

HIV Transmission in the United States: Considerations of Viral Load, Risk Behavior, and Health Disparities

H. Irene Hall · David R. Holtgrave ·
Tian Tang · Philip Rhodes

Published online: 2 March 2013
© Springer Science+Business Media New York (outside the USA) 2013

Abstract Ongoing HIV transmission is related to prevalence, risk behavior and viral load among persons with HIV. We assessed the contribution of these factors to HIV transmission with transmission rate models and data reported to National HIV Surveillance and published rates of risk behavior. We also estimated numbers of persons with risk behaviors and unsuppressed viral load among sexual risk groups. The transmission rate is higher considering risk behavior (18.5 infections per 100 people with HIV) than that attributed to unsuppressed viral load (4.6). Since persons without risk behavior or suppressed viral load presumably transmit HIV at very low rates, transmission can be attributed to a combination of these factors (28.9). Service needs are greatest for MSM; their number with unsuppressed viral load engaging in unprotected discordant sex was 8 times the number of male heterosexuals and more than twice the number of female heterosexuals with high-risk transmission potential. While all persons with HIV need optimal care, treatment as prevention is most relevant when risk behavior is present among persons with unsuppressed HIV viral load.

Keywords HIV · HIV transmission · Men who have sex with men · Disparities · Race/ethnicity

Introduction

The hallmark of an epidemic is a number of infections in excess of what is expected [1]. In the United States, the number of new HIV infections has remained relatively stable over the past decade with about 50,000 new infections per year [2, 3], a level of infections sustained with little disease transmission from external sources through migrants or travelers. To understand transmission dynamics, HIV epidemiology has mostly described those who get infected [4]. To understand what sustains ongoing, endemic HIV transmission and ultimately reduce such transmissions, we also need to assess who transmits HIV and what leads to instances of transmission.

Holtgrave et al. [5, 6] have shown that less than 5 people are newly infected each year for every 100 people living with HIV, a transmission rate much reduced since HIV was introduced in the United States 30 years ago. However, the 20 % of persons who are not aware of their HIV infection contribute a relatively higher proportion of transmissions (transmission rate per 100 persons living with HIV, 10.4) than persons with HIV aware of their infection (transmission rate, 2.7) [7]. Therefore, prevention efforts have long focused on detecting persons living with HIV but unaware of their infection [8]. Persons aware of their infection reduce risk behavior that might transmit the virus [9], and recent evidence indicates substantial reductions in HIV transmission among those with suppressed viral load [10]. We have shown earlier the effect of increased viral suppression on the HIV transmission rate [7].

The factors that drive continued HIV transmission in the United States—prevalence, risk behavior, and viral

H. I. Hall (✉) · P. Rhodes
Division of HIV/AIDS Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control & Prevention, 1600 Clifton Road NE, MS E-47, Atlanta, GA 30333, USA
e-mail: ixh1@cdc.gov

D. R. Holtgrave
Department of Health, Behavior & Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

T. Tang
ICF International, Atlanta, GA, USA

load—also drive the disparate HIV infection rates among subpopulations such as race/ethnicity groups or risk groups, including men who have sex with men (MSM), injection-drug users (IDU), and heterosexuals. Understanding the overall relations between the factors contributing to transmission as well as the distributions and inequities of these factors in subpopulations allows for better targeting of prevention efforts. Our analyses explore the interplay of awareness of HIV infection, risk behavior, and viral suppression, and show the relevance of these factors to transmission rates. Because of mixing in sexual networks between population groups, transmission rates cannot be precisely determined for such subgroups. However, transmission rates are dependent on the size of the underlying populations. Therefore, we determined the contribution of these factors to HIV transmission by calculating the size of risk populations (populations at risk for transmitting).

Methods

Using the transmission rate model developed by Marks et al. [9, 11] and the estimated number of persons aware and unaware of their HIV infection at the end of 2009, we estimated transmission rates (number of persons newly infected per year per 100 persons living with HIV [(incidence/prevalence) * 100]) for persons aware of their infection and who are living with unsuppressed viral load, engage in risk behavior, or both. We obtained parameters for the model, including the estimated number of persons aware and unaware of their HIV infection and the percentage of persons aware of their HIV infection with viral suppression (36.2 %) (percentage based on a threshold of ≤ 200 copies/mL) using data reported to the Centers for Disease Control and Prevention's National HIV Surveillance System (2, 12), and reviewed the literature to obtain the percentage of persons aware of their infection and engaged in risk behavior (16 %) [9]. We assumed that people with no risk behavior, suppressed viral load, or both do essentially not transmit HIV (transmission rate ≈ 0), as well as independence of risk behavior and viral suppression (Table 1). We defined persons with no risk behavior as persons who did not have unprotected sex or share injection equipment in sero status discordant partnerships.

Accurate transmission rates for subgroups by risk behavior (e.g., men who have sex with men [MSM],

heterosexual contact) cannot be determined precisely because of mixing among these groups. Instead, we estimated the sexual transmission potential by assessing the factors contributing to HIV transmission—HIV prevalence, risk behavior, and viral suppression among people living with HIV—by transmission category (the risk factor most likely responsible for transmission [4]; i.e., MSM, male heterosexual, and female heterosexual). Using data on HIV prevalence and viral suppression among persons diagnosed and living with HIV from the National HIV Surveillance System, and information on unprotected discordant sex (defined as sexual contact between a person with and a person without HIV infection) among persons with HIV and viral suppression from the behavioral survey of persons in care of the national Medical Monitoring Project [12], we determined the number of persons with sexual transmission potential (number of persons with transmission potential = [persons aware of their HIV infection with unsuppressed viral load] \times [proportion with unprotected discordant sex]).

To further describe care and prevention needs among MSM, the risk group most affected by HIV, we determined the number of black/African American, Hispanic/Latino, and white MSM aware and unaware of their infection, and their viral suppression status using data from the National HIV Surveillance System. We assumed similar risk behavior among the race/ethnicity groups based on earlier findings [13], and applied the information on unprotected discordant sex among MSM with HIV and viral suppression from the behavioral survey of persons in care [12] to estimate the number of MSM with transmission potential (see formula above).

Data analyses were based on HIV surveillance data. Public health disease surveillance activities are not considered research, and therefore are not subject to human subjects review.

Results

Overall, persons aware of their HIV infection are less likely to transmit the virus to others (3.0 persons newly infected for every 100 persons living with HIV aware of their infection) than persons unaware of their HIV infection (transmission rate 10.8) (Table 2). Among persons with HIV aware of their infection, the estimated transmission

Table 1 HIV transmission with unprotected risk behavior and unsuppressed viral load in serostatus discordant partnerships

In a serostatus discordant partnership	Unprotected transmission relevant risk behavior present	No unprotected transmission relevant risk behavior
Unsuppressed viral load	Concentration of transmission	Essentially no transmission
Suppressed viral load	Essentially no transmission	Essentially no transmission

Table 2 Estimated prevalence and rates of HIV transmission attributed to risk behaviors and viral suppression among persons aware of their HIV infection, United States

	Number	Transmission rate
People with HIV		4.4
Incidence	50,125	
Prevalence	1,148,200	
Persons unaware of their HIV infection		10.8
Incidence	22,364	
Prevalence	207,824	
Persons aware of their HIV infection		3.0
Incidence	27,761	
Prevalence	940,376	
Persons with risk behavior (16 %)	150,460	18.5
Persons with unsuppressed viral load (63.8 %)	599,960	4.6
Persons with risk behavior and unsuppressed viral load	95,994	28.9
No risk behavior		~0
Suppressed viral load		~0
No risk behavior and suppressed viral load		~0

rate is higher considering risk behavior (18.5) compared to a transmission rate attributed to unsuppressed viral load (4.6), i.e., the number of persons with HIV (aware) with risk behavior is smaller than the number with unsuppressed viral load. However, many of the approximately 940,400 persons aware of their HIV infection do not engage in risk behavior, have suppressed viral load values, or both and therefore presumably do not transmit HIV (transmission rate ≈ 0). Therefore, HIV transmission can be attributed to a combination of risk behavior and unsuppressed viral load,

Table 3 Number of persons living with HIV aware of their HIV infection with viral suppression and risk behavior, by risk behavior

	Men who have sex with men		Male heterosexual		Female heterosexual	
	Number	%	Number	%	Number	%
Persons living with HIV	592,100	100.0	100,600	100.0	207,100	100.0
Awareness of HIV infection						
Persons not aware of their HIV infection	123,500	20.9	24,500	24.4	36,400	17.6
Persons aware of their HIV infection	468,600	79.1	76,100	75.6	170,700	82.4
Viral suppression						
Persons aware of their HIV infection with suppressed viral load	186,971	39.9	24,885	32.7	58,892	34.5
Persons aware of their HIV infection with unsuppressed viral load	281,629	60.1	51,215	67.3	111,809	65.5
Risk behavior						
Persons aware of their HIV infection with unsuppressed viral load engaging in unprotected discordant sex	45,061	16.0	5,634	11.0	19,007	17.0

with a transmission rate of 28.9 new infections per 100 persons with HIV with these characteristics.

The percentage of persons with HIV with unsuppressed viral load was higher among heterosexuals than MSM; however, the number of MSM living with HIV and without viral suppression was higher than the number of male and female heterosexuals (Table 3). Based on the levels of risk behavior among these groups, service needs are greatest among MSM as the number of MSM with unsuppressed viral load engaging in unprotected discordant sex was 8 times the number of male heterosexuals and more than twice the number of female heterosexuals with high-risk transmission potential.

Among MSM living with HIV, a lower percentage of black/African American (74.7 %) and Hispanic/Latino MSM (75.5 %) are aware of their HIV infection compared with white MSM (84.4 %) (Table 4). In addition, a lower percentage of black/African American (28.2 %) and Hispanic/Latino MSM (37.0 %) with diagnosed HIV infection have viral suppression compared to white MSM (46.8)—with similar levels of risk behavior among these groups resulting in disproportionate numbers of black/African American and Hispanic/Latino MSM aware of their HIV infection with unsuppressed viral load engaging in unprotected discordant sex. An estimated 8.5 % of white MSM (19,007/223,300) compared to 11.5 % (16,083/140,000) of black/African American and 10.1 % (9,042/89,700) of Hispanic MSM were in the combined risk group.

Discussion

The Panel on Antiretroviral Guidelines for Adults and Adolescents recommends that patients who are at risk of transmitting HIV to sexual partners should be offered

Table 4 Number of men who have sex with men living with HIV aware of their HIV infection with viral suppression and risk behavior, by race/ethnicity

	Black/African American		Hispanic/Latino		White	
	Number	%	Number	%	Number	%
Number of persons living with HIV	187,300	100	118,800	100	264,700	100
Awareness of HIV infection						
Number of persons not aware of their HIV infection	47,300	25.3	29,100	24.5	41,400	15.6
Number of persons aware of their HIV infection	140,000	74.7	89,700	75.5	223,300	84.4
Viral suppression						
Number of persons aware of their HIV infection with suppressed viral load	39,480	28.2	33,189	37.0	104,504	46.8
Number of persons aware of their HIV infection with unsuppressed viral load	100,520	71.8	56,511	63.0	118,796	53.2
Risk behavior						
Persons aware of their HIV infection with unsuppressed viral load engaging in unprotected discordant sex	16,083	16.0	9,042	16.0	19,007	16.0

treatment [14]. Our results show that of about 150,000 people aware of their HIV infection with risk behavior, about 96,000 are at risk of transmitting the disease because of risk behavior and unsuppressed viral load and should therefore be offered treatment. In addition, one of the goals of the National HIV/AIDS Strategy is to increase the percentage of blacks/African Americans, Hispanics, and MSM with viral suppression by 20 % [15]. However, the same Strategy goals applied across groups would not eliminate disparities between race/ethnic groups as the percentage of white MSM in care and on treatment is higher than that of black/African American or Hispanic/Latino MSM.

Disparities in viral suppression are important to consider in reducing incidence. While we cannot easily determine transmission rates for subpopulations because of mixing, within-group sexual networks (i.e., risk and race/ethnicity groups) explain some of the differing incidence rates and would vary by prevalence, risk behavior, and viral suppression. Among MSM there is little difference in risk behavior among race/ethnicity groups [13]; however, differences in HIV prevalence and viral suppression will continue to affect incidence rates unless additional prevention efforts are implemented. To eliminate difference in viral suppression, an estimated additional 38,920 black/African American MSM and 17,043 Hispanic/Latino MSM would need to be on treatment (compared to the 20 % increase National Strategy goal of 7,896 and 6,638, respectively) to raise viral suppression levels to the goal of 56 % for white MSM aware of their infection. These goals are particularly important for prevention among youth, who mature into sexual activity with minimal HIV among them from perinatal exposure. Yet HIV incidence is increasing among young MSM [3]. Young MSM who partner with older MSM are more likely to encounter partners infected with HIV and young MSM of color are more likely to

encounter MSM with unsuppressed viral load or undiagnosed HIV.

Our analyses are subject to several limitations. First, the percentage of persons with viral suppression may vary based on the definition used, but the estimate used here is consistent with earlier estimates from other studies [16]. Second, the review of the literature provided little new information on reduction in risk behavior or on risk behavior among persons with viral suppression. Third, for this analysis, we assumed that viral suppression and protected sex does not lead to HIV transmission. No transmission can occur when there is no sexual behavior. However, even with viral suppression a small risk of transmission remains among heterosexual couples and more information is needed to determine the magnitude in transmission risk reduction for other groups such as MSM [10]. In addition, concerns have been raised about increased risk behavior in the presence of treatment [17, 18]. The possible impact of assuming reductions in transmission risk from viral suppression that are too high can result in overestimating the transmissions rate when risk behavior and unsuppressed viral load are present. Fourth, the input parameters of the number and percentage of undiagnosed are based on back-calculation methodology, and results may vary by the confidence intervals of the estimates [19]. Finally, we assumed similar risk behavior levels for people in care compared to people not in care, using behavioral survey data [12].

In summary, while all persons with HIV need optimal care and treatment and current treatment guidelines recommend offering antiretroviral therapy to all persons with HIV [14], treatment as prevention to reduce incidence, a primary goal of the National HIV/AIDS Strategy [15], is most relevant when risk behavior is present among persons with unsuppressed HIV viral load [20]. The CDC's

approach to reducing HIV infections in the United States calls for high-impact HIV prevention through a combination of interventions that are scientifically proven, cost-effective, and scalable and that are targeted toward the populations in need in specific geographic areas [21]. Challenges to prevention efforts include care and treatment coverage, with more than 4,000 persons on AIDS Drug Assistance Program (ADAP) waiting lists and more than half of persons living with HIV not accessing regular HIV care [22–24]. In addition, less than half of persons with HIV in care reported receiving prevention counseling by a health care provider [23]. Resources must be directed to support effective behavioral interventions, including access to condoms and sterile syringes, prevention counseling, partner services, substance-abuse treatment, and medication adherence [10, 25].

Disclaimer The findings and conclusions in this study are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

References

1. Last JM. A dictionary of epidemiology. New York: Oxford University Press; 1995.
2. Hall HI, Song R, Rhodes P, Prejean J, An Q, Lee LM, et al. Estimation of HIV incidence in the United States. *JAMA*. 2008;300:520–9.
3. Prejean J, Song R, Hernandez A, Ziebell R, Green T, Walker F, et al. Estimated HIV incidence in the United States, 2006–2008. *PLoS One*. 2011;6:e17502. doi:10.1371/journal.pone.0017502.
4. Centers for Disease Control and Prevention. HIV Surveillance Report, 2010. <http://www.cdc.gov/hiv/topics/surveillance/resources/reports/> (2012). Accessed 14 Oct 2012.
5. Holtgrave DR, Hall HI, Rhodes PH, Wolitski RJ. Updated annual HIV transmission rates in the United States, 1978–2006. *J Acquir Immune Defic Syndr*. 2009;50:236–8.
6. Holtgrave DR, Hall HI, Prejean J. HIV transmission rates in the United States, 2006–2008. *Open AIDS J*. 2012;6:20–2.
7. Hall HI, Holtgrave DR, Maulsby C. HIV transmission rates from persons living with HIV who are aware and unaware of their infection. *AIDS*. 2012;26:887–96.
8. Centers for Disease Control and Prevention. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR*. 2006;55:1–17.
9. Marks G, Crepaz N, Janssen RS. Estimating sexual transmission of HIV from persons aware and unaware that they are infected with the virus in the USA. *AIDS*. 2006;20:1447–50.
10. Cohen MS, Muessig KE, Smith MK, Powers K, Kashuba ADM. Antiviral agents and HIV prevention: controversies, conflicts and consensus. *AIDS*. 2012;26:1585–98.
11. Pinkerton SD. HIV transmission rate modeling: a primer, review, and extension. *AIDS Behav*. 2011;16:791–6.
12. Freedman M, Mattson C, Johnson C, et al. Medical Monitoring Project, 2009 to 2010. National representative estimates of sexual risk behaviors among HIV + adults receiving medical care: U.S. 19th Conference on retroviruses and opportunistic infections. Seattle, Washington, 2012.
13. Millett GA, Flores SA, Peterson JL, Bakeman R. Explaining disparities in HIV infection among black and white men who have sex with men: a meta-analysis of HIV risk behaviors. *AIDS*. 2007;21:2083–91.
14. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services, 1–239. 2012. <http://www.aidsinfo.nih.gov/ContentFiles/AdultandAdolescentGL.pdf>. Accessed 20 April 2012.
15. The White House Office of National AIDS Policy. National HIV/AIDS strategy for the United States. 2010. <http://www.whitehouse.gov/administration/eop/onap/nhas/>. Accessed 20 April 2012.
16. Marks G, Gardner LI, Craw J, Giordano TP, Mugavero MJ, Keruly JC, et al. The spectrum of engagement in HIV care: do more than 19 % of HIV-infected persons in the US have undetectable viral load? *Clin Infect Dis*. 2012;53(11):1168–9. doi:10.1093/cid/cir678.
17. Hasse B, Ledergerber B, Hirschel B, Vernazza P, Glass TR, Jeannin A, et al. Frequency and determinants of unprotected sex among HIV-infected persons: the Swiss HIV Cohort Study. *Clin Infect Dis*. 2010;51:1314–22.
18. Heijman T, Geskus RB, Davidovich U, Coutinho RA, Prins M, Stolte IG. Less decrease in risk behaviour from pre-HIV to post-HIV seroconversion among MSM in the combination antiretroviral therapy era compared with the pre-combination antiretroviral therapy era. *AIDS*. 2012;26:489–95.
19. Centers for Disease Control and Prevention. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data—United States and 6 U.S. dependent areas—2010. HIV Surveillance Supplemental Report 17(No. 3, part A). 2012. <http://www.cdc.gov/hiv/topics/surveillance/resources/reports/>. Accessed 28 June 2012.
20. Holtgrave DR, Maulsby C, Wehrmeyer L, Hall HI. Behavioral factors in assessing impact of HIV treatment as prevention. *AIDS Behav*. 2012;16:1085–91.
21. Centers for Disease Control and Prevention. High-impact HIV prevention. 2012. http://www.cdc.gov/hiv/strategy/dhap/pdf/nhas_booklet.pdf. Accessed 20 April 2012.
22. National Alliance of State & Territorial AIDS Directors (NASTAD). ADAP Watch. 2012. http://www.nastad.org/Docs/012236_ADAP%20Watch%20update%20-%202.24.12.pdf. Accessed 20 April 2012.
23. Centers for Disease Control and Prevention. Vital signs: HIV prevention through care and treatment—United States. *MMWR*. 2011;60:1618–23.
24. Hall HI, Gray KM, Tang T, Li J, Shouse L, Mermin J. Retention in care of adults and adolescents living with HIV in 13 U.S. areas. *J Acquir Immune Defic Syndr*. 2012;60:77–82.
25. Centers for Disease Control and Prevention. Compendium of evidence-based HIV behavioral interventions: risk reduction chapter. 2012. <http://www.cdc.gov/hiv/topics/research/prs/compendium-evidence-based-interventions.htm>. Accessed 31 Dec 2012.