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The economic returns of ending the AIDS epidemic as a public health threat

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ABSTRACT

Background: In 2016, countries agreed on a Fast-Track strategy to "end the AIDS epidemic by 2030". The treatment and prevention components of the Fast-Track strategy aim to markedly reduce new HIV infections, AIDS-related deaths and HIV-related discrimination. This study assesses the economic returns of this ambitious strategy.
Methods: We estimated the incremental costs, benefits and economic returns of the Fast-Track scenario in low- and middle-income countries, compared to a counterfactual defined as maintaining coverage of HIV-related services at 2015 levels. The benefits are calculated using the full-income approach, which values both the changes in income and in mortality, and the productivity approach.
Findings: The incremental costs of the Fast-Track scenario over the constant scenario for 2017–2030 represent US$86 billion or US$13.69 per capita. The full-income valuation of the incremental benefits of the decrease in mortality amounts to US$88.14 per capita, representing 6.44 times the resources invested for all countries. These returns on investment vary by region, with the largest return in the Asia-Pacific region, followed by Eastern and Southern Africa. Returns using the productivity approach are smaller but ranked similarly across regions.
Interpretation: In all regions, the economic and social value of the additional life-years saved by the Fast-Track approach exceeds its incremental costs, implying that this strategy for ending the AIDS epidemic is a sound economic investment.

1. Introduction

AIDS is one of the leading causes of death in low- and middle-income countries (LMICs). In response, the international community has channelled unprecedented resources to these countries to prevent HIV infections and expand antiretroviral therapy (ART) for people living with HIV. Donor governments have been disbursing an average of US$7.45 billion annually for the last ten years [1]. By 2017, the global response improved population health, reducing AIDS-related deaths by 51% since their peak in 2004 [2].

However, the battle is not yet won. Given that only about 57% of those needing treatment in low- and middle-income countries were receiving it in 2017 [2] and that the number needing prevention and treatment services continues to grow, the flattening of annual investment between 2012 and 2016, combined with the absence of significant new commitments from donors in 2017 [3], raises concerns regarding the achievement of the goals agreed by the United Nations General Assembly in the 2016 Political Declaration on HIV/AIDS [4].

Health economists have long eschewed attaching dollar values to health benefits, preferring to compare health investments only to other health investments using cost-effectiveness analysis. But without dollar valuation of health benefits, economists can provide little guidance to policymakers with an overarching remit, such as finance ministers, on whether investments in population health should increase relative to other non-health public investments. Indeed, the application of cost-effectiveness analysis alone, rather than justifying an expansion of spending on all health interventions, arguably forces advocates of different health interventions to compete among themselves for a limited budget.

A series of articles [5–10] culminating in the report of the Lancet Commission on Investing in Health [11] (hereafter CIH) has adopted a more ambitious approach, arguing that global wellbeing would improve by investing more in health, even at the expense of other public investments. Empirical studies of the dollar value that individuals assign to a reduced probability of death—a con-

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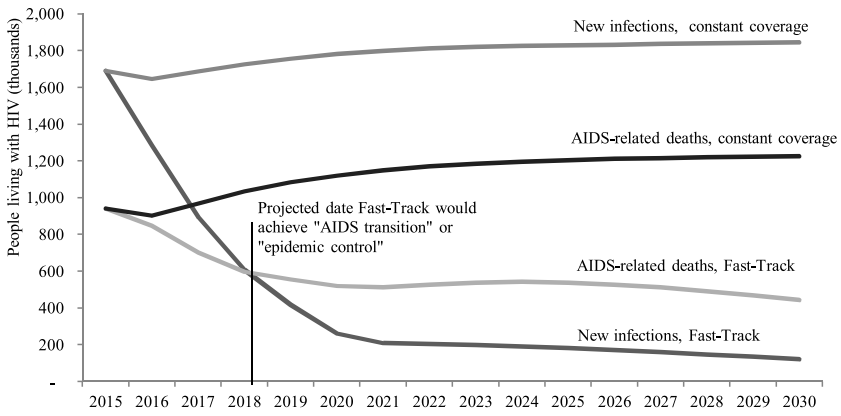

Fig. 1. Key outcomes of Fast-Track and constant scenarios, all low- and middle-income countries.

cept called the "value of a statistical life" or VSL—argue that health can in fact be valued in dollar terms and added to other components of a nation's production to arrive at a "full-income" measure of economic well-being [12]. In other terms, the social value of increasing the life expectancy of an individual for say one year, exceeds the economic value of his or her productivity. According to CIH, "Between 2000 and 2011, about 24% of the growth in full-income in low-income and middle-income countries resulted from health improvements." In countries with high prevalence of HIV, where ART has expanded rapidly, the contribution of health improvements to full-income growth has been much larger. CIH estimated that health improvements in sub-Saharan Africa during the period 2000–2011 contributed almost 6% per year to the growth of full-income measures of per-capita wellbeing.

The present study asks whether, in comparison to a baseline scenario in which coverage with HIV prevention and treatment services remains constant, the social value of health purchased with the "Fast-Track" strategy exceeds its additional cost.

2. Material and methods

We considered two scenarios. First, a "Fast-Track" scenario, which is designed to reduce new HIV infections and AIDS-related deaths by 90% between 2010 and 2030 (UNAIDS' definition of "ending the epidemic as a public health threat") (Fig. 1). Second, a "constant-coverage" scenario where the coverage of HIV-related services were kept constant at 2015 levels.

Under the constant-coverage scenario, the total number of people living with HIV continues to expand, while the Fast-Track scenario projects much greater reductions in AIDS-related mortality, with new HIV infections pushed even lower, so that for the first time since the beginning of the epidemic the total number of people living with HIV begins to decline. Having reached this milestone, known as the *AIDS transition* [13] or *epidemic control* [14,15], the Fast-Track strategy must sustain prevention and treatment implementation for at least another decade to achieve the criteria suggested by UNAIDS as "ending of the AIDS epidemic as a public health threat".

Eq. (1) gives a standard algebraic definition of the incremental benefit-cost ratio as a measure of the economic rate of return of the investment:

$$\text{Benefit} - \text{cost Ratio} = \frac{\Delta B}{\Delta C} = \frac{\left(B^{FT} - B^{CC}\right)}{\left(C^{FT} - C^{CC}\right)} \quad (1)$$

The subscripts FT and CC denote the Fast-Track and constant-coverage scenarios, and all amounts are the present values of the future stream of dollar amounts over the 2017–2030 period, discounted to 2017 at a 3% discount rate.

We reviewed and estimated the country-specific unit costs of the 20 key interventions of the AIDS response for both the constant-coverage and the Fast-Track scenarios (see supplement S1 and Stover et al [16]). The epidemiological projections were performed using the Spectrum and Goals models distributed and maintained by Avenir Health [17]. We applied the Goals model to 28 countries representing 90% of new HIV infections in LMICs and then projected the scenarios for the other LMICs based on their national estimates, coverage rates, epidemiological projections and specific parameters for progression and mortality rates. The health impacts (i.e. number of new HIV infections, people living with HIV, people on ART, AIDS-related deaths) of 20 key interventions were estimated per country and per year. For each country, these interventions were provided at coverage levels according to the two scenarios described earlier.

We further assume that both scenarios will have a similar future cost function, meaning that improvements in efficiency and reductions in unit costs (e.g. with the introduction of medicines in the pool of generics) apply to both the Fast-Track and the constant-coverage scenarios. Regional estimates of the incremental benefit-cost ratio are the summation of the incremental benefits of the countries in a region divided by the summation of their incremental costs.

GDP per country was taken from the IMF World Economic Outlook database until 2021 and has been projected for 2022–2030. GDP per capita is in US dollars, expressed in real 2015 value in order to align with the resource needs estimates prepared by UNAIDS for both scenarios. Regional GDP per capita is the average of each country of the region weighted by its HIV burden. Working age population is defined as the 15-64-year-old populations of each country. Demographic estimates are taken from the United Nations World Population Prospects, and the share of people living with HIV under working age is derived from UNAIDS estimates and projections using Spectrum [18].

We use the full-income approach, as recently developed [12] and applied by CIH, to evaluate the comprehensive economic benefits of improved health, measured by change in mortality risk. The mathematical models are presented in supplement S2. We define a standard mortality unit (SMU) as a reduction of 1 in 10,000 in the probability of death within a single year. Its value ($VSMU_{zt}$) represents the value that individuals in country z and year t are willing to pay for this small reduction (1 in 10,000) in their mortality risk. For consistency with CIH, the value of a SMU is 1.8% of that country's GDP per capita in that year. As CIH and other authors have emphasized, this assumption is strong and subject to revision as individual LMICs perform VSL studies [19]. In supplement S2, we also present a sensitivity analysis of our main results with respect to alternative values of the VSMU in the United States and of the elasticity of that value with respect to a country's GDP per capita.

Table 1
Productivity coefficients.

	CD4 cells count (cells/μL)	Productivity coefficient	Reference
HIV-negative population	–	1.00	–
Newly infected (within a year)	Within the first year of infection	1.00	–
In need of treatment	CD4 cell counts not specified	0.69	Ghailan et al [20]; Larson et al [21]
On treatment	CD4 $\leq$ 350 cells/μL	0.75	Resch et al [22]
	CD4 > 350 cells/μL	1.00	Thirumurthy et al [23]
Late-stage disease/treatment failure	One year before AIDS-related death	0.20	Resch et al [22]

2.1. The economic returns under a productivity approach

We also calculated the economic returns using the productivity approach. Under this approach, the incremental benefit considers, for each country and year, the potential productivity of people affected by HIV under each scenario. We estimated the potential productivity gains for five groups of individuals: i) the HIV-negative population; ii) those newly infected; iii) the people living with HIV in need of treatment but not accessing it; iv) those on treatment and responsive to it, subdivided in two subgroups based on average CD4 cells count at initiation of treatment: CD4 $\leq$ 350 cells/ μ L and CD4 > 350 cells/ μ L; and v) people living with HIV with a late stage of the disease or in treatment failure. Table 1 presents the productivity coefficient extracted from the literature and assigned to each of these five groups relative to a person who is uninfected or infected in the previous 12 months [20–23].

The incremental potential productivity of ending the AIDS epidemic as a public health threat is the sum, per year and discounted (r = 3%), of the per capita GDP weighted potential productivities of the incremental number of people averting infection for a given year, and of the five groups of people affected by HIV (see supplement S2).

3. Results

Investing in ending the AIDS epidemic as a public health threat by 2030 will generate large benefits among low- and middle-income countries in terms of wellbeing (Table 2). Under the constant-coverage scenario, the number of people living with HIV will continue to grow, leading to increasing social and fiscal burdens. In contrast, the high up-front investment within the Fast-Track scenario will trigger disproportionate gains in material income and gains in longevity. We estimate that the Fast-Track scenario will generate net additional economic returns to the low- and middle-income countries of more than US$466.86 billion compared to the constant-coverage scenario. These benefits represent an average reduction of 1.09 SMU for all low- and middle-income countries over 2017–2030. This reduction in mortality represent US$88.14 per capita.

For all low- and middle-income countries, the incremental cost to reach these benefits represents US$13.69 per capita. The economic returns represent 6.44 times the investment it requires. Such a return is consistent with the 9–20 benefit-cost ratio for all health interventions estimated by CIH [11] using a comparable full-income approach, value of a SMU, income elasticity and discount rate. Analysis by region reveals substantial variation around this global average, with the full-income social benefits per incremental dollar ranging from US$1.05 in Eastern Europe and Central Asia to $6.58 in Asia-Pacific.

Considering that 100% of these benefits will be reaped by the countries themselves, and that 12%, 45% and 95% of resource needs will be from domestic sources in 2020 for low-income, lower-middle-income and upper-middle-income countries, respectively [24], the actual returns of each US dollar from domestic resources invested in a Fast-Track approach will bring almost US$8.46, US$6.37 and even US$13.63 in low-income, lower-middle-income and upper-middle-income countries, respectively, making the Fast-Track approach a highly efficient investment of domestic resources in LMICs (see Supplement S3).

3.1. Comparing results with the productivity approach

Using the productivity approach, the economic returns of ending the AIDS epidemic by 2030 are US$2.55 [0.81–3.09] for each US dollar invested between 2017 and 2030. See Table 3. Unsurprisingly, these economic returns are lower than the ones estimated under the full-income approach. The excess of the full-income incremental benefit above the incremental benefit of the productivity approach can be viewed as a proxy for the valuation of health in excess of its contribution to productivity (see supplement S4). The size of the incremental benefit of better health varies from one region to another. One explanation probably lies in the fact that the configuration of the AIDS response varies between countries and regions; benefits of better heath are proportionately smaller

Table 2
Economic returns of the Fast-Track scenario of ending the AIDS epidemic by 2030: The full-income approach.

	Incremental benefits 2017-2030		Incremental costs 2017-2030		Returns on investment 2017-2030
Region	reduction in mortality in SMU ΔB	value of mortality reduc. per capita (US$) ΔB pc	cost (US$ bn) ΔC	cost per capita (US$) ΔC pc	benefit/cost ratio ΔBpc / ΔCpc
Africa - Eastern and Southern	4.82	291.82	25	45.18	6.46
Africa - West and Central	2.45	78.89	17	28.64	2.75
Asia and Pacific	0.47	34.15	21	5.19	6.58
Eastern Europe and Central Asia*	0.48	41.43	5	39.61	1.05
Latin America and Caribbean	0.70	117.09	13	22.79	5.14
Middle East and North Africa	0.15	12.84	4	11.21	1.15
Average for all LMIC	**1.09**	**88.14**	**86**	**13.69**	**6.44**
Low-income countries	2.63	35.80	27	34.80	1.03
Lower middle-income countries	0.80	32.36	36	11.25	2.88
Upper middle-income countries	0.94	129.03	23	9.94	12.98

Real US$ (2015), discounted (r = 3%); Value of a SMU = 1.80% GDPpc; Income elasticity of a SMU = 1.

* Russian Federation not included.

Table 3
Economic returns of the Fast-Track scenario of ending the AIDS epidemic by 2030: The productivity approach.

	Incremental benefits		Incremental costs		Benefit/cost ratio
Region	total (US$ bn) ΔB	*per capita* (US$) ΔB *pc*	total (US$ bn) ΔC	*per capita* (US$) ΔC *pc*	ΔB*pc* / ΔC*pc*
Africa - Eastern and Southern	80	139.54	25	45.18	3.09
Africa - West and Central	34	54.34	17	28.64	1.90
Asia and Pacific	65	16.01	21	5.19	3.08
Eastern Europe and Central Asia*	5	36.05	5	39.61	0.91
Latin America and Caribbean	35	59.86	13	22.79	2.63
Middle East and North Africa	3	9.08	4	11.21	0.81
Average for all LMICs	**222**	**34.97**	**86**	**13.69**	**2.55**
Low-income countries	18	22.28	27	34.80	0.64
Lower-middle-income countries	69	21.33	36	11.25	1.90
Upper-middle-income countries	74	32.30	23	9.94	3.25

Real US$, 2015, discounted (r = 3%).
* Russian Federation not included.

in countries and regions that cannot promptly reduce the share of people living with HIV in need of treatment.

4. Discussion

We estimated the economic return to ending the AIDS epidemic by 2030 by comparing two scenarios: The Fast-Track scenario and a constant-coverage scenario.

The constant-coverage scenario is consistent with donors, governments and their constituencies deciding to retreat from the advances of the past decade, thereby allowing a rapid increase in both AIDS-related mortality and in new HIV infections (Fig. 1) and subsequent growth of the burden of HIV. Thus, the constant-coverage scenario is a plausible lower bound on the policies and financing to combat AIDS in the next decades, justifying its role in our analysis as a counterfactual to the Fast-Track scenario.

Large economic returns accrue to countries under the Fast-Track scenario compared to the constant-coverage scenario for all regions, with each incremental US dollar spent yielding more than US$6 of social benefit. Benefits are proportionately higher as the income level of a country increases. Therefore, financing authorities such as ministers of finance from LMICs should find it attractive to invest financial resources to end the AIDS epidemic as a public health threat by 2030, considering the highly appealing investment it represents. Our results also highlight the importance for the international community to support LMICs in this endeavour, which remains a positive donor investment but with lower economic returns.

The above results are consistent with other estimates of the return on investment of public health interventions. A systematic review of public health interventions in high-income countries [25] found the median benefit-cost ratio to be 8.3. Also, the Lancet Commission on pollution and health [26], which valued the benefits of pollution mitigation and prevention in terms of both reduced mortality and economic gains, used methods which resemble the full-income approach. It is estimated that every US dollar invested in air pollution control in the United States could yield $30 in benefit. Finally, Pradhan and Jamison [27] applied a *full benefit-cost analysis* approach to education by adding the full-income value of mortality reduction to the usual wage benefits of education. They found a benefit-cost ratio of 3.2–6.7 for one additional year of schooling in LMICs.

Benefit-cost analyses such as the full-income approach enable national authorities to better allocate available resources by measuring the returns of health interventions. This approach differs from cost-effectiveness analysis by accounting for all significant outcomes, health and non-health, and valuing them using a monetary unit [28].

4.1. Limitations of this study

While the rate of return using a full-income approach is an important guide to investment, it should not be the only criterion being considered for prioritizing investment expenditure. For example, some health interventions may have a lower return on investment but nevertheless be essential to reducing the inequalities and poverty that arise from catastrophic health expenditures.

Cost per person living with HIV is negatively correlated (R= -0.59) with return on investment (see supplement S5). A closer look at the cost components of the AIDS response [24] explains the disparity across regions. Sub-Saharan Africa, together with Asia-Pacific, are home to almost 94% of the global number of people living with HIV. Over the period 2017–2030, these regions have substantially lower incremental total cost of the Fast-Track response per person living with HIV. These regions are most likely able to benefit from economies of scale [26], tailored service delivery models with increased efficiency [29] and generally less expensive human resources and antiretroviral drugs.

Some regions are facing proportionately much higher costs per person living with HIV. For example, the HIV epidemic in Eastern Europe and Central Asia is largely driven by people who inject drugs (PWID). Responding to this type of epidemic requires additional activities such as harm reduction programmes, whose costs accounts for 23% of the total cost of a Fast-Track approach for the region, the second largest cost after ART (27%).

In addition, the enforcement of enhanced bilateral trade agreements, also called TRIPS+, may raise the price for antiretroviral drugs now and in the future. Generic competition remains an essential factor for antiretroviral price reduction [30]. Patents for newer antiretroviral medicines and formulations are severely restricting or eliminating generic competition in many countries [31]. Studies show that countries from Latin America and the Caribbean could be treating up to 3.8 times more patients if procurement prices were closer to the lowest regional generic price [32].

Finally, the incremental reduction in the number of new HIV infections and AIDS-related deaths under the Fast-Track scenario compared to keeping coverage constant will generate additional benefits that are not captured by the two models developed here. First is the reduction in the cost of premature death, both from a household and a health system perspective. The latter should enable reallocation of resources to interrelated diseases, such as tuberculosis, human papillomavirus or hepatitis B/C, and trigger economies of scope. Second is the significant increase of expenditures on education and schooling as a result of reduced perception of mortality risk induced by the availability of ART, in addition to reducing the number of AIDS orphans and other social costs, especially in Eastern and Southern Africa.

5. Conclusion

Despite achieving dramatically reduced AIDS-related deaths and modest reductions in new HIV infections, the AIDS response cannot declare victory. As the world has embarked upon the Agenda for Sustainable Development, the Fast-Track strategy to *end the AIDS epidemic by 2030* requires increased financial commitment from low- and middle-income countries as well as from the international community. This study estimated the incremental costs, benefits and economic returns of ending the AIDS epidemic using a full-income approach, which values both the changes in income and in health, as well as a productivity approach. It appears that additional investment would be highly effective, providing significant returns from both human and economic perspectives. With a discounted average investment of US$18.8 billion per year between 2017 and 2030, representing an increment of US$4.5 billion yearly compared to a constant scenario, an additional 8.51 million deaths and 21.33 million new infections could be averted in all LMICs. Under the full-income approach, each US dollar invested generates US$6.44 in economic returns, corresponding to a net additional average social benefit of US$33.35 billion per year between 2017 and 2030. The investment to end the AIDS epidemic as a public health threat generates a high economic return and thus merits commensurate financial support.

Conflict of interest

The authors certify that they have no affiliations with or involvement in any organisation or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.healthpol.2018.11.007.

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