PrEP in 2017

In the EMIS-2017 questionnaire respondents were asked "If PrEP was available and affordable to you, how likely would you be to use it?" with five response options ranging from 'very unlikely' to 'very likely'. To assess subjective PrEP needs among MSM in Germany we calculated the proportion of survey participants who indicated their willingness to use PrEP ('quite likely' or 'very likely' = *intention to use PrEP*). To estimate "objective" PrEP needs, we determined the proportion of online survey participants without HIV diagnosis from Germany in EMIS-2017 who reported at least 2 non-steady partners with whom condomless anal intercourse (CAI) occurred in the previous 12 months.

We analysed the overlap between the subjective PrEP needs and the objective PrEP needs groups. We defined

- "intention to use PrEP" as having declared an interest to use PrEP;
- "no intention to use PrEP" as not having declared an interest in using PrEP;
- "low sexual risk" as having had less than 2 non-steady CAI partners within the last 12 months;
- "moderate/high sexual risk" as having had 2 or more non-steady CAI partners within the last 12 months.

We formed the following 4 groups:

- 1) intention to use PrEP, low sexual risk;
men with intention to use PrEP and less than 2 non-steady sex partners in the last 12 months were excluded from this group, assuming that most of them indicate a hypothetical need for PrEP in case they would have more partners, or a perceived need based on characteristics of their steady/regular partner;
- 2) intention to use PrEP, moderate/high sexual risk;
- 3) no intention to use PrEP, moderate/high sexual risk;
- 4) no intention to use PrEP, low sexual risk.

Groups 1-3 were defined as in need of/benefitting from PrEP use.

Factors associated with the intention to use PrEP were identified in the EMIS-2017 dataset by uni- and multivariable regression analysis. We considered demographic (age, education, settlement size, federal state, partnership status, exchange of sex for money), behavioural (number of non-steady sex partners in the last 12 months, substance use, CAI due to lack of access to condoms, multi-partner sex during last sexual encounter with non-steady partners), and other individual potentially PrEP-need associated factors (subjectively perceived risk from sex, sexual unhappiness, mental health (patient health questionnaire, PHQ-4), PrEP awareness ('Have you ever heard of PrEP?')).

Statistical methods

We calculated the proportions of EMIS respondents that belong to groups 1-3 as described above. To obtain absolute numbers of people in need of PrEP we had to extrapolate the results to the gay population in Germany. We assumed that 1.5% of the adult male population are gay (12, 13). The distribution of the gay population across federal states in Germany was estimated based on the relative federal state distribution of EMIS respondents (14). Next, we calculated self-selection biases of PrEP users participating in EMIS-2017 and in the three PrApp-Survey rounds. Then we estimated possible ranges for self-selection biases of EMIS-2017 participants for the four groups. We used rounded absolute numbers for the four predefined groups and four different assumptions about self-selection biases: a) a minimal self-selection bias (the relative proportion of the four groups in the gay population is the same as in EMIS-2017); b) and c) two variants of intermediate self-selection biases, based on different weightings for partner numbers and intended PrEP use as main components for determining self-selection bias (we chose weights of a magnitude of 2 – 2.5 as a combined effect of higher partner numbers and PrEP use intention, which is slightly lower than the empirically derived weight of 3 for EMIS respondents with a syphilis diagnosis in the previous 12 months), and d) a maximal self-selection bias for men with intended PrEP use, similar to the self-selection bias of actual PrEP users. Finally, we used one of the intermediate bias estimates to calculate the absolute number and proportion of men with intended PrEP use in 2017 (based on the proportion of EMIS-2017 participants with intended PrEP use) and compared this with the estimated number of people taking PrEP by June 2020, assuming that current PrEP users were recruited exclusively from men who intended to use PrEP in 2017. This group with “PrEP needs met” and the number and proportion of men in need of/potentially benefitting from PrEP who had *no* intention to use PrEP but sexual risks in 2017 were stratified by federal state.

3. Assessing the number of physicians licensed to prescribe PrEP on statutory health insurance in Germany as potential barrier for PrEP uptake

There is no publicly accessible data source for the number of physicians licensed to prescribe HIV drugs for HIV PrEP covered by statutory health insurance in Germany. As a proxy we searched the website of the German association of physicians in private practice providing HIV-care “Deutsche Arbeitsgemeinschaft niedergelassener Ärzte in der Versorgung HIV-Infizierter e. V. (dagnä)” for the number of HIV specialized care providers by federal state (15). We constructed a “PrEP prescriber density” by calculating the number of potential PrEP prescribers per 10,000 MSM for each federal state. We correlated this density factor with the extent of met PrEP-needs.

Results

Number of PrEP users in Germany

Drug prescription data

By end of October 2017, the company producing blister PrEP had filled orders for 513 monthly PrEP doses. In July 2018 this number had increased to 3,125 doses, and in Mai 2019 to 4,022 doses [personal communication by E. Tenberken].

By the end of 2019, the number of drug prescriptions assumed to be used for PrEP and covered by statutory health insurance companies had increased to 10,176 monthly doses. For the first two quarters of 2020 we calculated an average of 10,788 monthly prescriptions (see Table 1).

Survey data

The number of EMIS-2017 respondents living in Germany who indicated current PrEP use was 452, representing 2.1% of the survey respondents, 17 of whom did not provide information on their place of residence. In rounds 1 (July-September 2018), 2 (April/May 2019) and 3 (March-May 2020) of the PrApp-survey a total of 2,118, 3,071 and 964 PrEP users participated, of whom 2,252 and 790 in rounds 2 and 3 provided information on their place of residence, round 1 did not collect this information (see Table 1).

PlanetRomeo PrEP profiles

In June 2020, PlanetRomeo provided information on the geographical distribution of 15,633 user profiles in Germany who had indicated the use of HIV PrEP (n=9,207) or the combination of PrEP and condom use (n=6,426) as their “safer sex” preference [personal communication].

Estimating the number of PrEP users

We defined two scenarios to describe a possible range for the total number of PrEP users in Germany.

In scenario 1 (PrApp study scenario) we make the following assumptions: the proportion of on-demand/intermittent PrEP users was 33% for the time period before PrEP became reimbursable by statutory health insurance and dropped to 20% after September 2019 (based on respective responses in the PrApp study survey rounds 1-3). Intermittent/on-demand PrEP users will only obtain another prescription when

they have used all medication, thus they will be underrepresented in the monthly prescription data. We assumed that the actual number of intermittent/on-demand PrEP users will be on average three-fold higher than the monthly prescriptions for men from these two groups (i.e. a monthly PrEP dose is on average sufficient for three months intermittent/on-demand PrEP use).

In scenario 2 (PlanetRomeo scenario) we assume that a monthly PrEP dose meets the needs of six on-demand/intermittent PrEP users for one month and we also assume that – due to a possible systematic survey participation bias - the proportion of on-demand/intermittent PrEP users is 40% , and thus higher than indicated by respondents of the PrApp surveys, and that the proportion of self-payers who are not reimbursed by statutory health insurance might also be slightly higher than among the PrApp survey respondents. With these assumptions we arrive at an estimate that is compatible with drug prescription data and comes close to the number of PlanetRomeo profiles indicating PrEP use multiplied by 1.4 (N=21,600 vs. N=22,333), accommodating for a proportion of 30% PrEP users who do not provide PrEP use information in their online profiles (another information collected in the PrApp surveys).

Data from the PrApp surveys on the number of PrEP pills used per months by daily, intermittent, and on-demand users, and on the proportion of participating PrEP users indicating PrEP use on their online profiles is presented as supplemental Tables S1 and S2.

Table 1 shows our calculation of the estimated number of PrEP users in Germany at 5 different points in time (early November 2017, end of July 2018, end of May 2019, end of December 2019, and end of June 2020) based on drug prescriptions, proportions of daily and on-demand/intermittent PrEP use, assumptions on how many on-demand/intermittent PrEP users are supported by a monthly dose, and the proportion of additional drug sources as indicated by respondents of online surveys. We arrive at estimates of approximately 15,600 PrEP users in Germany by end of June 2020 for scenario 1, and of approximately 21,600 PrEP users in Germany by end of June 2020 for scenario 2.

Table 1: Data on PrEP access from online surveys in Germany, 2017-2020, and estimation of absolute number of PrEP users

	EMIS-2017	PrApp wave 1 (07/2018)	PrApp wave 2 (05/2019)	PrApp wave 3 ¹ , PrEP prescription data 12/2019	PrApp wave 3 ¹ , PrEP prescription data 06/2020	"PlanetRomeo" scenario 2 ^{**} 06/2020 PrEP prescription data 2020, presumed self-pay 20%, informal sources 5%
a) survey data	%	%	%	%	%	%
medical prescription in Germany	56	81	83	94	94	95
"Blister-PrEP"	56	54	58	n.a.	n.a.	n.a.
other sources (informal, self-pay non-Blister-PrEP generics, trials)	44	46	42	n.a.	n.a.	n.a.
prescription on statutory health insurance	n.a.	n.a.	5	80	80	75
prescription self-pay (Blister-PrEP + non-Blister-PrEP generics)	56	81	82	14	14	20
informal	44	19	13	6	6	5
proportion PrEP on demand	29	29	30	19	19	40
proportion of PrEP users participating in survey	37%	28%	34%		6%	n.a.
	Scenario 1 (survey-result based)*					Scenario 2 **
b) estimation of absolute number of PrEP users	N	N	N	N	N	N
number of "Blister-PrEP"/private self-pay prescriptions	513	3,125	4,022	1,796	1,904	2,877
number of monthly health insurance prescriptions				10,176	10,788	10,788
number of PrEP users supported by prescribed PrEP	660	4,018	5,171	13,814	14,644	20,497
number of PrEP users supported by informal sources/self-pay non-"Blister-PrEP" generics	518	3,423	3,745	882	935	1,079
estimated total number of PrEP users	1,178	7,440	8,916	14,695	15,579	21,576

n.a. = not applicable

¹ data from PrApp survey wave 3 was collected in 03/2020

* assumptions scenario 1: 33% (20%) on-demand/intermittent users, 3 on-demand/intermittent users supported by one full monthly dose

** assumptions scenario 2: 40% on-demand/intermittent users, 6 on-demand/intermittent users supported by one full monthly dose

Regional distribution of PrEP users

Figure 1 and Table 2 provide the estimated absolute numbers of PrEP-users by federal state at the time points 1) early November 2017; 2) end of July 2018 (PrApp-Survey round 1); 3) end of April 2019 (PrApp-Survey round 2); 4) end of December 2019 (PrApp-Survey round 3 distribution); 5) June 2020 (PrApp-Survey round 3 distribution), based on the regional distribution of PrEP users in the respective online surveys and the estimated totals from scenario 1. For scenario 2 the regional distribution was taken from the PlanetRomeo PrEP profiles and was only estimated for June 2020 (see Table 2), because PrEP user profile distributions on PlanetRomeo are not available for earlier time points.

Table 2: Estimated absolute numbers of PrEP-users by federal state at different time points

	Online survey-based distributions (scenario 1)*					PlanetRomeo profile-based distribution (scenario 2)**	
	November 2017 (EMIS-2017)	July 2018	Apr-May 2019	December 2019	June 2020	PrEP profiles PlanetRomeo, June 2020	Estimated number of PrEP users in June 2020
Baden-Wuerttemberg	86	533	639	1,061	1,126	992	1,371
Bavaria	149	982	1,239	2,184	2,318	2,151	2,972
Berlin	447	2,427	2,474	3,668	3,892	4,600	6,356
Brandenburg	14	78	84	162	172	155	214
Bremen	17	70	44	82	87	148	204
Hamburg	63	435	568	864	917	954	1,318
Hesse	102	637	763	1,302	1,382	1,201	1,659
Mecklenburg-Western Pomerania	3	28	48	123	130	95	131
Lower Saxony	39	256	324	684	725	679	938
North Rhine-Westphalia	190	1,403	1,939	3,109	3,299	3,204	4,427
Rhineland-Palatinate	19	160	239	475	504	457	631
Saarland	8	57	76	108	115	140	193
Saxony	25	229	364	548	582	432	597
Saxony-Anhalt	6	44	64	98	105	123	170
Schleswig-Holstein	30	126	76	155	165	211	292
Thuringia	3	34	60	77	82	91	126
Total number of PrEP users	1,200	7,500	9,000	14,700	15,600	15,633	21,600

Figure 2 shows 6 correlation graphs, demonstrating high correlations of the proportional distribution by federal state in Germany of EMIS-participants using PrEP, PrApp-Survey participants using PrEP, PlanetRomeo PrEP profiles, and PrEP prescription data. However, the correlations between the state distribution of PrApp-Survey participants using PrEP and PrEP prescription data as of end of 2019 and for 2020 show major deviations for Berlin with a higher proportion of prescriptions in Berlin compared to the proportion of PrApp-Survey participants using PrEP.

Table S3 provides the proportional regional distributions (by federal state) of all EMIS-2017 participants, EMIS-participants using PrEP, PrApp-Survey participants using PrEP, all PlanetRomeo profiles in Germany, and PlanetRomeo PrEP profiles.

Estimating PrEP needs in Germany

First, we identified the factors associated with PrEP use intention in EMIS-2017 by constructing a multivariable regression model. The univariate analysis shows that settlement size, federal state, education and sexual unhappiness have no impact on the intention to use PrEP (Table S5). The multivariable regression identifies partner numbers, partnership status, perceived subjective risk, and PrEP awareness as key factors determining PrEP use intention. Likewise, CAI due to lack of condoms, high levels of sexualised substance use, severe depression, multipartner sex, and age below 20 increase the intention to use PrEP (see Table 3).

Table 3: Univariable and multivariable analysis of factors associated with PrEP use intentions

	OR	95% CI	p	aOR	95% CI	p
Demographics						
Age						
20 and above	ref.					
age below 20	1.43	1.25 1.64	<0.001	1.37	1.17 1.62	<0.001
Partnership status						
I have a steady partner	ref.					
I am single	1.44	1.35 1.53	<0.001	1.34	1.25 1.44	<0.001
I'm not sure/ it's complicated	1.74	1.55 1.97	<0.001	1.56	1.36 1.78	<0.001
Behaviours						
Partner number						
0-1	ref.					
2-4	1.38	1.27 1.51	<0.001	1.32	1.19 1.46	<0.001
5-7	1.59	1.44 1.75	<0.001	1.47	1.31 1.64	<0.001
8-10	1.86	1.65 2.10	<0.001	1.63	1.42 1.87	<0.001
11-20	2.03	1.84 2.24	<0.001	1.78	1.58 2.00	<0.001
21-30	2.66	2.30 3.07	<0.001	2.28	1.93 2.68	<0.001
31-40	2.79	2.26 3.44	<0.001	2.33	1.84 2.94	<0.001
41-50	3.58	2.72 4.71	<0.001	3.04	2.24 4.11	<0.001
>50	4.04	3.37 4.83	<0.001	3.40	2.78 4.15	<0.001
Sex is always as safe as I want						
Strongly disagree	1.55	1.23 1.96	<0.001	1.59	1.21 2.08	0.001
Disagree	2.66	2.31 3.06	<0.001	1.97	1.68 2.31	<0.001
Neither or not sure	1.82	1.58 2.10	<0.001	1.74	1.46 2.07	<0.001
Agree	1.49	1.40 1.59	<0.001	1.31	1.21 1.41	<0.001
Strongly agree	ref.					
Morbidities						
Depression/Anxiety						
None	ref.					
Mild	1.16	1.09 1.24	<0.001	1.08	1.00 1.17	0.053
Moderate	1.17	1.05 1.31	0.005	1.03	0.90 1.18	0.653
Severe	1.27	1.11 1.45	<0.001	1.22	1.04 1.44	0.015
Sex under the influence of alcohol/drugs						
less than half	ref.					
more than half	1.71	1.55 1.90	<0.001	1.32	1.19 1.47	<0.001
Interventions						
Condom unavailability						
no CAI due to lack of condom	ref.					
CAI due to lack of condom (last 12m)	1.85	1.73 1.99	<0.001	1.60	1.48 1.73	<0.001

PrEP awareness (ever heard of PrEP)								
already heard of PrEP	ref.							
unaware	0.81	0.76	0.86	<0.001	0.90	0.83	0.96	0.003
cons.					0.21	0.19	0.23	<0.001

Table S4 provides absolute data for the size of the four PrEP-need groups in EMIS-2017.

To estimate the total size of these groups in the MSM population of Germany, we made assumptions about self-selection biases for these groups in EMIS-2017. Based on the PrEP user estimates at different time points, we determined that 30-35% of all PrEP users at these time points in Germany participated in EMIS-2017 and the first two rounds of the PrApp-Survey surveys, suggesting very high self-selection biases for actual PrEP users (see Table 1). For comparison, almost 6% of the estimated non-HIV-diagnosed population of gay men living in Germany (N = 350,000, 1.5% of adult males aged 15-64) took part in EMIS-2017 (20,000 male participants not diagnosed with HIV).

We assume that the intention to use PrEP is associated with a self-selection bias that is in-between the self-selection bias for PrEP users (30-35%) and the average self-selection bias for survey participants (6%). We also assume that the size of the bias is associated with factors such as PrEP use intention, and partner numbers, self-perceived risk, and PrEP awareness – the key factors we identified in the regression analysis. We chose weights of a magnitude of 2 – 2.5 as a combined effect of higher partner numbers and PrEP use intention, which is slightly lower than the empirically derived weight of 3 for EMIS respondents with a syphilis diagnosis in the previous 12 months. The distribution of partner numbers, PrEP awareness, and recency of HIV testing, which we consider a surrogate for self-perceived risk in this context, in the four groups is shown in Figure S1.

Based on these assumptions we provide in Table 4 range estimates for the sizes of all four PrEP need groups that were defined. The minimum size for the PrEP need groups would reflect a self-selection bias similar to actual PrEP users, the maximum size would reflect no specific self-selection bias for PrEP use intention. The two intermediate variants represent two different – arbitrary - assumptions of intermediate self-selection biases. The estimated PrEP need ranges between 49,500 and 109,000 men, the unsatisfied PrEP need between 33,500 and 93,000 men for the PrApp-Survey scenario as of June 2020, and between 27,500 and 87,000 for the PlanetRomeo scenario, assuming no change in PrEP needs between end of 2017 and June 2020, and using a total population size estimate of 350,000 adult gay men not diagnosed with HIV living in Germany (16).

In the next step, we compare how this estimated PrEP need from 2017 compares to the number of estimated PrEP users in 2020. To calculate a regional PrEP need distribution in Table 5, we used the totals from variant 1 shown in Table 4 and apply it to the PrApp-Survey scenario total of current PrEP users (N=15,600) and the PlanetRomeo scenario total of current PrEP users (N=21,600). The variant 1 estimate assumes that PrEP use intention and the number of sex partners in the last 12 months are the main determinants for the selection bias.

Table 5 shows proportions of satisfied intention to use PrEP and unmet needs with no intention to use PrEP by federal state by June 2020. Fig.3a shows the almost perfect correlation between the regional distribution of intention to use PrEP in November 2017 and the distribution of the gay population in Germany, while Fig.3b shows how intention to use PrEP correlates with actual PrEP use by mid-2020, suggesting an unequal regional distribution of unmet needs, regardless which of the two scenarios is used.

One likely important barrier for PrEP uptake is the number of HIV specialists that are able to prescribe PrEP. Since this number differs by federal state, it might explain the unequal regional distribution of unsatisfied PrEP needs. Thus, we analysed the correlation between satisfied PrEP needs and number of HIV specialists per 10,000 gay men practicing in the respective federal state (Fig 4). The strong correlation between these two parameters suggests that easy access to PrEP prescribers has indeed a large impact on meeting the needs of potential PrEP users.

Table 4: Estimating the size range of PrEP need groups in Germany

	intention, no reported risk*	intention and risk	no intention, but risk	no intention, no reported risk	estimated PrEP need	unmet PrEP need (PrApp scenario 1, 16,000 PrEP users)	unmet PrEP need (Romeo- scenario 2, 22,000 PrEP users)
absolute number, assumption: no self-selection bias	40,000	37,000	32,000	241,000	109,000	93,000	87,000
self-selection	6%	6%	6%	6%			
absolute number, assumption: medium self-selection bias, determined by PrEP use intention > partner numbers (variant 1)	22,000*	17,000*	27,000**	284,000	66,000	50,000	44,000
self-selection	11%	13%	7%	5%			
absolute number, assumption: medium self-selection bias, mainly determined by partner numbers > PrEP use intentions (variant 2)	20,000	15,000	17,000	298,000	52,000	36,000	30,000
self-selection	12%	15%	11%	5%			
absolute number, assumption: extreme self-selection, only determined by PrEP use intention	7,500	7,000	35,000	300,500	49,500	33,500	27,500
self-selection	31%	32%	5%	5%			

* N with intention in Table 5

** N with risk, no intention in Table 5

Table 5: Regional need distribution und unmet needs by federal states

	PrApp distribution (scenario 1)*						PlanetRomeo distribution (scenario 2)**			
	N with intention (variant 1 from Tab.4)	N with risk, no intention (variant 1 from Tab.4)	PrEP-user =15,600	% of intentional users actually using PrEP	in need of PrEP [^]	% in need with no intention (demand generation required)	PrEP-user = 21,600	% of intentional users actually using PrEP	in need of PrEP [^]	% in need with no intention (demand generation required)
Baden-Wuerttemberg	4,494	2,978	1,126	25.1%	6,346	46.9%	1,371	30.5%	6,102	48.8%
Bavaria	5,382	3,276	2,318	43.1%	6,340	51.7%	2,972	55.2%	5,686	57.6%
Berlin	6,140	4,215	3,892	63.4%	6,462	65.2%	6,356	103.5%	3,998	100.0%
Brandenburg	857	432	172	20.0%	1,117	38.7%	214	25.0%	1,074	40.2%
Bremen	392	357	87	22.3%	662	54.0%	204	52.2%	545	65.6%
Hamburg	1,614	1,355	917	56.8%	2,053	66.0%	1,318	81.6%	1,652	82.1%
Hesse	2,846	1,966	1,382	48.6%	3,430	57.3%	1,659	58.3%	3,153	62.4%
Mecklenburg-Western Pomerania	548	477	130	23.8%	895	53.3%	131	23.9%	894	53.3%
Lower Saxony	2,726	1,683	725	26.6%	3,684	45.7%	938	34.4%	3,471	48.5%
North Rhine-Westphalia	7,871	5,600	3,299	41.9%	10,171	55.1%	4,427	56.2%	9,043	61.9%
Rhineland-Palatinate	1,341	745	504	37.6%	1,582	47.1%	631	47.1%	1,454	51.2%
Saarland	471	402	115	24.3%	759	53.0%	193	41.0%	680	59.1%
Saxony	1,901	1,325	582	30.6%	2,644	50.1%	597	31.4%	2,629	50.4%
Saxony-Anhalt	668	506	105	15.6%	1,070	47.3%	170	25.4%	1,005	50.4%
Schleswig-Holstein	1,132	1,087	165	14.5%	2,054	52.9%	292	25.8%	1,927	56.4%
Thuringia	617	596	82	13.3%	1,131	52.7%	126	20.4%	1,087	54.8%
Total	39,000	27,000	15,600	40.0%	50,399	53.6%	21,600	55.4%	44,400	60.8%

* Regional distribution according to PrEP-user distribution in PrApp surveys round 2/3

** regional distribution according to PlanetRomeo preference profile-distribution early June 2020

[^] includes men with intention to use PrEP and/or with reported sexual risk minus those men already using PrEP

Discussion

We estimated absolute numbers of MSM using PrEP and their regional distribution in Germany between November 2017 and June 2020. Based on drug prescription data and self-reported PrEP use, the number of PrEP users in Germany during this period increased more than tenfold, but over time the increase appears to slow down. After an initial rapid increase in the number of PrEP users when affordable generics became available, we see a short phase of levelling off, and a second phase of rapid increase after PrEP, including associated tests, became reimbursable by statutory health insurance in Germany. The second rapid increase phase suggests that statutory health insurance reimbursement successfully removed a relevant PrEP access barrier. In 2020 we observed a second levelling-off of the increase, likely explained by behavioural adaptation to the SARS-CoV-2 (Corona- Virus) pandemic, and in some areas probably also satisfied PrEP demand. Unfortunately, only sparse data on sexual behaviour of German MSM during the SARS-CoV-2 pandemic in 2020 is available. A PlanetRomeo survey from early April 2020 with approximately 36,000 respondents from Germany showed dramatic reductions of sexual activity with non-steady partners (16). A small Facebook-survey among PrEP users conducted in May 2020, demonstrated reductions of daily PrEP use and increased on-demand use, likely reflecting a reduction of partner numbers (17).

Validity of assumptions

We want to focus now on the validity of the assumptions used for the two scenarios to estimate the total number of PrEP users in Germany:

For scenario 1 we have to discuss primarily the validity of the – PrApp-Survey derived - proportions of on-demand /intermittent use and the validity of the regional distribution, particularly the proportion of PrEP users from Berlin. For estimating proportions of on-demand/intermittent use and regional distribution of PrEP users, we used data on PrEP use from three consecutive online surveys among MSM in Germany. Usually, general health and sexual behaviour online surveys among MSM such as EMIS provide quite reliable data on proportional regional and age distribution (13-15). However, mono-thematic online surveys (such as the PrApp-Surveys) may be affected by more unpredictable participation biases, determined e.g. by unmet needs. A strong evidence for a large online survey participation bias are the very similar proportions of EMIS-2017 respondents and PlanetRomeo user profiles indicating PrEP use in November 2017 and June 2020, despite the more than tenfold increase of PrEP users (see supplemental Table S3). We tried to calibrate online survey data with PrEP use and prescription data from other sources. From these calibrations we can conclude that self-selection biases for PrEP users to participate in online surveys can be very high and can vary considerably between surveys, depending probably on various factors such as framing of the survey, recruitment methods and advertising of the survey, perceived relevance to individuals, community mobilisation around PrEP access, and competing social and health issues. In our experience, the proportion of estimated PrEP users in Germany participating in online surveys varied between 37% in 2017 and 6% of all MSM actually using PrEP in 2020 (see Tab.1). The low participation rate in spring 2020 is probably explained by a reduced intensity of recruitment activities, and the co-occurrence with Corona virus lockdowns and the overwhelming dominance of the Corona virus pandemic in public perception and discourse. It is thus conceivable that participation biases could also affect the proportions of on-demand/intermittent PrEP use reported, and be different between regions with high satisfied demand and easy access to PrEP such as Berlin, and regions with higher access barriers. This could result in disproportional lower participation of PrEP users from Berlin in the PrApp-Surveys, as well as disproportional lower participation of on-demand/intermittent PrEP users in the consecutive PrApp-Survey rounds.

The existence of such a participation bias in Berlin would reduce the discrepancy between the PrApp-Survey derived PrEP user proportion and the prescription-derived distribution and would thus be more consistent with the other explanations for these discrepancies.

For scenario 2 we have to discuss primarily the validity of the total number of PrEP user profiles. There are several reasons why the number of PrEP profiles on PlanetRomeo might overreport the number of PrEP users among PlanetRomeo users: reported safer sex preferences in PlanetRomeo profiles can be subject to reporting bias, e.g. it is possible that men already diagnosed with HIV prefer to state in their profile to take antiretroviral drugs for prevention and not for treatment. Other issues can be abandoned profiles created by, e.g., temporary visitors to an area that are used for some time and persist in the system even if these people have left the area; people creating multiple profiles; and former PrEP users not updating their profile information after they stopped using PrEP. Therefore, it might be possible that the number of online profiles located in a specific area overestimates the number of individuals with online profiles currently living in that area. In fact, an independent scientific analysis of PlanetRomeo profiles to estimate the MSM population size in Germany arrived at a number of active profiles that was considerably lower than the PlanetRomeo provided numbers (465,000 as of January 2016 vs. 643,000 as reported by PlanetRomeo in June 2020) (18). It should be noted that discrepancies mainly affected the absolute numbers and not the proportional regional distribution. It is unknown to what extent the number of PrEP user profiles would be affected by such an overestimate of PlanetRomeo profiles.

Likewise, it must be considered that not all PrEP users state their PrEP preference in their online profiles, and not all PrEP users in Germany have a PlanetRomeo profile. The question whether PrEP use is stated in their online profile was asked in the PrApp-Surveys. In the second PrApp-Survey round about one third of participating PrEP users reported not stating their PrEP use in their online profile. This would mean that the number PrEP users based on PrEP use profiles is underestimated.

We believe that the number of PrEP profiles reported from PlanetRomeo indeed overestimates the actual number of PrEP users stating this preference in their profile, however, the number is likely larger than the reported number if we accept that approximately 30% of PrEP users do not mention this in their profile. Unless we assume a very large overestimate of PrEP profiles on PlanetRomeo, this would imply that – in addition to a lower estimated average number of pills per month used by intermittent/on-demand PrEP users - other factors that are derived from the PrApp-Surveys such as the proportion of on-demand/intermittent users and/or the proportion of self-payers might be biased.

Regional distribution of PrEP users

Our regional distribution estimates reveal a distinct discrepancy regarding the number and proportion of PrEP users in Berlin between different data sources, most pronounced between PrApp-Survey data and prescription data.

In the prescription data, prescriptions are allocated to the geographical area of the prescribing care provider. This results in well-known geographical biases for HIV drug prescription data, since people living in rural areas usually attend HIV specialists in urban centres for HIV treatment as well as for PrEP prescription. This bias increases particularly the prescription data for Berlin and Hamburg, and decreases prescription data in the surrounding federal states Schleswig-Holstein, Lower Saxony, Mecklenburg-Western Pomerania, Brandenburg, Saxony-Anhalt, and Thuringia. However, if we assume that the discrepancy between the proportion of PrEP users in the PrApp-Survey and the prescription data is fully explained by this bias, we would have to assume large shifts from other federal states to Berlin to obtain prescriptions there. This is not impossible, but the extent appears implausible. We find it more plausible that the difference between the PrApp-Survey and prescription data-derived regional distribution for Berlin is explained by a combination of drug prescription shift to Berlin and a disproportional self-selection bias of PrEP users from Berlin in the PrApp-Survey. This could be the case if we assume that the comparatively high levels of satisfied PrEP need reached in Berlin would negatively impact the participation rate in a monothematic PrEP-focussed survey.

Thus, we believe it is likely that neither prescription data nor the PrApp-survey data represent the proportion of PrEP users living in Berlin correctly. The proportion observed in the PlanetRomeo PrEP profiles might be closer to the real distribution than PrApp-Survey and drug prescription data. This would also affect our estimates on satisfied PrEP needs. We presented two estimates, one based on a PrApp-survey-derived regional distribution and the other based on the PlanetRomeo PrEP profile distribution. A higher proportion of PrEP users in Berlin increases the proportion of satisfied PrEP needs in Berlin even further.

Another possible reason for unreliability of regional distribution of drug prescription data is the inability to distinguish between prescriptions for HIV treatment and prescriptions for PrEP use. As described, to account for PrEP prescriptions we designated excess prescriptions of TDF/FTC from the third quarter 2019 onwards assuming no relevant changes in the amount of TDF/FTC used for HIV treatment. If TDF/FTC use in HIV treatment developed differently in some regions this would affect the regional distribution.

Self-selection biases

If our assumptions on self-selection biases are correct, different self-selection biases in countries with different social and political contexts must be considered for multi-country surveys such as EMIS, which would have consequences for comparability of estimates for PrEP use and PrEP needs across countries (19).

It is also difficult to estimate the self-selection biases for survey participants intending to use PrEP or “in need of PrEP” based on number of reported sex or CAI partners in the last 12 months. There are indications that sexual activity is an important factor contributing not only to perceived PrEP need, but also to self-selection for survey participation, suggesting that higher sexual activity is associated with a higher probability for survey participation. One aspect of this self-selection is the probability of seeing a survey recruitment message on a dating app. One of the apps we used for recruitment broadcasted each survey advertisements only for a period of 24 hours. That means that frequent app users would have had a higher chance to see this message than infrequent users. This needs to be considered when extrapolating absolute numbers of PrEP users, intentional PrEP users, and men “in need of PrEP” based on their sexual risks, to the total MSM population of a country from proportions found in online surveys. In addition, other observations on the EMIS data suggest self-selection biases with increased sexual activity: e.g. the comparison of self-reported syphilis diagnoses in the last 12 months with syphilis cases among MSM reported to the German infectious disease surveillance system suggests a threefold higher probability that men diagnosed with syphilis had participated in the survey compared to a random distribution. In the absence of an established method to estimate survey participation biases, the estimates based on sexual activity we chose are arbitrary, yet plausible. For this reason, we reported ranges with a minimum and a maximum estimated number.

A sizeable fraction of MSM indicated an intention to use PrEP if PrEP were available and affordable in a country, but did not report sexual risks defined as two or more non-steady CAI partners in the previous 12 months. These may be men who have been able to effectively manage risks, e.g. by using condoms, but who would consider switching to PrEP use as alternative or additional risk management strategy if PrEP became available to them. Due to this group of men who would consider using PrEP, but who have also been able to manage their HIV risks effectively by using condoms, it is inherently difficult to estimate PrEP needs. We can show that this group of men with PrEP use intention and low risk reported in the past is not very different in terms of sexual partner numbers and HIV test uptake from the large group of men with no PrEP use intention and low reported risk (see Fig.S1). The groups with intention to use PrEP differ from the groups not intending to use PrEP by a slightly higher awareness of PrEP (see Table 3). How many of the men will use PrEP will likely depend on circumstances such as how convenient access to and monitoring of PrEP is, how PrEP use is advertised, how PrEP use is perceived by the gay community, how people assess risks and adverse effects of PrEP use for themselves, how satisfied these men are with the quantity and quality of the sex they have, and their expectations how this would change if they take PrEP. In addition, the size of this group may increase as PrEP knowledge and awareness is increasing in the MSM population.

PrEP need estimates

With our approach to estimate PrEP-needs in Germany we arrive at estimates of approximately 52,000 (variant 2) to 66,000 (variant 1) MSM currently in need of PrEP, of which approximately 16,000 (PrApp-Survey scenario) to 22,000 (Romeo scenario) were taking PrEP as of June 2020. The estimated number of PrEP need is close to the actual estimated number of MSM diagnosed with HIV in Germany (20) and would be equivalent to 7.5% of the estimated total MSM population aged 18-65, or 15% of the openly gay population aged 18-65.

The proportion of MSM with intention to use PrEP in 2017 that is using PrEP in 2020 may vary between approximately 63% and 104% in Berlin (104% would mean that more people took PrEP in Berlin in June 2020 than people indicating PrEP use intention in 2017) and is below or around 20% in the federal states with the lowest coverage. This suggests marked regional differences and persistent barriers to access PrEP for people who intend to use PrEP.

One possible barrier after costs were covered by health insurance would be limited access to health care providers licensed to prescribe PrEP covered by health insurance, either due to geographic distance, limited number of prescribers, or inconvenience associated with scheduling an appointment, or due to individual barriers like fear to discuss safer sex or sex in general with a health care provider, or lack of perceived social support for taking PrEP (21).

For MSM in Germany, taking up HIV PrEP requires to out oneself towards a health care provider, just like for other medical interventions such as HIV testing. Thus, factors identified as barriers to uptake of regular HIV testing among MSM in Germany such as problems identifying and making appointments with a gay-friendly health care service, not feeling comfortable with being out about their own sexual orientation towards friends, family members, and co-workers, or not feeling at risk for HIV due to perceived familiarity with sex partners will likely play a similar role for HIV PrEP uptake (22). Particularly the problem identifying and making appointments with a gay-friendly health care service are likely to play a major role since the number of services providing PrEP prescriptions is much smaller than the number of services providing HIV testing. This assumption is supported by the strong correlation between satisfied PrEP needs and number of HIV specialists at federal state level. This correlation is exacerbated by the practical difficulties of getting PrEP prescriptions experienced by men not living in or near the largest cities, where most of the HIV specialists work. While the skewed geographical distribution of HIV specialists appears to have no major impact on access to treatment for HIV, this skewed distribution still appears to be a major barrier for accessing drugs for prophylaxis. This assumption regarding PrEP uptake in Germany is supported by a similar analysis of the French EMIS-2017 dataset which concludes: "(PrEP-)Eligible MSM who are not using PrEP are mostly younger, students, less "out", living in small cities, using condoms more frequently but still with low self-efficacy regarding safe sex and more distant from preventive health care and information than PrEP users. Despite free PrEP availability in France, results suggest that PrEP is not fully accessible and that there is a need to increase PrEP demand and decentralize PrEP delivery" (23).

If we consider MSM who might benefit but are currently not taking PrEP, a proportion of almost 50% of them may not have had an intention to use PrEP when asked in 2017. For informed decision making, these men may need balanced and targeted information on PrEP. They may benefit from being offered PrEP proactively and from opportunities to discuss advantages and disadvantages of taking PrEP. This would require a pro-active approach including sexual history taking by health care providers and HIV test counsellors to actively provide this information and might encourage demand by MSM who likely benefit from PrEP.

Limitations

There are several limitations to our data sources and consequently to our analysis: the self-selection bias of men intending to use PrEP if available and affordable to participate in online surveys is unknown, and our attempts to estimate this bias can be biased by halo effects. When estimating met and unmet needs for PrEP, we combine data collected by the end of 2017 with data collected in 2020. The population indicating intention to use PrEP may have changed during this time due to increased awareness of and empirical experience with PrEP use. Grouping survey participants based on reported sexual risks such as CAI is subject to recall and social desirability biases.

The extent and number of individuals with on-demand/intermittent PrEP use is difficult to estimate based on our data. The PrApp-Surveys asked for the number of pills taken per month in categories (e.g. 1-11 pills/month) and in months when PrEP was used, not collecting information on the frequency and duration of PrEP use episodes. As these parameters remain unknown, the number of intermittent or on-demand PrEP users that can be supported by a full monthly PrEP dose remains uncertain. To address this uncertainty, we calculated the impact of different assumptions in our sensitivity analyses.

Conclusions

PrEP use in Germany has increased considerably between October 2017 and June 2020, but large regional inequalities persist. Outside of metropolitan areas the proportion of people with unsatisfied PrEP needs is high, which correlates to a lower density of physicians able to prescribe health insurance-covered PrEP. Thus, access to PrEP in rural areas needs to be addressed in the future. In the largest cities with already relatively high PrEP uptake, encouraging demand for PrEP among men with high sexual risks and no intention to use PrEP will be necessary to take full advantage of the preventive effects of PrEP.

Declarations

Ethics approval and consent to participate

EMIS-2017 received a favourable ethical opinion from the Observational Research Ethics Committee at the London School of Hygiene and Tropical Medicine (review reference 14421 /RR/8805) on 31 July 2017.

The **PrApp study** was approved by the ethics commission of the Berlin Chamber of Physicians (Ref: Eth-14/18). All participants had to provide informed consent before starting the survey.

Consent for publication

Not applicable.

Availability of data and materials

Most data generated or analysed during this study are included in this published article and its supplementary information files.

The remaining data that support the findings of this study are available from the London School of Hygiene and Tropical Medicine but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the London School of Hygiene and Tropical Medicine.

Competing interests

UK owns 'Exchange-traded fund' (ETF) shares, which may include stocks of pharmaceutical companies that produce or develop PrEP. The other authors declare that they have no competing interests.

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Authors' contributions

U.M. and S.B.S. contributed and analysed data from EMIS-2017, D.S. contributed and analysed drug prescription data, U.K. contributed data from the PrApp study. U.M. wrote the first draft of the main manuscript and prepared tables and figures, all authors contributed to consecutive drafts and reviewed the final manuscript.

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Figures

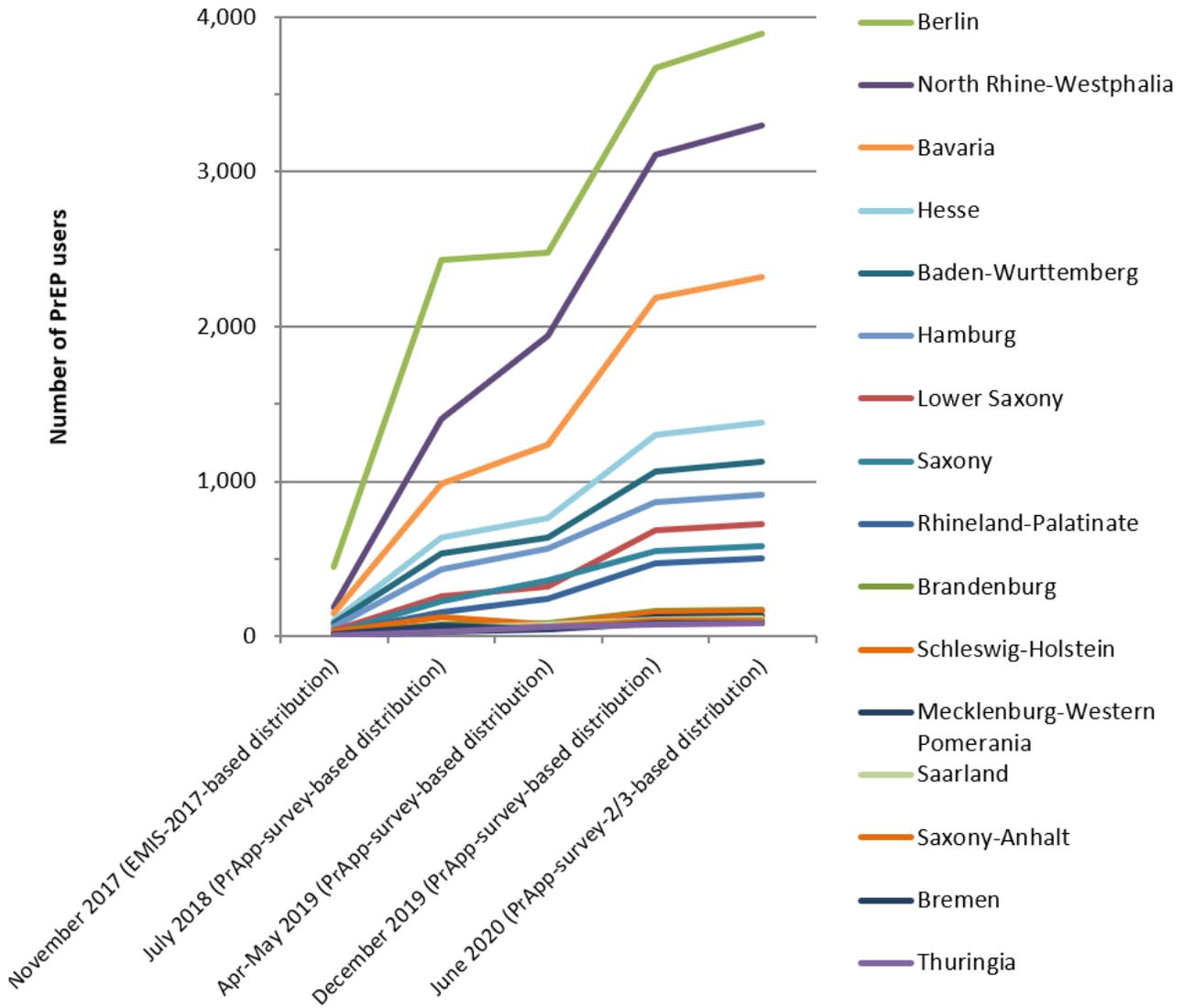


Figure 1

Number of PrEP Users

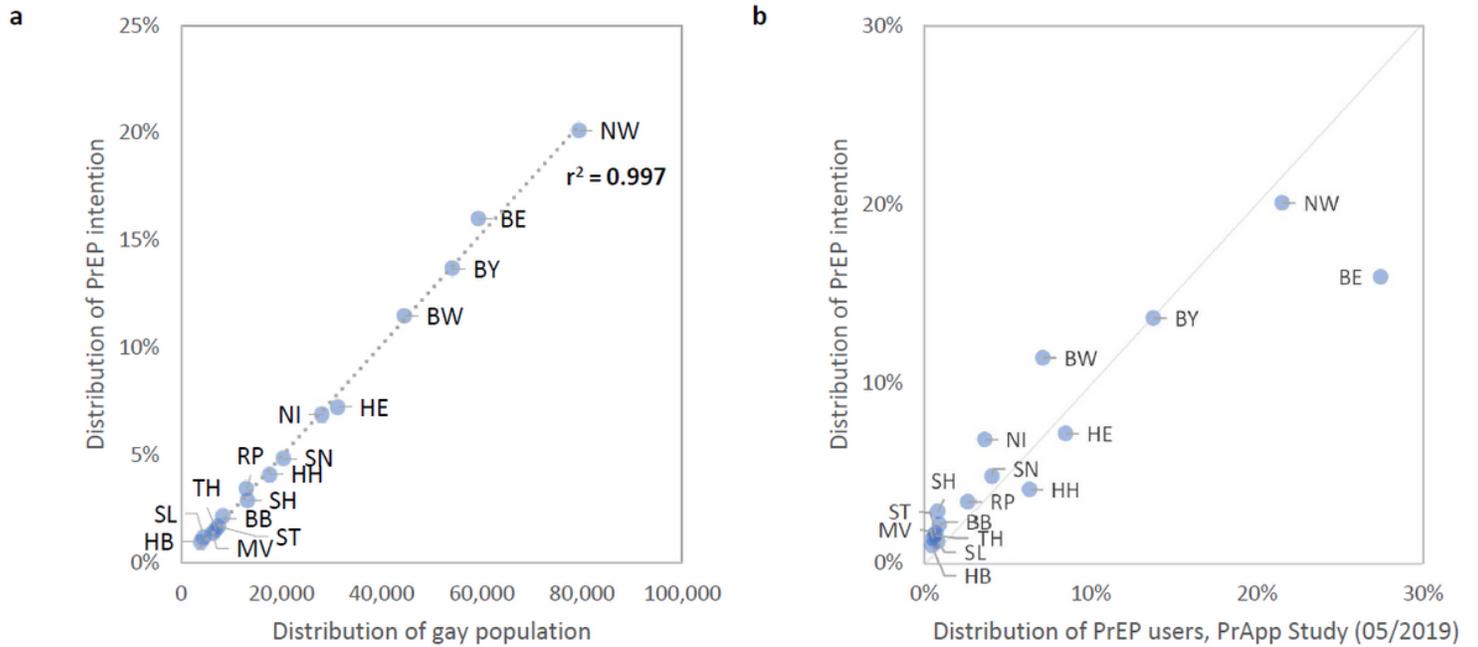


Figure 3

a) Correlation between the regional distribution of PrEP use intention in 2017 and the regional distribution of the gay population in Germany; b) Correlation between regional distribution of PrEP use intention in 2017 and PrEP use as indicated by the PrApp Study in 05/2019. BW: Baden-Wurttemberg, BY: Bavaria, BE: Berlin, BB: Brandenburg, HB: Bremen, HH: Hamburg, HE: Hesse, MV: Mecklen-burg-Western Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, SH: Schleswig-Holstein, TH: Thuringia.

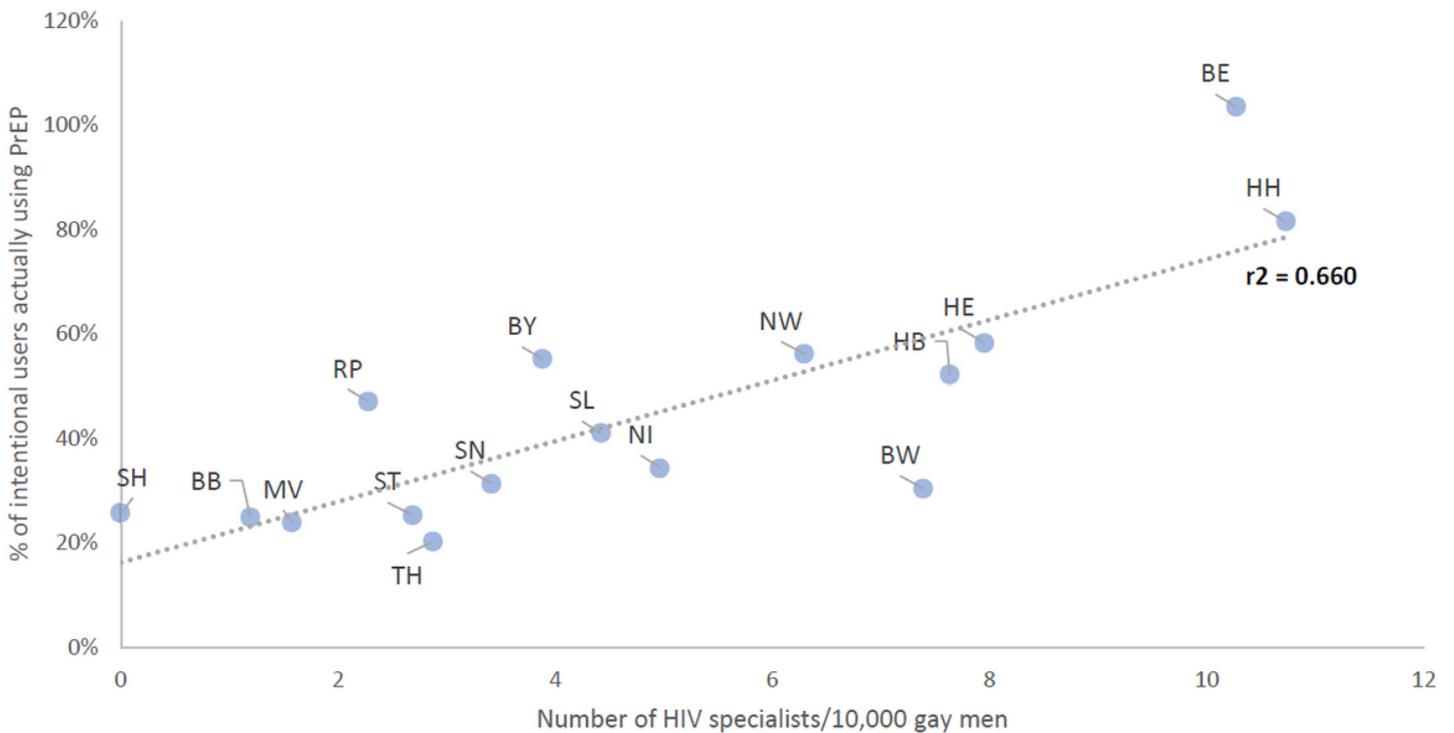


Figure 4

Correlation between the number of PrEP prescribers per 10,000 gay population by federal state and PrEP needs met as estimated using scenario 2 PrEP user estimate and variant 1 PrEP need estimate. BW: Baden-Wurttemberg, BY: Bavaria, BE: Berlin, BB: Brandenburg, HB:

Bremen, HH: Hamburg, HE: Hesse, MV: Mecklen-burg-Western Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, SH: Schleswig-Holstein, TH: Thuringia.

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