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ORIGINAL PAPER

Data-Driven Goals for Curbing the U.S. HIV Epidemic by 2030

Heather Bradley[1] · **Eli S. Rosenberg**[2] · **David R. Holtgrave**[2]

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Abstract
Progress in reducing HIV infections has been suboptimal despite availability of effective prevention and treatment interventions and national strategies to bring them to scale. As part of a community-driven process, we expanded previous epidemiologic models using updated surveillance data from the Centers for Disease Control and Prevention to estimate quantitative parameters for ambitious but attainable national HIV prevention goals. We estimated new HIV infections could be reduced by up to 67% and prevalence could begin to decline by 2030 if 95% targets for diagnosis, care retention, and viral suppression are met by 2025 and an additional 20% of transmissions are averted through targeted interventions such as pre-exposure prophylaxis. Notably, this would require the percentage of diagnosed persons retained in HIV care to increase by more than 35 percentage points, which would necessitate innovative models and a substantial expansion of supportive services. Although the HIV incidence reduction goal of 90% as unveiled in the 2019 State of the Union Address is likely unachievable with the current intervention toolkit, it is possible to begin to substantially reduce HIV prevalence in the next decade with sufficient investments and innovation.

Keywords Surveillance · HIV care continuum · HIV incidence · HIV prevalence

Background

In its fourth decade, HIV infection affects more than 1.1 million Americans, and about 40,000 persons were diagnosed annually from 2013 to 2017 [1]. These diagnoses were highly concentrated among a few groups of people: nearly 70% were among men who have sex with men (MSM), 50% were among persons living in the South, and more than 40% were among African Americans. Although incidence is estimated to have declined by 15% during 2008–2015, prevalence climbed by about 17% during the same period, indicating inadequate progress in controlling the U.S. epidemic [2].

Sufficiently scaled tools for HIV diagnosis, treatment, and prevention can reduce national HIV burden [3]. Highly accurate HIV tests are available in a variety of clinical and non-clinical settings [4]. For persons diagnosed with HIV, antiretroviral therapies greatly reduce morbidity and render HIV transmission risk negligible when taken consistently [5–7]. These therapies have also been adapted for use as highly effective pre-exposure (PrEP) and post-exposure prophylaxis (PEP) [8, 9]. In addition to bio-medical methods, behavioral strategies including condom use and harm reduction interventions remain viable and effective strategies for preventing HIV transmission [10–15].

The first comprehensive National HIV/AIDS Strategy (NHAS), launched in 2010, aimed to reduce new HIV infections by 25% over 5 years [16]. Despite important gains in HIV care and prevention goals, estimates from the Centers for Disease Control and Prevention (CDC) indicate the number of new HIV infections declined by 8% during 2010–2015 [1]. A 2015 update to the Strategy shifted its aim to reducing HIV diagnoses, which represent detection of prevalent HIV infections rather than incidence, by 25% during the years remaining until 2020 [17]. The 25% reduction in diagnoses goal is also unlikely to be achieved. HIV diagnoses declined from 39,964 in 2015 to 38,281 in 2017, just over a 4% reduction [1]. Heading into the next decade, new national strategies are needed that look towards ambitious but achievable goals, built on the best available data and evidence.

✉ Heather Bradley
hbradley@gsu.edu

[1] Department of Population Health Sciences, Georgia State University School of Public Heath, Urban Life Building, 140 Decatur Street, Ste. 463, Atlanta, GA 30303, USA

[2] School of Public Health, University at Albany-SUNY, New York, USA

Meaningfully reducing HIV infections in the U.S. will require substantial progress in improving HIV care continuum outcomes. UNAIDS has adopted a strategy to end HIV by 2030 by increasing each of the following to 95%: the percentage of persons living with HIV who are diagnosed, the percentage of diagnosed persons who are on ART, and the percentage of persons on ART who are virally suppressed [18]. Despite the U.S. having not signed onto this strategy, some U.S. states and cities have made significant progress toward these goals, and many now have "Ending the Epidemic" plans to eliminate HIV primarily by improving care continuum outcomes [19]. Nationally, during 2010–2015, the percentage of persons living with HIV who were diagnosed remained stable around 85%, and the percentage of diagnosed persons receiving HIV care (as a proxy for on ART) hovered just under 60% [20, 21]. Substantial progress was made for the last 95% goal—the percentage of people in care who are virally suppressed—which increased 10 percentage points from 67% to 77% during 2009 – 2013 [20]. Improvements are needed, particularly in care retention, and adopting a national framework with clear goals such as 95–95–95 may help to incite progress.

The current U.S. federal administration recently announced a multi-agency strategy to reduce new HIV infections by 75% in 5 years and by 90% in 10 years [22]. Although few details of this plan have been revealed, it is likely to involve commitments to improving HIV care continuum outcomes and PrEP coverage. In anticipation of an updated federal HIV strategy, in late 2018 a community coalition led by AIDS United assessed the current landscape of prevention tools, community needs, and available surveillance data for the purpose of informing new HIV prevention goals. As part of this work, we used HIV surveillance data together with assumptions about transmission rates and the distribution of persons living with HIV along the HIV care continuum to estimate how much change in HIV incidence and prevalence would be possible if 95–95–95 targets were met. We additionally considered what it would take in terms of both HIV care continuum improvements and infections averted through other interventions to "bend the epidemic curve" (bringing the number of new HIV infections under the number of deaths among persons living with HIV) by 2030. Here, we present expanded findings from this analysis to provide quantitative parameters for ambitious but attainable national HIV prevention goals and to provide context for proposed HIV goals recently released by the federal administration.

Methods

Modeling Approach

We developed a dynamic life-table model to project the U.S. HIV epidemic, based on previous models [23, 24] and current surveillance data and parameter estimates from 2010 to 2015 (Table 1), under several possible scenarios of care and prevention goal achievement through 2030.

For each given year, we estimated the next year's prevalence as $Prevalence\ (t+1) = Prevalence(t) + Incidence(t) - Deaths(t)$. The latter two quantities were computed as follows.

Incidence (*t*)

The current total prevalence(t) was divided according to that year's care continuum into four mutually exclusive groups of care categories: those undiagnosed, diagnosed but not retained in care, retained in care but not virally suppressed, and virally suppressed. Retention in care was defined as having at least one HIV clinical care visit during the index year, and viral suppression was defined as having a viral load < 200 copies/mL at last viral load test. The total persons in each care category was multiplied by an assumed care-stage-specific transmission rate, which represents the number of HIV transmissions per person estimated from the observed clinical and behavioral profiles of persons at that stage of care [25]. The sum of these transmissions equals that year's incident infections. In scenarios that considered highly effective prevention with HIV-negative persons (e.g.

Table 1 Source of model parameter estimates

National parameter	Years represented	Source
Persons living with HIV infection	2010–2015	CDC [21]
Persons with diagnosed HIV infection	2010–2015	CDC [21]
Persons retained in HIV care	2010–2013	Bradley et al. [20]
Persons virally suppressed	2010–2013	Bradley et al. [20]
Incident HIV infections	2010–2013	CDC [21]
Deaths among persons with a diagnosis	2010–2015	CDC [30]
Rates of HIV transmission among persons undiagnosed, diagnosed but not retained in care, retained in care but not virally suppressed, and virally suppressed	2009	Skarbinski et al. [25]

PrEP), this was modeled as a proportional reduction in the total incident infections for that year.

Deaths (*t*)

The number of deaths was estimated as the previous year's prevalence times the current year's death rate among those diagnosed.

Calibration and Initial Estimates

We calibrated predicted incidence estimates to published CDC incidence in the years 2010–2015 by scaling predicted values by the quantity sum (published CDC 2010–2015 values)/sum(predicted 2010–2015 values). To bring the latest surveillance estimates up to 2018, we assumed that care continuum parameters of percent diagnosed, retained, and virally suppressed continued to improve at a linear rate since last observed; after 2018 these parameters formed the basis of intervention scenarios. After 2015, we assumed the mortality rate continued the proportional 2.9% annual decline observed during 2011–2015 [23].

Scenarios from 2019 to 2030

After 2018, we projected the HIV epidemic under 3 scenarios: (1) no change in care continuum from estimated 2018 values [87.0% diagnosed, 68.6% of diagnosed persons in care, and 89.9% of persons in care virally suppressed], (2) achieving 95–95–95 by 2025, (3) achieving 95–95–95 by 2030. In the latter two scenarios, we linearly increased each conditional care target to reach 95% by the target year. These scenarios also considered additional prevention from PrEP (and other additional prevention with HIV-negative persons) at levels of 10, 20, and 30% averting transmission events. The 20% of infections averted by PrEP scenario approximately corresponds to earlier estimates that 40% PrEP coverage with 69% high adherence among MSM meeting CDC's PrEP guidelines would avert 33% of expected HIV transmissions from this group [26], who make up 69% of incident infections ($0.69 \times 0.33 = 0.23$) [2]. No PrEP assumptions were made for persons with HIV acquisition risk apart from male-to-male sexual behavior.

Results

Assuming current estimates for HIV care continuum outcomes are maintained over time, we project the annual number of new HIV infections will increase from 41,600 in 2018 to 55,100 in 2030, translating to cumulatively 622,900 new HIV infections during 2018–2030 (Fig. 1). Under the assumption that 95–95–95 goals are met by 2025, new HIV infections will decline from 41,600 in 2018 to 17,900 in 2030, cumulative incidence is 332,800 during 2018–2030, and 290,000 HIV infections are averted during this time period compared to maintaining the 2018 care continuum. If 95–95–95 goals are met by 2030, annual new HIV infections decline from 41,600 in 2018 to 18,900 in 2030, cumulative incidence is 412,400 during 2018–2030, and 210,500 infections are averted.

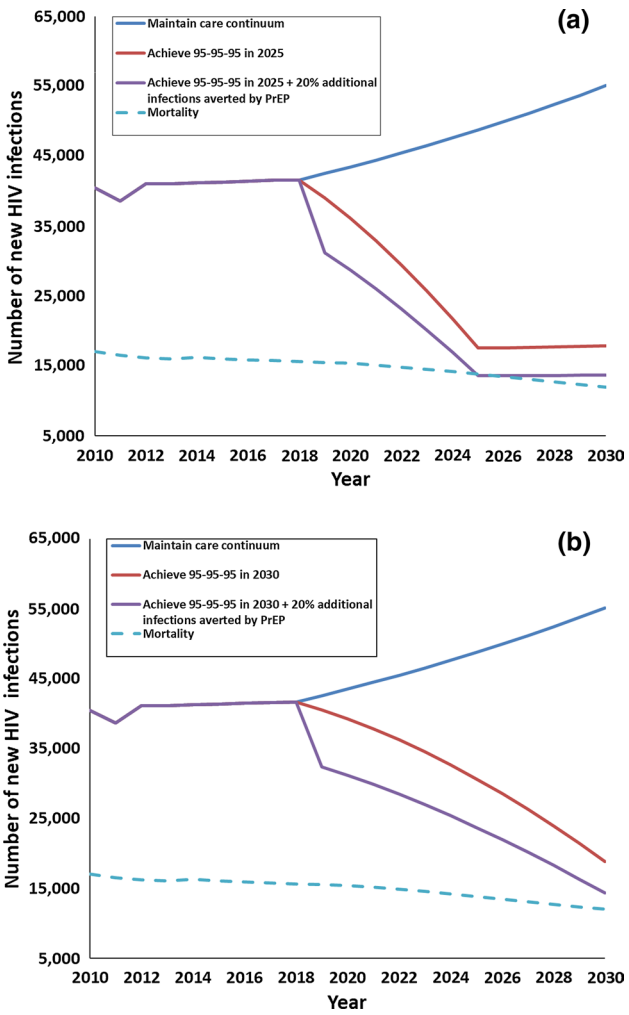

Fig. 1 Estimated incidence and mortality in the United States under varying assumptions of achieving 95–95–95 care continuum targets in (**a**) 2025 and (**b**) 2030

If, in addition to achieving care continuum goals by 2025 or 2030, 20% of infections are averted due to PrEP use among persons at high risk for acquisition, the number of new infections in 2030 is estimated to be 13,700 and 14,300, respectively. Assuming care continuum targets are met by 2025 and 20% of infections are averted due to PrEP use, the estimated number of deaths would be greater than the number of new infections in 2025 and would begin to bend the prevalence curve (14,200 deaths vs. 13,700 new infections),

although additional effort would be needed to maintain a prevalence decline post 2025. If care continuum targets are met by 2025 and 10% or 30% of infections are averted due to PrEP use among persons at high risk for acquisition, the number of new infections in 2030 is estimated to be 15,700 or 11,800, respectively. Similarly, if care continuum targets are met by 2030 and 10% or 30% of infections are averted due to PrEP use, the number of new infections in 2030 is estimated to be 16,500 or 12,200, respectively (data not shown). For a 90% reduction in HIV incidence during the next 10 years, 95–95–95 targets would need to be reached by 2030 and 74% of residual transmissions (beyond those averted through treatment of persons living with HIV), rather than the 20% indicated in our model, would need to be averted through further PrEP scale up, other evidence-based prevention tools to prevent HIV acquisition, and possibly novel strategies as yet untested (data not shown).

In terms of HIV prevalence, if current estimates for HIV care continuum outcomes are maintained over time, the annual number of prevalent HIV infections will increase from approximately 1,200,000 in 2018 to 1,588,700 in 2030 (Fig. 2). Under the assumption that 95–95–95 goals are met by 2025, the estimated number of persons living with HIV in 2030 is 1,344,500, or approximately 242,200 fewer than if care continuum outcomes are maintained. If 95–95–95 goals are met by 2030, the estimated number of persons living with HIV in 2030 is 1,419,700, or 169,000 fewer than if care continuum outcomes are maintained. If 20% of infections are averted due to PrEP use among persons at high risk for acquisition in addition to achieving care continuum goals by 2025 or 2030, the number of prevalent HIV infections in 2030 is estimated to be 1,289,100 and 1,346,700, respectively.

Achieving 95–95–95 care continuum goals by either 2025 or 2030 will require substantial increases from current estimates for percentages of persons diagnosed, in care, and virally suppressed. Achieving 95–95–95 by 2025 would require a 1.3% average percent annual increase in the percentage diagnosed starting in 2019 compared to an average annual percent increase of 0.6% prior to 2019. For retention in care to reach 95% by 2025, an average annual increase of 4.8% would be needed beginning in 2019 compared to an average annual increase of 0.3% before 2019. Viral suppression among persons in care increased by an estimated 3.2% annually, on average, during 2010–2018, and a 0.8% annual increase would be sufficient thereafter to reach 95% in 2025. To reach 95–95–95 in 2030, average annual percent increases of 0.8, 2.8, and 0.5% would be needed for percentage diagnosed, in care, and virally suppressed, respectively, starting in 2019. During the period 2019–2030, this would require retaining an estimated 187,500 more persons living with HIV in care (translating to an additional 2,252,000 person-years of care) and helping 199,000 more persons in care achieve and sustain viral suppression (translating to 2,390,000 person-years of viral suppression) (data not shown).

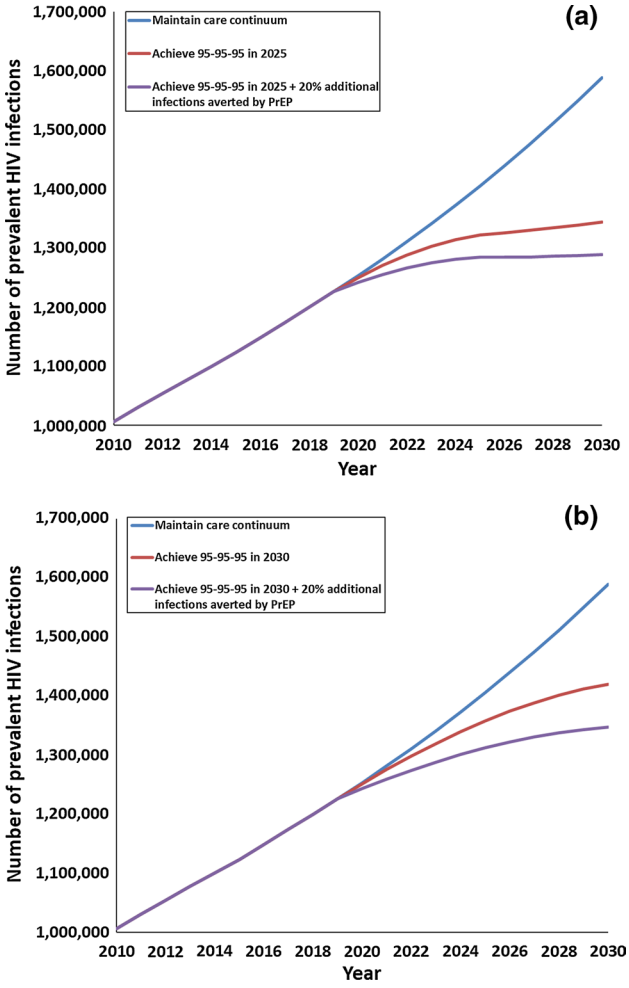

Fig. 2 Estimated HIV prevalence in the United States under varying assumptions of achieving 95–95–95 care continuum targets in (**a**) 2025 and (**b**) 2030

Discussion

Using HIV surveillance estimates and a life-table model, we demonstrated that achieving 95–95–95 goals for HIV care continuum outcomes by 2025 or 2030 would result in an estimated 55–57% reduction from 2018 incidence if care continuum targets are met by 2030 or 2025, respectively. If PrEP is additionally scaled to 40% coverage among MSM at high risk for HIV acquisition, an estimated 66–67% reduction in new HIV infections could be achieved by 2030. Considerable improvements in coverage of prevention and treatment interventions would be needed to achieve these incidence reductions. In a matter of 6–11 years, the

percentage of persons diagnosed with HIV who are in HIV care would need to increase by more than 35% points, from 59% to 95%, and PrEP coverage among MSM with sexual risk for HIV would need to increase from an estimated 12% (94,236 PrEP users in 2017 [27] /813,970 MSM meeting PrEP guidelines [28]) to 40%. These improvements would require substantial investment of resources and innovation in implementation models for reaching populations at highest risk for HIV infection—both at levels never seen before in the course of the U.S. epidemic (Fig. 3).

Early description of the federal administration's HIV strategy indicates that HIV incidence will be reduced primarily through demographic and geographic targeting of interventions such as early HIV detection, expanded HIV care and treatment services, PrEP scale up, and HIV molecular cluster investigation and response [22]. Dramatically reducing new HIV infections by focusing efforts on populations with disproportionate burden of disease is an admirable goal but one which should be grounded in data. Surveillance data indicate at most a 67% reduction in incident infections can be achieved by 2030 if 95–95–95 care continuum targets are met by 2025 and PrEP coverage increases to 40% of MSM with HIV risk. History suggests that national HIV prevention goals should be ambitious but achievable, and that resources allocated should be commensurate with those goals in order to avoid predictable failure to reach targets, pessimism in the HIV community about the ability to effect change, and further stalled progress in addressing the U.S. HIV epidemic [16, 17].

Although we used the most recent HIV surveillance estimates and a transparent analytic approach based on earlier CDC models [24] we note several limitations. Our initial population prevalence, incidence, and care continuum estimates are susceptible to uncertainty inherent in the underlying data sources, but the most recent estimates were used in each case, including a recent update to nationally representative care estimates from the HIV Medical Monitoring Project [20]. Further, because estimates for diagnosis, retention in care, viral suppression, and mortality were not available to the present date, we assumed they improved at a constant rate since last observed. Similarly, HIV transmission rates within each continuum stage were assumed constant over time, but these could evolve due to future behavior changes among persons within each stage and/or the efficacy of ART in reducing transmission. As noted in earlier models, assumed mortality rates may insufficiently account for background deaths among those without a diagnosis, future cohort aging, or future life-span benefits of ART [24, 29]. Although the first two might increase mortality, making targets achievable slightly earlier, whereas the latter might push estimates in the other direction, we expect variation due to uncertainty in future mortality to minimally impact overall findings.

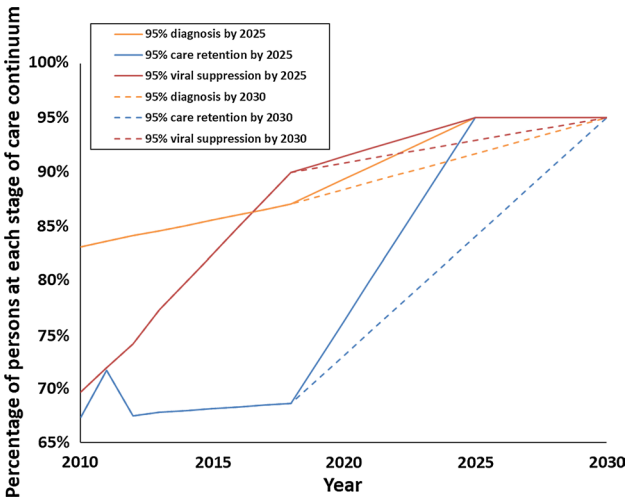

Fig. 3 HIV care continuum annual improvements needed to achieve 95–95–95 targets in 2025 and 2030

The 95–95–95 framework requires that, on average, all populations, regardless of demographic or HIV risk group, reach a nearly universal level of infections diagnosed, in care among diagnosed, and viral suppression among those in care. Even larger improvements in care continuum outcomes than those outlined here would be needed for populations with the highest burden of HIV disease and poorest care continuum outcomes. In 2015, 7% fewer blacks and 5% Hispanic/Latinx persons with diagnosed HIV were engaged in care compared to whites, while 13% fewer blacks and 5% fewer Hispanic/Latinx persons engaged in HIV care were virally suppressed compared to whites [30]. Large racial/ethnic disparities have also been documented for PrEP coverage [31]. Addressing these disparities is paramount for improving health equity and because overall HIV incidence and prevalence declines will require the largest gains are made in populations with disproportionate burden.

Increasing the percentage of persons with diagnosed HIV who are engaged in care to 95% will be the most challenging part of reaching 95–95–95 targets. Evidence-based interventions for improving engagement in care include patient navigation services, strengths based counseling, and centralized services for HIV and non-HIV healthcare needs, including management of mental illness and substance use disorders [32–35]. Although these interventions have proven efficacy, bringing them to scale will require addressing unmet needs for housing, nutrition, and transportation that prevent many people living with HIV from accessing them. In large-scale evaluations of national linkage and care retention programs, implementers cite socio-economic needs of clients as the most significant barriers to achieving desired care retention outcomes. [36, 37] A systematic review of linkage and care engagement interventions found that inclusion of housing support, food

assistance, mental health services and patient navigation services positively mediated both intervention uptake and longer term success [38]. The Ryan White HIV/AIDS Program has delivery models for supportive services that are associated with improved HIV care outcomes, particularly for persons living below poverty guidelines, and can provide guidance for expanding these services [39, 40]. Retention in care targets and associated resource projections should consider that improved social determinants of health among persons living with HIV will be necessary to optimize intervention uptake.

The model described here was developed as part of a collaborative process with the End AIDS Coalition [41]. Led by AIDS United, the process included input from community organizations that have worked to improve the health of persons living with HIV and prevent new HIV infections since the beginning of the epidemic. To be responsive to community needs and locally implementable, national HIV prevention and treatment goals should be set in conjunction with proactively solicited community stakeholder participation. It will be especially important for groups representing populations with the highest burden of HIV disease, such as black MSM and transgender women, to inform goal setting and implementation plans. Last, strategies for intervention scale-up should be flexible and locally adaptable, and better surveillance data, both for local geographic areas and for key populations, will be needed to monitor outcomes at these levels.

Conclusions

These results highlight that, although the administration's goal of 90% incidence reductions by 2030 is likely unachievable with the current toolkit of interventions (unless they are implemented to essentially perfect scale and coverage), it is possible to see incidence reductions that bend the curve of HIV prevalence in the next decade. To do so, extraordinary efforts in HIV care and prevention will be needed. The results presented here can be used to guide estimation of investments needed to achieve these improvements. These estimates will need to consider additional resources and programmatic infrastructure for robust retention programs emphasizing supportive services and to account for the increasing difficulty of diagnosing and treating the last remaining infections as progress is made. Given the unacceptable stagnation of progress in HIV in the U.S. overall, particularly among key minority and risk groups, a new national HIV strategy with achievable targets is critically needed. Political commitment should be accompanied by adequate resources and an implementation strategy that is flexible enough to adapt to local needs and populations.

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