23 million years of life: The survival benefits of antiretroviral therapy for HIV in the US

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PLAIN LANGUAGE SUMMARY: Using a mathematical model, we estimated that HIV treatment in the US has saved over 23 million life-years since 1996. Per-person survival benefit has more than doubled from 1996 to 2025 as treatments improved.

BACKGROUND

- Life expectancy for people with HIV (PWH) on antiretroviral therapy (ART) has increased dramatically since 1996.
- Objective: To quantify the aggregate clinical benefit of ART in the United States from 1996 to 2025.

METHODS

- Design: CEPAC microsimulation model of HIV.
- Population: People newly diagnosed with HIV in the US, 1996–2023 (1.5 million total).
- Comparison: ART vs. No ART for each of 7 cohort eras, including effect of linkage and adherence to ART.
- Projection of benefit if linkage to care had been 100%.
- Outcomes: Per-person and population-level life-years gained, projected lifetime and through 2025.

Table 1. Select model input parameters

Eras (years)	Mean CD4 at diagnosis, cells/uL	30d linkage, %	1yr virologic suppression, %	CD4 treatment eligibility, cells/uL[17]
Era 1: Early unboosted PIs (1996-1997)	269[1]	47[3]	27[5,7,8]	<350
Era 2: 1st generation NNRTIs (1998-1999)	274[1]	47[3]	36[5,9]	<350
Era 3: Boosted PIs (2000-2002)	294[1]	47[3]	43[5,10,11]	<200
Era 4: Improved boosted PIs (2003-2006)	309[1]	47[3]	48[5,13]	<200
Era 5: Diversified salvage regimens including INSTI (2007-2008)	323[1]	65[4]	60[5,14]	<350
Era 6: 1st generation INSTIs as initial ART (2009-2014)	348[2]	75[4]	73[6,15]	<350-Treat all
Era 7: 2nd generation INSTIs (2015-2025)	371[2]	82[4]	80[6,16]	Treat all

PI, protease inhibitor-based ART; NNRTI, non-nucleoside reverse transcriptase inhibitor-based ART; INSTI, Integrase strand transferase inhibitor-based ART

[1] Althoff, *CID* 2010
[2] Lee, *CID* 2020
[3] Gardner, *CID* 2011
[4] CDC supplemental HIV surveillance report, 1996-2023
[5] Nance, *Annals* 2018
[6] CDC HIV Surveillance report, 2010-2016
[7] Staszewski, *NEJM* 1999
[8] Baxter, *JAIDS* 2000
[9] Pozniak, *JAIDS* 2006
[10] Boyd, *Lancet* 2013
[11] Paton, *NEJM* 2014
[12] Gallant, *NEJM* 2006
[13] Yazdanpanah, *CID* 2009
[14] Madruga, *Lancet* 2007
[15] Walmsley, *NEJM* 2013
[16] Sax, *Lancet* 2017
[17] HHS ART guidelines, 1996-2024

Advances in antiretroviral therapy have more than doubled per-person survival benefit since 1996.

RESULTS

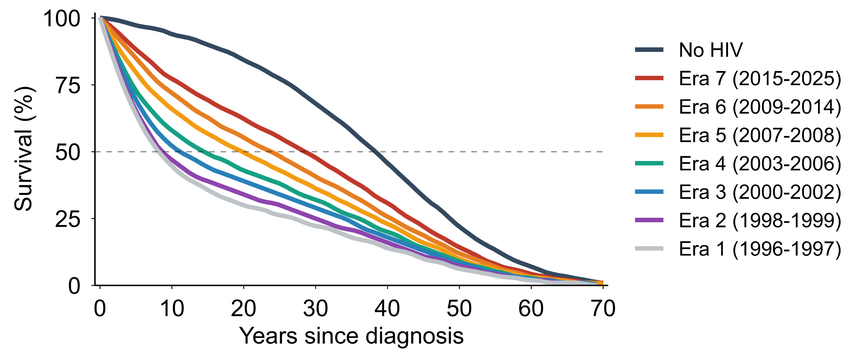
Table 2. Model projected life-years saved by ART among people newly diagnosed with HIV in the US from 1996 through 2025

Eras	People newly diagnosed HIV (n)	Projected over lifetime: LYs saved, per person (yrs)	Projected over lifetime: LYs saved, population (yrs)	Realized through 2025: LYs saved, per person (yrs)	Realized through 2025: LYs saved, population (yrs)
Era 1	173,400	9.5	1,641,400	6.2	1,073,100
Era 2	161,800	10.6	1,718,900	6.4	1,042,800
Era 3	195,200	12.1	2,362,800	6.6	1,286,600
Era 4	224,700	13.6	3,044,600	6.1	1,379,700
Era 5	101,200	15.8	1,600,500	6.0	609,200
Era 6	252,900	17.5	4,436,600	4.6	1,154,400
Era 7	417,100*	19.9	8,316,800	1.1	469,600
Total	1,526,300		23,121,600		7,015,600

*New HIV diagnoses for 2024 and 2025 projected using linear regression with 2019-2023 data

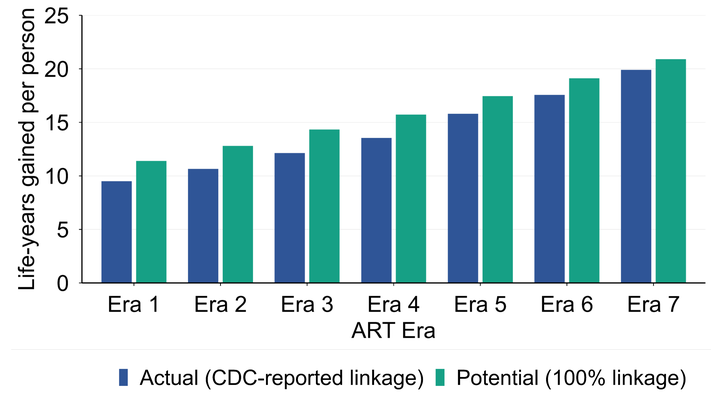
- Total survival benefit: 23.1 million life-years saved since 1996.
- Life years realized by 2025: 7.0 million years; Projected future benefit: 16.1 million additional years (in people diagnosed through 2025).

Figure 1. Projected survival curve of people diagnosed with HIV, by ART era



RESULTS (CONTINUED)

Figure 2. Potential survival benefits by ART era, varying linkage to care



- Varying linkage to care and virologic suppression rates yielded projected benefits of 22.1–25.7 million life-years saved.
- If all diagnosed individuals had linked to care immediately, an additional 2.6 million life-years could be saved over their lifetimes, of which 1.2 million would be realized by 2025.

LIMITATIONS

- Model-based projections rely on published surveillance and ART effectiveness data.
- We did not capture potential impacts of COVID-19 pandemic on HIV diagnosis rates, care engagement, or treatment outcomes during 2020-2021.
- We did not explicitly model prevention benefits of ART and the additional life-years saved from preventing transmissions.

CONCLUSIONS

- Advances in antiretroviral therapy have yielded an estimated 23 million life-years saved in the United States since 1996.
- As treatment has improved since the early ART era, the per-person survival benefit has more than doubled, increasing from 9.5 to 19.9 years across successive eras of care.
- Suboptimal linkage has limited the full population impact of these advances, resulting in an estimated 2.5 million unrealized life-years.
- Continued progress in both treatment and care engagement is critical to fully achieve the life-saving potential of modern HIV treatment.

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