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A Pilot Study to Increase the Efficiency of HIV Outreach Testing Through the Use of Timely and Geolocated HIV Viral Load Surveillance Data

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Background: Eliminating HIV transmission in a population necessitates identifying population reservoirs of HIV infection and subgroups most likely to transmit. HIV viral load is the single most important predictor of HIV transmission. The objective of this analysis was to evaluate whether a public health practice pilot project based on community viral load resulted in increases in the proportion of time spent testing in high viral load areas (process measure) and 3 outcome measures—the number and percent of overall HIV diagnoses, new diagnoses, and high viral load positives—in one mid-Atlantic US city with a severe HIV epidemic.

Methods: The evaluation was conducted during three, 3-month periods for 3 years and included the use of community viral load, global positioning system tracking data, and statistical testing to evaluate the effectiveness of the pilot project.

Results: The proportion of time spent outreach testing in high viral load areas (69%–84%, $P < 0.001$) and the overall number and percent of HIV positives ((60 (3%) to 127 (6%), $P < 0.001$) significantly increased for 3 years. The number and percent of new diagnoses (3 (0.1%) to 6 (0.2%)) and high viral load positives (5 (0.2%) to 9 (0.4%)) increased, but the numbers were too small for statistical testing.

Discussion: These results suggest that using community viral load to increase the efficiency of HIV outreach testing is feasible and may be effective in identifying more HIV positives. The pilot project provides a model for other public health practice demonstration projects.

Eliminating HIV transmission in a population necessitates identifying population reservoirs of HIV infection and subgroups most likely to transmit. HIV viral load is the single most important predictor of HIV transmission.[1–3] The National HIV/AIDS Strategy and the US Centers for Disease Control and Prevention (CDC) recommend the use of HIV viral load data to inform local programs and implementation strategies for the prevention and control of HIV based on evidence that suggests that treatment to achieve viral load suppression reduces perinatal and sexual HIV transmission.[4–14] The recommendations suggest that public health departments use viral load information to identify key populations with a high proportion of HIV-infected persons who are not virally suppressed, that is, populations and networks that may be mostly likely to transmit infection. Aggregating viral loads to geographic areas, often called community viral load, may be a useful indicator of the local transmission potential.[5,6] It follows then that offering HIV and sexually transmitted infection testing and other transmission prevention interventions such as enhanced linkage and retention in care services (Treatment as Prevention) and preexposure prophylaxis (PrEP) for HIV to individuals living or socializing in high community viral load areas may reduce transmission by reducing both the transmission and acquisition of infection.

Evidence from 2 ecologic analyses suggests that such interventions may be effective in reducing HIV transmission and acquisition. Montaner et al.[7] showed a strong, statistically significant association between increased highly active antiretroviral therapy treatment coverage, decreased community viral load, and decreased new HIV diagnoses per year at the population level in Vancouver, British Colombia. Das et al.[8] showed that decreased annual community viral load was significantly associated with temporal decreases in the number of new HIV diagnoses in San Francisco, California.

Despite the recommendations and evidence, few if any demonstration projects have attempted to use and evaluate community viral load in public health practice as a targeted HIV control strategy. One major barrier to the implementation of such a population-level strategy is the lack of access to timely and complete viral load information by local health departments.[9–14] Viral load measurements are routinely ordered as a part of standard HIV clinical care, that is, in-care viral loads. Given that there is often a lag between when individuals are diagnosed and when they seek care, data on viral loads are often not up-to-date. In addition, the data do not include information on diagnosed individuals not currently or ever in care. Estimates suggest that approximately 45% of all HIV-diagnosed individuals are not linked or actively engaged in care, suggesting that routinely collected HIV viral load data are often very incomplete.[10]

We designed a pilot project to test the effectiveness of using HIV community viral load to target places for the identification of newly HIV-infected individuals and those who were virally unsuppressed, with the ultimate goal of informing public health

practice focused on decreasing HIV transmission. The objective of this analysis was to evaluate whether this pilot project embedded in public health practice resulted in increases in the proportion of time spent testing in high viral load areas (process measure) and 3 outcome measures—the number and percent of overall HIV diagnoses, new diagnoses, and high viral load positives for 3 years in one mid-Atlantic US city with a severe HIV epidemic.

METHODS

Setting

The Baltimore-Towson metropolitan statistical area including Baltimore City has one of the most severe HIV epidemics in the United States with severe racial/ethnic and minority disparities. In 2012, the HIV diagnosis rate per 100,000 in the metropolitan statistical area was 31.2 overall, 85.6 among blacks and 8.1 among non-Hispanic whites.[11] For comparison, the HIV diagnosis rate in Maryland was 31.2 per 100,000 and that in the United States was 1.59 per 10,000 (Baltimore City Health Department [BCHD]; CDC 2011). Although new diagnoses have declined overall in this city and nationally, they have increased among key populations such as persons identified as gay, bisexual, transgender, and men who have sex with men (MSM) of color.[12]

Overview

This pilot project was a public-private collaboration between the BCHD, the Maryland Department of Health and Mental Hygiene (DHMH), and the Johns Hopkins University Center for Child and Community Health Research. The pilot involved the evaluation of a targeted HIV testing strategy designed by the Child and Community Health Research and the BCHD and conducted by BCHD HIV outreach teams using mobile vans. The locations for testing were determined based on community viral load measures collected by the BCHD and DHMH during approximately a 4½-year period. The targeted testing strategy was evaluated in 3-month periods for 3 years. In the following, we describe measures used (community viral load and process and outcome measures), the use of global positioning system (GPS) tracking data, and statistical testing to evaluate the effectiveness of the testing strategy. Ethical approval for the evaluation of the program was granted by the Johns Hopkins University School of Medicine Institutional Review Board.

Generation of the Community Viral Load Measure and Community Viral Load Maps

The community viral load measure was constructed from 2 sources of information including viral load information on in-care individuals and viral load information taken at the point of diagnosis. In-care viral loads are reportable by law to the DHMH. The most recent in-care viral load information for HIV-positive individuals and their residential census tract at the time of the viral load was obtained from January 2009 to December 2011 from the DHMH HIV surveillance databases representing the period for which the most recent in-care viral load data were available from the DHMH in January 2014 when the community viral load measure was created.

To improve the timeliness and completeness of the in-care viral load data for our measure of community viral load, we included viral loads taken at the point of diagnoses according to a new protocol implemented by the BCHD from October 2012 to January 2014. The new surveillance viral load protocol is a protocol whereby every diagnosis of HIV (new or prevalent where the testing provider was unable to confirm documentation of an HIV-positive

test at the time of the test) identified by the BCHD receives a viral load test, heretofore called a surveillance viral load. The protocol requires that all confirmed HIV-infected individuals tested through BCHD and affiliate programs (e.g., street and venue-based outreach, 2 publicly funded sexually transmitted infection clinics, 4 emergency departments, community-based organizations, and HIV testing for uninsured patients at 12 private health care providers) are routinely viral load tested. These testing activities yield approximately 57% of all diagnoses annually. To perform the viral load testing, eligible specimens are sent to the DHMH laboratory for viral load testing using reverse transcription–polymerase chain reaction assays developed and validated by the DHMH Laboratory. The results of the surveillance viral load assays are used strictly for epidemiologic purposes and not for HIV diagnosis or patient management protocols. Viral loads that were undetectable were assigned a viral load value of half the lower level of detection of the test used. For surveillance viral loads, the lower limit of detection was 1000 copies/mL; for in-care viral loads, this ranged from 40 to 200 copies/mL. Residential address at the time of diagnosis was obtained and geocoded to census tracts.

To generate a census tract community viral load measure, in-care and surveillance viral loads were combined and a geometric mean viral load of cases by census tract was calculated.[13] The geometric mean was used compared with, for example, an arithmetic mean because it is less sensitive to extreme outliers. Maps of community viral load were generated to guide targeted outreach testing, and census tracts were classified into 3 categories of community viral load geometric mean—high ($\geq$1500 copies/mL), low (<1500 copies/mL), and no viral load information—as a proxy for transmission risk.[1] The cutoff of 1500 copies/mL was chosen based on work by Quinn et al.[1] showing no transmission events among discordant couples where the HIV-positive individual had a viral load less than 1500 copies/mL. We conducted a series of informal discussions with HIV experts (i.e., Drs Quinn, Agwu, Page, and Beyrer) to explore the validity of this threshold at the population level and for the concentrated HIV epidemic transmission dynamics in Baltimore City. Experts agreed unanimously on the cutoff of 1500 copies/mL and could not identify another similar evidence-based threshold for utilization.

The Use of GPS Tracking Data. Global positioning system units were placed on the 2 mobile HIV outreach testing vans to identify outreach testing locations and time spent at each location. The GPS units captured location data every 10 minutes during outreach testing shifts, yielding 8093 data points during the study period. The location data were then cleaned to omit nontesting time such as travel to and from outreach testing locations and special testing events resulting in 6517 data points. Special testing events conducted by BCHD's mobile outreach team, (i.e., Pride, Mayor Sponsored Health Fairs) were excluded because the testing locations were predetermined outside the BCHD's control and without consideration of community viral load.

Evaluation Data and Statistical Testing. Three, 3-month periods for 3 years were used to evaluate this pilot project. The first period, or baseline, used HIV outreach testing information from April to June 2013. The second and third periods for evaluation, April to June 2014 and April to June 2015, respectively, were selected after implementation and to correspond in calendar time with the baseline to control for any seasonal differences in outreach activities. Use of the community viral load maps to guide outreach testing was implemented in 2014, with the night shifts and in 2015, with the day and night shifts.

Evaluation data for the 3 periods for 3 years included the number of encounters over time and the proportion of time spent testing in high viral load areas (process measure). The latter measure was calculated as the amount of time in hours spent in high

viral load census tracts over the total time spent outreach testing. Evaluation data also included 3 outcome measures—the number and percent of HIV diagnoses, new diagnoses, and high viral load positives including new diagnoses or previous positives. High viral load individuals were defined as having a viral load of at least 1500 copies/mL.

Statistical testing from baseline to the 2 follow-up periods was conducted using χ^2 trend tests for proportions where counts were greater than 5. Statistical testing for the number of encounters trending over time was conducted with Poisson regression where all analyses were in STATA.

RESULTS

Study Population

A total of 1382 viral loads were available for this analysis including 214 surveillance and 1168 in-care viral loads. Ninety-five percent (n = 1313) had census tract information representing 63% (1313/2100) of all HIV diagnoses during the study period. The community viral load geometric mean was 665 (unexponeniated, the geometric mean [SD] is 2.82 [1.33]), and the median was 500 (range, 20–7,915,484). At the census tract level (n = 200), 55% (n = 110) were identified as high viral load (≥1500 copies/mL), 38% (n = 76) as low viral load (<1500 copies/mL), and 7% (n = 14) as having no viral load information (see Fig. 1).
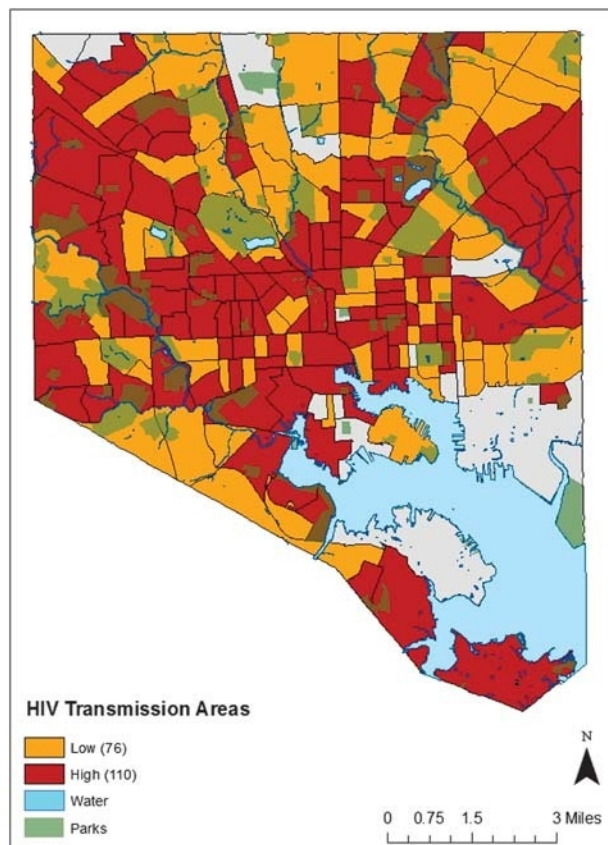

Figure 1. HIV community viral load areas (high and low) including in care and surveillance viral load information, Baltimore City, 2009 – April 2013 (n = 186).

TABLE 1. The Total Hours Spent Conducting HIV Outreach Testing by Community Viral Load Area (High, Low, No Information) During 3-Month Periods for 3 Years, 2013–2015, Baltimore City

Year	No. Testing Hours	Community Viral Load Areas		
		High (n = 89)	Low (n = 76)	No Information (n = 14)
2013	332.8	69%	30%	1%
2014	178.2	73%	28%	0%
2015	279.0	84%*	15%	1%

*$P < 0.001$.

Process and Outcome Measures

The proportion of time spent outreach testing in high viral load areas increased from 69% (230/333 hours), to 73% (130/178 hours), to 84% (235/279 hours), respectively ($P < 0.001$; Table 1). The number of encounters increased significantly over the study period— 3-month periods for 3 years—although not consistently, from 1896 to 1117 to 2094 ($P = 0.002$; Table 2). The number and proportion of HIV diagnoses overall increased significantly from 60 (3%), to 46 (4%), to 127 (6%) ($P < 0.001$) during the three, 3-month periods. The number and proportion of new diagnoses increased from 3 (0.1%), to 5 (0.4%), to 6 (0.2%) and high viral load cases increased from 5 (0.2%), to 6 (0.5%), to 9 (0.4%). Because small cell sizes, we were unable to determine the statistical significance of these latter 2 outcome increases.

DISCUSSION

Through a public-private collaboration, we designed, implemented, and evaluated a public health practice pilot project which used HIV community viral load to target places for the identification of HIV-positive individuals overall, those who had new diagnoses, and those who were virally unsuppressed with the ultimate goal of decreasing HIV transmission. We were able to demonstrate significant increases in the time spent in high viral load areas and, by 2-fold, the overall HIV diagnoses over time. We also were able to demonstrate an increase in those cases identified with a higher transmission potential (i.e., new diagnoses and higher viral load), but we could not test the significance of these increases because of small cell sizes. Notably, despite the doubling of the numbers and proportions over the 3 years, the proportion of HIV diagnoses identified as new or high viral load remained low rising in the second year and decreasing (although still increased from the first year) in the third year. These data suggest that work still needs to be done to increase the efficiency of HIV outreach testing and to increase the proportion of those tested who are recently infected

TABLE 2. The Total Encounters and 3 HIV Outreach Testing Outcomes Including Number and Percent HIV Positives, New Positives, and High Viral Loads Identified During 3-Month Periods for 3 Years, 2013–2015, Baltimore City

Year	Encounters	HIV Positives, n (%)	New Positives, n (%)	High Viral Load Positives, n (%)
2013	1896	60 (3)	3 (0.1)	5 (0.2)
2014	1117	46 (4)	5 (0.4)	6 (0.5)
2015	2094*	127 (6)*	6 (0.2)†	9 (0.4)†

*$P < 0.001$.
†Not statistically tested due to small cell sizes.

to link them to care or those previous positives that are virally unsuppressed and require linkage or relinkage to care services. These results suggest that targeted HIV outreach testing based on community viral load is feasible and may be effective in identifying greater numbers of HIV-infected individuals and greater proportions of individuals most likely to transmit, that is, those unaware of their infection and with a transmissible viral load.

Results from efficacy and demonstration HIV Prevention Trials Network (HPTN) studies add promise to these findings in that they suggest that there are efficacious interventions available to link identified infected individuals to care and high-risk uninfected individuals to PrEP. This protocol may help identify access points for these 2 types of individuals. Specifically, the results from a multicontinent, randomized, controlled trial, the HPTN 052 trial, demonstrated that there was a relative reduction of 96% in the number of HIV transmissions between serodiscordant couples when the HIV-infected partner received early active retroviral treatment, as compared with delayed therapy.[14] The results from a demonstration study, the HPTN 073, showed high uptake and self-report of adherence of oral PrEP among black MSM in the United States.[15] In addition, a comparison between self-report and biologic markers of adherence demonstrated consistency and suggests that approximately 60% of participants took 4 or more doses per week, a level that has been previously demonstrated to protect MSM from HIV infection.[16] These studies together suggest that there are efficacious interventions available to link infected individuals to care or to link high-risk uninfected individuals to PrEP once they are identified.

There were a number of limitations to the study. This was a pilot project in a real-world public health practice setting, which means that the protocol was not necessarily strictly adhered to as compared with a research study protocol. An example of lack of strict adherence was the inconsistent use of the GPS unit on the mobile van. This in part resulted in a more limited period for monitoring and evaluation. Another limitation was that some census tracts may have been misclassified by community viral load status. This may have been due to the fact that data on viral loads were not complete including less timely information on in-care viral loads. This may have also been due to the fact that the measure of community viral load used, that is, geometric mean viral load per census tract, may not be the most valid and reliable measure.[17] Despite the use of community viral load among HIV researchers[6,8,7,18] and recommendations in the National HIV/AIDS Strategy and by the US CDC that community viral load be incorporated into routine surveillance activities,[19,20] there is a lack of consensus regarding how to measure community viral load (i.e., how to aggregate individual level viral loads to the community level to best reflect population reservoirs of HIV infection).[21,22] If the measure of community viral load we selected based on the best evidence at the time did not represent the most valid measure, then our results would be subject to exposure misclassification bias. This would mean that some of the high community viral load areas may in fact have been low community viral load areas and vice versa; and this would have likely resulted in a decreased ability of our intervention to show meaningful effects. Recent evidence including our own work suggests that percent virally unsuppressed may be a better measure than the geometric mean viral load per area to indicate the HIV transmission potential of an area.[18,23] We have amended the current testing protocol to reflect this new measure, and we plan to evaluate the use of this new measure. Another limitation is that the percent identified in non–high community viral load areas may have decreased because we took resources away from these areas to target with high viral load.

Current advances in both science and technology provide unprecedented opportunities for public health professionals to improve the practice of HIV prevention and control. Translating the science and technology into more effective public health practice will require the synthesis of the current state of the best science, careful measurement of the implementation of new interventions, sustained collaborations between researchers and practitioners, careful evaluation, common sense, and political acumen.[24] Much remains to be learned about how who, what, where, and how to deliver the emerging arsenal of tools in HIV prevention and control for maximum population impact.

REFERENCES

1. Quinn TC, Wawer MJ, Sewankambo N, et al. Viral load and heterosexual transmission of human immunodeficiency virus type 1. N Engl J Med 2000; 342:921–929.
2. Gray RH, Wawer MJ, Brookmeyer R, et al. Probability of HIV-1 transmission per coital act in monogamous, heterosexual, HIV-1–discordant couples in Rakai, Uganda. Lancet 2001; 357:1149–1153.
3. Kumarasamy N, Venkatesh KK, Srikrishnan AK, et al. Risk factors for HIV transmission among heterosexual discordant couples in South India. HIV Med 2010; 11:178–186.
4. Garcia PM, Kalish LA, Pitt J, et al. Maternal levels of plasma human immunodeficiency virus type 1 RNA and the risk of perinatal transmission. Women and Infants Transmission Study Group. N Engl J Med 1999; 341:394–402.
5. Stall RD. What's driving the U.S. epidemic in men who have sex with men. Presented at: Conference on Retroviruses and Opportunistic Infections; 2008; Boston.
6. Castel AD, Befus M, Willis S, et al. Use of the community viral load as a population-based biomarker of HIV burden. AIDS 2012; 26:345–353.
7. Montaner JSG, Lima VD, Barrios R, et al. Association of highly active antiretroviral therapy coverage, population viral load, and yearly new HIV diagnoses in British Columbia, Canada: A population-based study. Lancet 2010; 376:532–539.
8. Das M, Chu PL, Santos G, et al. Decreases in community viral load are accompanied by reductions in new HIV infections in San Francisco. PLoS One 2010; 5:e11068.
9. Frieden TR. The future of public health. N Engl J Med 2015; 373:1748–1754.
10. Skarbinski J, Rosenberg E, Paz-Bailey G, et al. Human immunodeficiency virus transmission at each step of the care continuum in the United States. JAMA Intern Med 2015; 175:588–596.
11. Baltimore City HIV/AIDS Epidemiological Profile, Fourth Quarter 2012 (Maryland Department of Health and Mental Hygiene Web site). Available at: http://phpa.dhmh.maryland.gov/OIDEOR/CHSE/Shared%20Documents/Baltimore-City.pdf. Accessed May 21, 2015.
12. Johnson A, Hall H, Hu X, et al. Trends in diagnoses of HIV infection in the United States, 2002–2011. JAMA Intern Med 2014; 312:432–434.
13. Center for Disease Control and Prevention. Guidance on Community Viral Load: A Family of Measures, Definitions and Method for Calculations (CDC Web site). Available at: http://www.ct.gov/dph/lib/dph/aids_and_chronic/surveillance/statewide/community_viralload_guidance.pdf. Accessed May 3, 2015.
14. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. N Engl J Med 2011; 365:493–505.
15. Wheeler D, Fields S, Nelson L. HPTN 073: PrEP uptake and use by black men who have sex with men in 3 U.S. cities. Presented at: Conference on Retroviruses and Opportunistic Infections; 2016; Boston.
16. Wheeler D, Fields S, Nelson L. Correlates for levels of self-reported PrEP adherence among black men who have sex with men in 3 U.S. cities. Presented at: International AIDS Conference; 2016; Durban.
17. Miller WC, Powers KA, Smith M, et al. Community viral load as a measure for assessment of HIV treatment as prevention. Lancet 2013; 13:459–464.
18. Soloman SS, Mehta SH, McFall AM, et al. Community viral load, antiretroviral therapy coverage, and HIV incidence in India: A cross-sectional, comparative study. Lancet HIV 2016; 3:183–190.
19. White House Office of National AIDS Policy. National HIV/AIDS Strategy for the United States (White House Office of National AIDS

Policy website). Available at: https://www.whitehouse.gov/sites/default/files/uploads/NHAS.pdf. Accessed November 4, 2016.

20. Centers for Disease Control and Prevention. Guidance on Community Viral Load: A Family of Measures, Definitions, and Method for Calculation (CDC Website). Available at: https://stacks.cdc.gov/view/cdc/28147. Accessed July 9, 2016.

21. Miller WC, Powers KA, Smith MK, et al. Community viral load as a measure for assessment of HIV treatment as prevention. Lancet Infect Dis 2013; 13:459–464.

22. Rigo F, Vento S. Revisiting the methodology of measuring HIV community viral load. J Acquir Immune Defic Syndr 2013; 63: 82–84.

23. Leifheit KM, Schumacher CM, Chaulk P. Community viral load: Measure validation and public health utility. Presented at: The Conference on Retroviruses and Opportunistic Infections; 2016; Boston.

24. Brownson R, Baker E, Leet T. Evidence-Based Public Health. New York, NY: Oxford University Press, 2003.