

Estimating national rates of HIV infection among MSM, persons who inject drugs, and heterosexuals in the United States

Nicole Crepaz, Kristen L. Hess,
David W. Purcell and H. Irene Hall

Background: Calculating national rates of HIV diagnosis, incidence, and prevalence can quantify disease burden, and is important for planning and evaluating programs. We calculated HIV rates among MSM, persons who inject drugs (PWID), and heterosexuals in 2010 and 2015.

Methods: We used proportion estimates of the US population classified as MSM, PWID, and heterosexuals along with census data to calculate the population sizes which were used as the denominators for calculating HIV rates. The numerators (HIV diagnosis, incidence, and prevalence) were based on data submitted to the National HIV Surveillance System through June 2017.

Results: The estimated HIV diagnosis and incidence rates in 2015 were 574.7 and 583.6 per 100 000 MSM; 34.3 and 32.7 per 100 000 PWID; and 4.1 and 3.8 per 100 000 heterosexuals. The estimated HIV prevalence in 2015 was 12 372.9 per 100 000 MSM; 1937.2 per 100 000 PWID; and 126.7 per 100 000 heterosexuals. The HIV diagnosis rates decreased from 2010 to 2015 in all three transmission categories. Black individuals had the highest HIV diagnosis rates at both time points. The HIV incidence rates decreased among white MSM, MSM aged 13–24 years, PWID overall, and male and female heterosexual individuals; however, it increased among MSM aged 25–34 years.

Conclusions: The estimated HIV diagnosis and HIV infection rates decreased for several transmission categories, and also race/ethnicity and age subgroups. MSM continue to be disproportionately affected. Disparities remain and have widened for some groups. Efforts are needed to strengthen prevention, care, and supportive services for all persons with HIV infection.

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Introduction

Calculating national rates of HIV infection can quantify the burden of disease and is particularly important for planning and evaluating programs, and guiding resource allocation. HIV incidence measures the number of new infections during a specific time (e.g. year). Estimated HIV incidence rates can be used to assess characteristics of

persons most at risk for acquiring HIV infection. HIV diagnoses refer to the number of persons who may have been infected at any time, from years before up to the year when the diagnosis was made. HIV diagnosis rates reflect the trends in HIV incidence and access to HIV testing, and can be used to partially monitor HIV-testing efforts. HIV prevalence refers to the number of persons living with HIV at a given time regardless of the time of

Division of HIV/AIDS Prevention, the U.S. Centers for Disease Control and Prevention, Atlanta, Georgia, USA.

Correspondence to Nicole Crepaz, Division of HIV/AIDS Prevention, The U.S. Centers for Disease Control and Prevention, 1600 Clifton Rd., Mailstop E-37, Atlanta, GA 30329, USA.

Tel: +1 404 639 6149; e-mail: ncrepaz@cdc.gov

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infection or whether the person has received a diagnosis. Estimated HIV prevalence rates can be used to monitor the number of persons in need of care and treatment services for HIV infection.

At present, census data are not available to determine HIV rates for different groups at risk of HIV infection such as MSM, person who inject drugs (PWID), or heterosexuals, and such rates are therefore not routinely reported [1]. Using data from national surveys, the Centers for Disease Control and Prevention (CDC) developed an approach to estimate the proportions of the US population classified as MSM, PWID, and heterosexuals, and applied the proportion estimates to census data to produce population sizes for these three transmission categories [2–4]. National HIV infection rates can then be calculated using national HIV surveillance data for the numerators and the population size estimates for the denominators [2–4].

The purpose of this study was to update estimated HIV diagnosis rates [2–4] and, for the first time, to estimate and compare the rates of HIV incidence, for 2010 and 2015 among MSM, PWID, and heterosexuals. The rates of persons living with diagnosed and undiagnosed HIV infection (i.e. HIV prevalence) were also estimated for 2015. These analyses allow cross-group comparisons at different times to inform progress toward meeting the national goal of reducing health disparities [5].

Methods

We calculated three types of HIV rates for persons aged 13 years or older: diagnosis rates in 2010 and 2015; incidence rates in 2010 and 2015; and prevalence rate in 2015. The MSM, PWID, and heterosexual classifications were created to best correspond to the HIV transmission categories presented in the national HIV surveillance report [1]. Transmission category summarizes a person's possible HIV risk factors based on the presumed hierarchical order of transmission probability. Persons with more than one reported risk factor are classified in the category listed first in the hierarchy (for men, male-to-male sexual contact, injection drug use, heterosexual contact; for women, injection drug use and heterosexual contact) [1]. One exception is MSM who inject drugs; this group makes up a separate transmission category [1].

The numerators: HIV diagnosis, incidence, and prevalence

We used national HIV surveillance system (NHSS) data from all 50 States and the District of Columbia (DC) reported to CDC as of June 2017. All jurisdictions had fully implemented name-based HIV reporting by April 2008. CDC periodically assesses the portfolio of NHSS to determine whether methods and efficiencies in data

collection and analysis meet the information needs of the nation. Due to the improvement of data quality over the years, in 2016, CDC determined that the adjustments for reporting delays were no longer necessary [6]. We used data reported through June 2017 for year 2015 to allow reporting of diagnoses and especially deaths, for which 18 months reporting delay is needed to allow time for matching HIV surveillance data with vital statistics data [1]. Some cases of HIV infection were reported to CDC without an identified risk factor [1]. Multiple imputation was used to assign a transmission category [7].

The number of HIV diagnoses in 2010 and 2015 were the cases reported to NHSS (<https://www.cdc.gov/nchhstp/atlas/>). The HIV incidence and prevalence were estimated based on a well characterized CD4⁺-depletion model [8–10]. Because HIV targets CD4⁺ cells, without treatment, HIV reduces the number of CD4⁺ cells. Using the first CD4⁺ cell count after diagnosis and the estimated depletion of CD4⁺ cells over time, the time between infection and diagnosis can be estimated with the assumption that no treatment has been received [8]. Based on the estimated time from HIV infection to diagnosis, the diagnosis delay distribution can be calculated, which is then used for estimating HIV incidence. Cumulative HIV incidence minus cumulative deaths among persons with HIV yields an estimate of prevalence, the total number of persons with diagnosed and undiagnosed HIV infections [8]. Similar CD4⁺ models have been used in estimating HIV incidence and prevalence in the European Union/European Economic Area [11,12].

The denominators: estimated population sizes for MSM, persons who inject drugs, and heterosexuals in the United States

We used the previously published estimates of proportions of the US population classified as MSM [2], PWID [3], and heterosexuals [4] (see Appendix A, <http://links.lww.com/QAD/B414>) to calculate the population sizes for these three transmission categories. The previously published proportion estimates were derived from meta-analyses of national probability surveys across multiple years and were not stratified by year. For our analyses, the proportion estimates were assumed to remain the same for 2010 and 2015. While the proportions of the US population classified as MSM, PWID, and heterosexuals were estimated based on multiple national surveys, the proportion estimate for MSM who inject drugs was only based on a single national survey – National Health and Nutrition Examination Survey (NHANES) [13]. According to the NHANES data from 1999 to 2008, 0.35% [confidence interval (CI) 0.18–0.52] of males aged at least 18 years old were MSM who inject drugs [13]. Due to the limitation of a single survey for estimating the proportion of MSM who inject drugs and the small number of HIV

cases among this group, they were excluded from the analyses.

To calculate the population sizes, we applied the proportion estimates for MSM, PWID, and heterosexuals to the population data for 2010 and 2015 obtained from the Vintage 2016 postcensal estimates from the US Census Bureau. The estimated population sizes were used as the denominators for calculating the HIV prevalence rates. For HIV diagnosis rates, the denominators for 2010 and 2015 were calculated by subtracting the number of persons who were living with diagnosed HIV infection at year-end 2009 and 2014, respectively, from the population estimates. For HIV incidence rates, the denominators for 2010 and 2015 were calculated by subtracting the number of persons who were living with diagnosed and undiagnosed HIV infection at year-end 2009 and 2014, respectively, from the population estimates.

Analyses for rates of HIV diagnosis, incidence, and prevalence for MSM, persons who inject drugs, and heterosexuals in the United States

We calculated HIV diagnosis rates in 2010 and 2015 stratified by race/ethnicity and age groups for MSM, PWID, and heterosexuals. For the rates of HIV incidence and prevalence, the race/ethnicity and age-specific stratifications were conducted only for MSM. Relative standard errors were greater than 30%, indicating low reliability of estimated HIV incidence and prevalence rates for the race/ethnicity and age-specific stratifications of PWID and heterosexuals. Thus, we only reported the rates of HIV incidence and prevalence by sex and not by race/ethnicity and age for PWID and heterosexuals.

All rates were calculated per 100 000 population. Uncertainties associated with the estimated numerators and denominators were calculated using the delta method to derive the standard error for calculating the 95% CIs for estimated rates [14]. We also calculated rate ratios to directly compare rates by transmission category, sex, race/ethnicity, and age. For rate ratios, men, whites, and the youngest age group (13–24 years) served as the referent groups. Differences in estimated rates for the years 2010 (referent group) and 2015 were assessed by the z test. Differences were deemed statistically significant at P less than 0.05. For transparent reporting, the percentage of increase or decrease and associated P value were presented.

Results

Estimated HIV diagnosis rates in 2010 and 2015

The estimated HIV diagnosis rates decreased from 2010 to 2015 for all three transmission categories: MSM: 587.8 and 574.7 per 100 000, respectively (-2.2% ; $P=0.012$); PWID: 52.4 and 34.3 per 100 000, respectively (-34.5% ; $P<0.0001$); and heterosexuals: 5.5 and 4.1 per 100 000,

respectively (-24.5% ; $P<0.0001$) (Table 1). Rate ratio comparing MSM to PWID was 11 times as high in 2010 and 17 times as high in 2015, whereas rate ratio comparing MSM to heterosexuals was 107 times as high in 2010 and 140 times as high in 2015.

Among MSM, the highest HIV diagnosis rates were among non-Hispanic blacks/African Americans (hereafter referred to as blacks) at both time points, and the rate increased from 2190.5 in 2010 to 2269.2 in 2015 ($+3.6\%$; $P=0.019$). The HIV diagnosis rate among Hispanic/Latino MSM also increased (944.1 in 2010 and 995.3 in 2015; $+5.4\%$; $P=0.003$). Comparing black MSM to white MSM, the HIV diagnosis rate was about eight times as high in 2010 and nine times as high in 2015. Comparing Hispanic/Latino MSM to white MSM, the HIV diagnosis rate was three times as high in 2010 and four times as high in 2015. MSM who were 25–34 years old had the highest rates of HIV diagnosis at both time points. The HIV diagnosis rates increased from 2010 to 2015 for MSM aged 13–24 and 25–34 years ($+4.5\%$ and $+18.1\%$; both $P<0.001$), whereas the HIV diagnosis rates decreased for the older age groups (35–44 years: -22.6% ; 45–54 years: -7.2% ; 55 years and older: -9.8% ; all $P<0.01$).

Among PWID, the HIV diagnosis rates decreased 35.6% for men (45.0 in 2010 and 28.9 in 2015; $P<0.0001$) and 33.1% for women (70.0 in 2010 and 46.8 in 2015; $P<0.0001$). The highest rates in 2010 and 2015 were among black PWID. The HIV diagnosis rates decreased in both sexes among black PWID, Hispanic/Latino PWID, and PWID of other races. However, the HIV diagnosis rate increased among white male PWID ($+18.7\%$; $P=0.015$). For female PWID, HIV diagnosis rates increased ($+15.4\%$), although this was not found to be statistically significant ($P=0.056$). Comparing black male PWID to white male PWID, the HIV diagnosis rate was 17 times as high in 2010 and six times as high in 2015. Comparing black female PWID to white female PWID, the rate was 11 times as high in 2010 and four times as high in 2015. The differences in HIV diagnosis rates in 2010 and 2015 were also narrowing when comparing Hispanic/Latino PWID to white PWID for both sexes. Among PWID by age groups, the diagnosis rates decreased among age groups older than 35 years (all $P<0.001$), but remained stable for persons aged 13–24 and 25–34 years for both men and women.

Among heterosexuals, the HIV diagnosis rates decreased 24.4% for both men (3.8 in 2010 and 2.9 in 2015; $P<0.0001$) and women (6.9 in 2010 and 5.2 in 2015; $P<0.0001$). The highest rates in 2010 and 2015 were among black heterosexuals. Comparing black male heterosexuals to white male heterosexuals, the diagnosis rate was 33 times as high in 2010 and 29 times as high in 2015. Comparing black female heterosexuals to white female heterosexuals, the diagnosis rate was 27 times as

Table 1. Estimated rates of HIV diagnosis among MSM, persons who inject drugs (PWID), and heterosexuals, by selected characteristics and years (2010 and 2015).

	2010						2015						P value of z test: rate 2010 = rate 2015
	Reported HIV diagnosis	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate	Upper 95% confidence interval for estimated rate	Rate ratio	Reported HIV diagnosis	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate	Upper 95% confidence interval for estimated rate	Rate ratio	
MSM	26 277	4 470 442	587.8	515.7	661.8	Referent	26 459	4 604 040	574.7	503.1	648.5	Referent	0.012
Race/ethnicity													
White	8550	3 045 320	280.8	247.2	315.0	Referent	7447	3 063 852	243.1	213.8	272.9	Referent	0.000
Hispanic ^a	6285	665 698	944.1	824.7	1067.8	3.4	7265	729 936	995.3	866.7	1129.2	4.1	0.003
Black	9780	446 461	2190.5	1886.1	2515.2	7.8	10129	446 395	2269.2	1935.4	2632.3	9.3	0.019
Other ^b	1662	312 962	531.0	466.7	596.8	1.9	1618	363 857	444.8	390.6	500.4	1.8	0.000
Age at diagnosis, years													
13–24	6932	1 018 299	680.8	602.2	760.1	Referent	7231	1 016 031	711.7	629.2	795.1	Referent	0.009
25–34	7748	746 909	1037.3	911.0	1166.7	1.5	9525	777 711	1224.7	1071.5	1382.9	1.7	0.000
35–44	5844	674 552	866.3	752.5	985.5	1.3	4566	681 098	670.4	584.0	760.4	0.9	0.000
45–54	4158	723 203	575.0	498.7	655.2	0.8	3521	659 871	533.6	459.6	612.5	0.7	0.002
55 and above	1595	1 307 479	122.0	107.5	136.7	0.2	1617	1 469 330	110.0	96.6	123.8	0.2	0.006
PWID	3421	6 532 822	52.4	41.1	76.3	Referent	2347	6 844 304	34.3	26.9	49.9	Referent	0.000
Male PWID	1987	4 420 771	45.0	33.6	68.1	Referent	1343	4 640 587	28.9	21.6	43.8	Referent	0.000
Race/ethnicity													
White	409	3 129 365	13.1	10.1	18.4	Referent	492	3 173 651	15.5	12.0	21.8	Referent	0.015
Hispanic/Latino ^a	501	421 476	118.7	84.1	201.8	9.1	330	476 541	69.2	49.1	117.0	4.5	0.000
Black	986	449 148	219.5	154.9	376.6	16.8	465	485 733	95.8	67.8	162.9	6.2	0.000
Other ^b	92	194 694	47.4	28.5	141.4	3.6	57	228 890	24.8	14.9	73.4	1.6	0.000
Age at diagnosis, years													
13–24	105	478 086	21.9	15.1	39.4	Referent	119	479 327	24.8	17.1	44.6	Referent	0.420
25–34	337	700 456	48.1	32.0	91.3	2.2	349	753 359	46.4	30.9	87.9	1.9	0.656
35–44	494	820 557	60.2	47.2	82.8	2.8	288	817 119	35.3	27.7	48.4	1.4	0.000
45–54	655	805 285	81.4	63.8	108.1	3.7	327	780 615	41.9	32.9	55.5	1.7	0.000
55 and above	397	1 207 532	32.8	26.0	42.8	1.5	260	1 388 544	18.7	14.8	24.5	0.8	0.000
Female PWID	1434	2 048 831	70.0	55.7	103.0	Referent	1004	2 142 676	46.8	37.3	68.9	Referent	0.000
Race/ethnicity													
White	409	1 375 357	29.7	26.4	34.0	Referent	475	1 386 005	34.3	30.4	39.2	Referent	0.056
Hispanic/Latino ^a	203	121 433	166.9	114.0	241.7	5.6	139	139 308	99.8	68.4	143.8	2.9	0.000
Black	726	217 026	334.7	191.1	1344.6	11.3	339	232 801	145.4	83.5	562.6	4.2	0.000
Other ^b	96	120 991	79.6	60.5	116.4	2.7	51	141 976	35.9	27.3	52.4	1.0	0.000
Age at diagnosis, years													
13–24	150	252 933	59.1	53.7	73.9	Referent	122	253 492	48.0	43.6	60.0	Referent	0.135
25–34	305	240 862	126.5	108.1	152.4	2.1	294	257 720	114.0	97.5	137.1	2.4	0.273
35–44	356	396 544	89.7	71.2	130.3	1.5	227	396 896	57.2	45.5	82.5	1.2	0.000
45–54	436	343 545	126.9	100.2	190.1	2.1	218	328 994	66.1	52.3	99.0	1.4	0.000
55 and above	188	494 885	38.0	28.4	57.6	0.6	144	556 222	25.9	19.2	39.4	0.5	0.007
Heterosexuals	12 138	222 097 551	5.5	5.3	5.6	Referent	9588	232 249 608	4.1	4.0	4.3	Referent	0.000
Male heterosexuals	4025	105 097 858	3.8	3.7	4.0	Referent	3187	110 119 938	2.9	2.8	3.0	Referent	0.000
Race/ethnicity													
White	477	70 148 872	0.7	0.6	0.7	Referent	407	71 123 727	0.6	0.5	0.6	Referent	0.021
Hispanic/Latino ^a	755	16 446 928	4.6	4.5	4.7	6.8	595	18 471 966	3.2	3.2	3.3	5.6	0.000
Black	2604	11 573 257	22.5	20.8	24.4	33.1	2048	12 361 211	16.6	15.3	18.0	28.9	0.000
Other ^b	189	6 917 611	2.7	2.6	2.9	4.0	138	8 098 828	1.7	1.6	1.8	3.0	0.000
Age at diagnosis, years													
13–24	284	18 658 588	1.5	1.4	1.6	Referent	260	18 704 146	1.4	1.3	1.5	Referent	0.321
25–34	767	18 408 479	4.2	4.1	4.2	2.7	702	19 765 031	3.6	3.5	3.6	2.6	0.003
35–44	1105	18 152 989	6.1	5.8	6.4	4.0	770	17 933 380	4.3	4.1	4.5	3.1	0.000
45–54	1150	19 456 641	5.9	5.7	6.1	3.9	767	18 673 426	4.1	4.0	4.2	3.0	0.000
55 and above	720	31 470 376	2.3	2.2	2.4	1.5	688	36 403 394	1.9	1.8	2.0	1.4	0.001

Table 1 (continued)

	2010					2015					P value of z test: rate 2010 = rate 2015			
	Reported HIV diagnosis	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate	Upper 95% confidence interval for estimated rate	Rate ratio	Reported HIV diagnosis	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate		Upper 95% confidence interval for estimated rate	Rate ratio	
Female heterosexuals	8112	117 295 434	6.9	6.7	7.1	Referent	6401	122 425 509	5.2	5.1	5.4	Referent	0.000	
Race/ethnicity														
White	1053	77 852 474	1.4	1.3	1.4	Referent	961	78 451 182	1.2	1.2	1.3	Referent	0.034	
Hispanic/Latino ^a	1315	16 669 886	7.9	7.8	8.0	5.8	1052	18 917 114	5.6	5.5	5.6	4.5	0.000	
Black	5310	14 498 861	36.6	36.0	37.3	27.1	4075	15 343 100	26.6	26.1	27.1	21.7	0.000	
Other ^b	434	8 208 715	5.3	5.1	5.5	3.9	313	9 583 524	3.3	3.1	3.4	2.7	0.000	
Age at diagnosis, years														
13–24	1327	18 287 439	7.3	6.9	7.6	Referent	945	18 305 011	5.2	4.9	5.4	Referent	0.000	
25–34	2127	19 385 424	11.0	10.6	11.3	1.5	1686	20 599 385	8.2	7.9	8.5	1.6	0.000	
35–44	2074	19 576 132	10.6	10.3	10.9	1.5	1542	19 323 097	8.0	7.7	8.2	1.5	0.000	
45–54	1665	20 937 895	8.0	7.4	8.6	1.1	1300	19 996 105	6.5	6.0	7.1	1.3	0.000	
55 and above	919	39 797 564	2.3	2.2	2.4	0.3	928	45 219 313	2.1	2.0	2.2	0.4	0.016	

PWID, persons who inject drugs.

^aHispanic/Latino can be of any race.

^bOther race/ethnicity category includes American Indian/Alaska Native, Asian, Native Hawaiian/other Pacific Islander, and multiple races.

high in 2010 and 22 times as high in 2015. With regard to age groups, male heterosexuals aged 35–44 years and female heterosexuals aged 25–34 years had the highest HIV diagnosis rates. The HIV diagnosis rates decreased among all racial/ethnic groups and age groups, except heterosexual men aged 13–24 years who had a stable HIV diagnosis rate.

Estimated HIV incidence rates in 2010 and 2015

The estimated HIV incidence rates in 2010 and 2015 were 605.0 and 583.6 per 100 000 MSM; 43.0 and 32.7 per 100 000 PWID; and 5.0 and 3.8 per 100 000 heterosexuals (Table 2). The rate ratios indicated substantial disparities between MSM and PWID, and MSM and heterosexuals. Comparing MSM to PWID, the HIV incidence rate was 14 times as high in 2010 and 18 times as high in 2015. Rate ratio comparing MSM to heterosexuals was 121 times as high in 2010 and 154 times as high in 2015.

The estimated HIV incidence rate was stable for MSM overall (–3.5%; $P=0.373$). However, it decreased among white MSM (–14.1%; $P=0.024$). Blacks had the highest HIV incidence rates at both time points, and the incidence rate remained stable (–2.2%; $P=0.747$). For Hispanic MSM, the HIV incidence rate increased (+10.6%), although this was not found to be statistically significant ($P=0.201$). Comparing black MSM to white MSM, the HIV incidence rate was about nine times as high in 2010 and 10 times as high in 2015. The rate ratio comparing Hispanic/Latino MSM to white MSM was four times as high in 2010 and five times as high in 2015. MSM 25–34 years old had the highest rates of HIV incidence at both time points, followed by MSM who were 13–24 years old. In contrast to the diagnosis rate, the HIV incidence rate decreased among MSM aged 13–24 years (–21.9%; $P<0.01$). However, similar to the diagnosis rate, the incidence rate increased among MSM aged 25–34 years (+27.8%; $P<0.0001$).

Among PWID, the overall estimated HIV incidence rate decreased (–23.9%; $P=0.03$). Comparing female to male PWID, the HIV incidence rates were approximately 1.5 times as high in 2010 and in 2015.

Among heterosexuals, the estimated HIV incidence also decreased overall (–24.7%; $P<0.0001$), and for men (–26.5%; $P=0.026$) and women (–23.8%; $P<0.0001$). Comparing female to male heterosexuals, the HIV incidence rates were approximately two times as high in 2010 and in 2015.

Estimated HIV prevalence rates in 2015

The estimated rates of HIV prevalence in 2015 were 12 372.9 per 100 000 MSM; 1937.2 per 100 000 PWID; and 126.7 per 100 000 heterosexuals (Table 3). The estimated HIV prevalence rate among MSM was six times

Table 2. Estimated rates of HIV incidence among MSM, persons who inject drugs (PWID), and heterosexuals, by selected characteristics and years (2010 and 2015).

	2010						2015						P value of z test: rate 2010 = rate 2015
	Estimated HIV incidence	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate	Upper 95% confidence interval for estimated rate	Rate ratio	Estimated HIV incidence	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate	Upper 95% confidence interval for estimated rate	Rate ratio	
MSM	26 400	4 364 386	605.0	524.7	685.3	Referent	26 200	4 497 605	583.6	496.2	671.1	Referent	0.373
Race/ethnicity													
White	8200	3 014 113	271.9	235.3	308.5	Referent	7100	3 034 686	233.6	193.2	274.0	Referent	0.024
Hispanic/Latino ^a	6500	637 546	1025.0	871.1	1179.0	3.8	7900	699 952	1133.4	909.3	1357.4	4.9	0.201
Black	10 000	4 07 036	2459.0	2045.9	2872.1	9.0	9800	4 06 347	2405.6	1898.3	2912.8	10.3	0.747
Other ^b	1700	305 690	544.7	447.6	641.7	2.0	1400	356 620	407.2	265.7	548.6	1.7	0.100
Age at infection, years													
13–24	9700	979 317	989.5	858.0	1120.9	Referent	7600	986 438	773.0	631.9	914.1	Referent	0.001
25–34	7600	719 705	1057.1	907.3	1206.9	1.1	10 000	740 265	1351.0	1109.0	1593.1	1.7	0.000
35–44	4800	652 559	739.6	622.5	856.6	0.7	4300	661 924	654.8	508.2	801.3	0.8	0.212
45–54	3200	709 957	456.6	381.2	532.1	0.5	3000	645 112	462.4	343.2	581.6	0.6	0.914
55 and above	1000	1 302 850	79.5	63.5	95.5	0.1	1300	1 463 867	89.3	59.3	119.2	0.1	0.516
PWID	2800	6 520 671	43.0	29.6	56.3	Referent	2200	6 835 719	32.7	20.6	44.8	Referent	0.030
Male	1600	4 413 009	36.8	23.3	50.4	Referent	1300	4 635 079	28.1	15.1	41.2	Referent	0.124
Female	1200	2 044 442	57.5	39.1	76.0	1.6	930	2 139 599	43.5	24.9	62.1	1.5	0.112
Heterosexuals	11 200	222 046 788	5.0	4.7	5.3	Referent	8800	232 204 569	3.8	3.3	4.2	Referent	0.000
Male	3700	105 078 203	3.5	3.1	3.9	Referent	2800	110 102 010	2.6	1.9	3.2	Referent	0.026
Female	7500	117 264 326	6.4	6.0	6.8	1.8	6000	122 398 400	4.9	4.2	5.5	1.9	0.000

PWID, persons who inject drugs.

^aHispanic/Latino can be of any race.^bOther race/ethnicity category includes American Indian/Alaska Native, Asian, Native Hawaiian/other Pacific Islander, and multiple races.

the rate for PWID and 98 times the rate for male heterosexuals.

Among MSM, the HIV prevalence rates were higher for both black and Hispanic/Latino MSM compared with white MSM. Among all age groups, MSM aged 45–54 years had the highest HIV prevalence rate. Among PWID, the HIV prevalence rate was higher among women than men (rate ratio 1.4). Similarly, the HIV prevalence rate was higher among female heterosexuals than male heterosexuals (rate ratio 1.9).

Discussion

The analysis is the first to comprehensively examine the national rates of HIV diagnosis, incidence, and prevalence among MSM, PWID, and heterosexuals in the United States. These national HIV rates show the disease burden, relative to the sizes of the populations, providing a more refined picture of HIV epidemic for guiding resource allocation. The analyses of HIV rates for each transmission category at two time points (2010 and 2015) and by subgroups allowed monitoring the progress toward the goal of reducing health disparities. We found that the overall national diagnosis rates decreased between 2010 and 2015 for all three transmission categories and also for several race/ethnicity and age subgroups. The incidence rates decreased among white MSM, MSM aged 13–24 years, PWID overall, and male and female heterosexuals. While the evidence of progress is encouraging, health disparities remain and have widened for some groups.

The estimated rates of HIV diagnosis, incidence, and prevalence presented here quantify the disproportionate HIV disease burden among MSM compared to PWID and heterosexuals. In addition, our data quantify persistent racial/ethnic disparities among MSM. The estimated rates continue to be substantially higher for black and Hispanic/Latino MSM than for white MSM. Only among white MSM did the HIV incidence rate, and also HIV diagnosis rate decrease. The HIV diagnosis rates increased in black MSM and Hispanic/Latino MSM, whereas the HIV incidence rates remained stable for both groups. The number of new infections among Hispanic/Latino MSM has increased between 2010 and 2015 (the estimated numerator) [9]. However, our analyses could not corroborate an increase in the HIV incidence rate when accounting for the adjusted population size (the estimated denominator). It is possibly due to the uncertainty from the estimated denominator that was added to the HIV incidence rate estimate. The increase in the HIV diagnosis rate and decrease in the HIV incidence rate among MSM aged 13–24 years may reflect targeted testing efforts to identify young MSM with undiagnosed HIV [9]. The result of targeted testing efforts is also reflected in the increased percentage of MSM aged 13–24

Table 3. Estimated rates of HIV prevalence among MSM, persons who inject drugs (PWID), and heterosexuals, by selected characteristics, 2015.

	Estimated HIV prevalence	Estimated population size	Estimated rate per 100 000 persons in the selected population	Lower 95% confidence interval for estimated rate	Upper 95% confidence interval for estimated rate	Rate ratio
MSM	632 300	5 110 077	12 372.9	10 910.5	13 835.3	
Race/ethnicity						
White	240 900	3 271 445	7363.7	6472.0	8255.4	Referent
Hispanic/Latino ^a	151 200	844 249	17 907.0	15 610.9	20 203.2	2.4
Black	201 800	600 384	33 607.6	29 313.2	37 902.1	4.6
Other ^b	38 400	393 999	9748.5	8280.0	11 217.0	1.3
Age at end of 2015, years						
13–24	47 700	1 039 166	4589.9	4033.4	5146.5	Referent
25–34	137 000	867 355	15 789.7	13 942.8	17 636.7	3.4
35–44	123 200	785 621	15 684.0	13 857.8	17 510.3	3.4
45–54	184 700	828 751	22 283.8	19 700.1	24 867.5	4.9
55 and above	139 700	1 589 185	80791.9	7769.9	9813.8	1.9
PWID	135 100	6 972 145	1937.2	1371.1	2503.4	
Male	81 000	4 716 995	1716.4	1133.9	2298.9	Referent
Female	54 100	2 194 109	2465.9	1752.5	3179.3	1.4
Heterosexuals	294 500	232 494 212	126.7	121.1	132.3	
Male	93 600	110 194 234	84.9	78.5	91.3	Referent
Female	201 000	122 595 818	163.9	156.5	171.3	1.9

PWID, persons who inject drugs.

^aHispanic/Latino can be of any race.

^bOther race/ethnicity category includes American Indian/Alaska Native, Asian, Native Hawaiian/other Pacific Islander, and multiple races.

years living with diagnosed HIV infection [9]. However, MSM aged 25–34 years had increased rates of HIV incidence, and also diagnosis, pointing out an important age group for intensifying prevention, and also testing efforts.

Racial/ethnic disparities are also apparent among PWID. Among both male and female PWID, blacks had the highest rates of HIV diagnosis. Even though the HIV diagnosis rates in black male and female PWID decreased, the rates were still six and four times as high when compared to white male and female PWID in 2015. Among PWID, white men was the only group that showed a significant increased rate of HIV diagnosis. While we found the overall HIV incidence rate among PWID decreased from 2010 to 2015 and was stable when stratified by sex, our analysis did not directly test whether there was a significant increase in the HIV incidence rate among white men due to the relative standard error above 30%, indicating low reliability of the estimated HIV incidence for this subgroup. However, findings from a CDC study conducted in 20 selected metropolitan statistical areas showed a higher percentage of white PWID than Hispanic/Latino and black PWID reported receptive syringe sharing and sharing injection equipment – behaviors that put them at risk for HIV infection [15]. Whites also reported higher rates of misuse of prescribed pain relievers, tranquilizers, stimulants, and sedatives in 2015 than blacks and Hispanics/Latinos [16]. Increased injection of opiates within a network of people who inject drugs might have fueled HIV infections, especially among white male PWID [17].

The magnitude of racial/ethnic disparities in HIV diagnosis rates among heterosexuals is even larger than

the disparities observed in MSM and PWID. HIV diagnosis rates were between 22 and 33 times as high among blacks compared with the rates among whites and between five and seven times as high among Hispanics/Latinos compared with rates among whites. Several individual, social, and structural factors such as risk behavior, relationship dynamic, stigma, health literacy, health insurance coverage, access to care and HIV treatment, and housing status may have contributed to disparities [18]. Additionally, one recent study showed that blacks had a higher number of HIV infections diagnosed between 2010 and 2015 attributed to heterosexual contact with partners previously known to be HIV-infected than other racial/ethnic groups [19]. Many of the infections from partners known to be HIV-infected could have been averted if discordant couples were aware of and were offered effective biomedical and behavioral prevention methods [19]. Continued efforts to promote HIV testing, treatment for HIV-infected partners, and pre-exposure prophylaxis (PrEP) and other prevention services for HIV-negative partners, not only for MSM and PWID, but also for heterosexuals, are needed to further reduce health disparities.

There are limitations to our analyses due to assumptions made when calculating HIV rates and rate ratios. First, we used the previously published proportion estimates derived from meta-analyses of national probability surveys and thus our analyses are also subject to general limitations that come with estimating population sizes as described in detail for each population in the previous publications [2–4]. Second, we applied the same proportion estimates of the US population classified as MSM, PWID, and heterosexuals to 2010 and 2015 census data, thereby assuming that the proportion of each

transmission category remained the same over time. Third, HIV incidence and prevalence were estimated based on a CD4⁺ depletion model that relies on a series of assumptions [8]. Due to low reliability of estimated HIV incidence and prevalence rates for the race/ethnicity and age-specific stratifications of PWID and heterosexuals, the rates of HIV incidence and prevalence by race/ethnicity and age were reported for MSM only. These limitations point out the need of re-assessing the HIV rates and rate ratios when more data become available.

Despite these limitations, our estimated rates of HIV diagnosis, incidence, and prevalence quantify the burden of HIV disease and point out the groups that need intensified prevention and care efforts, using the most recent and available data. The national HIV diagnosis rates decreased overall for all three transmission categories and several race/ethnicity and age subgroups. The incidence rates decreased among white MSM, persons aged 13–24 years, PWID overall, and male and female heterosexuals. However, MSM continue to be disproportionately affected and health disparities remain and have widened for some groups. Blacks continued to have the highest rates of HIV diagnosis among all racial/ethnic groups of all three transmission categories. Continued efforts are needed to strengthen interventions that offer HIV testing, PrEP, and other prevention services for at-risk populations and improve access to HIV treatment, promote medication adherence, and address barriers to clinical care and supportive services for all persons with diagnosed HIV infection.

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Conflicts of interest

There are no conflicts of interest.

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