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ORIGINAL PAPER

The welfare costs of HIV/AIDS in Eastern Europe: an empirical assessment using the economic value-of-life approach

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Abstract Based on the aggregation of individual willingness-to-pay for a statistical life, we calibrate an inter-temporal optimisation model to determine the aggregate welfare loss from HIV/AIDS in 25 Eastern European countries. Assuming a discount rate of 3%, we find a total welfare loss for the whole region that exceeds US $800 billion, approximately 10% of the region's annual GDP between 1995 and 2001. Although prevalence and incidence rates diverge sharply between countries—with central Europe far less affected than major countries in the Commonwealth of Independent States and the Baltics—the epidemic is likely to spread to all countries unless a coherent strategy of prevention and treatment is backed up by substantial increases in healthcare investments. The sheer size of this task and the international nature of the epidemic render this one of the most important current challenges for all of Europe.

Keywords HIV/AIDS · Eastern Europe · Value of life · Social costs · Human capital · Calibration

JEL Classification D91 · I12 · I18 · J17

Introduction

HIV/AIDS impacts the economies of Eastern Europe—here broadly defined to include Central Europe—in many ways. Greater morbidity and mortality reduce the labour supply, lower government tax revenues, and trigger more health spending. In an inter-temporal context, HIV/AIDS may depress savings and discourage investment, especially in human capital, as the return on investment declines with poorer population health. In Eastern Europe, the spread of HIV/AIDS may even contribute to population aging and demographic decline. To assess the full economic cost of HIV/AIDS in monetary value, we estimate country-level population-wide aggregates of individual willingness-to-pay for an HIV/AIDS-free life given the rising threat of the epidemic in Eastern Europe. We do so by adapting Philipson and Soares' [1] estimation approach for the welfare loss from HIV/AIDS in Sub-Saharan Africa, and find that, despite lower prevalence, the aggregate or social willingness-to-pay for the absence of HIV/AIDS are about as high in Eastern Europe, mainly because per capita income levels and growth rates are higher and more human capital has been accumulated than in sub-Saharan Africa. These findings are relevant to a number of urgent policy questions, such as how much money should be spent on HIV/AIDS prevention and treatment, what countries would gain the most, how much help would be warranted from the European Union, and which countries should be prioritised.

In most countries of Eastern Europe, the official numbers of AIDS cases, as reported in UNAIDS for 2004, 2005 and 2006 [2–5], are still comparatively low, and the rate of HIV-infection in children seems close to zero, although HIV prevalence among pregnant women is a problem and gaps in the data may be a source of underestimation in some countries. Yet even the official figures for Ukraine and Russia are alarming and imply an increasing threat also to their neighbours. Ukraine and Russia report the highest and second-highest HIV prevalence and 21% and 66%, respectively, of all new HIV diagnoses in Eastern Europe

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and Central Asia in 2005. In Central Europe, two-thirds of all HIV infections are reported from Poland and Romania. The main transmission route throughout Eastern Europe is intravenous drug use, accounting for more than 60% of new HIV cases for which the transmission mode is known, and resulting in a particularly high prevalence of HIV/AIDS among the young, between 15 and 30 years of age. In the Russian Federation, UNAIDS data suggest that 66% of newly registered HIV cases are due to injecting drug use, and 80% of HIV infections through intravenous drug use are in persons below 30 years of age. In Belarus, 60% of HIV-infected persons are aged 15–24, in Ukraine 25% are under 20, and in Kazakhstan about 70% are under 30 years of age. Figures 1 and 2 summarise country-level trends in HIV-prevalence and incidence rates.

Both in terms of transmission routes and access to treatment, the situation varies substantially between countries. In Hungary, Slovenia and the Czech and Slovak Republics, the number of HIV/AIDS-cases has been kept at a low level, with the main transmission route being men having sex with men. In parts of South Eastern Europe, especially those countries in conflict and difficult transition, drug use and risky sexual behaviour are the main factors, making a rapid spread of the epidemic more likely. Access to antiretroviral therapy (ART) also differs sharply across countries. While many Central European countries provide access on a similar level as Western Europe, reaching more than 75% of those in need, the countries of Eastern Europe reach on average only 15%—the second lowest ART coverage of any world region of low- and middle-income countries reported by UNAIDS. Russia, with one of the highest rates of HIV prevalence, is estimated to provide ART access for less than 2% of the people in need of treatment. Expanding access to treatment would lower mortality, but may increase the number of diseased for whom AIDS would become a chronic condition. Our analysis ignores the welfare loss of the chronically ill and values only changes in mortality.

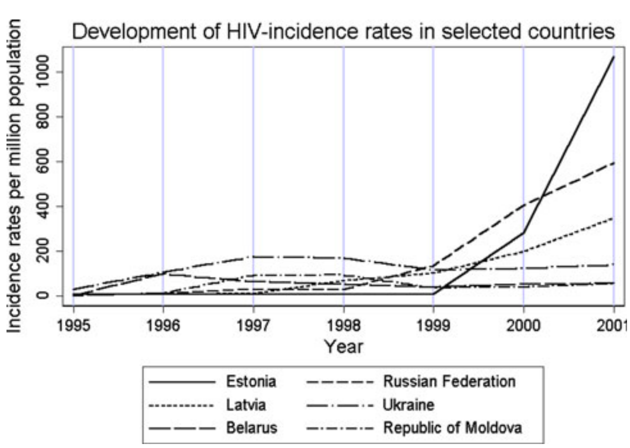


Fig. 1 Development of HIV-incidence from 1995 to 2001

To aggregate individual willingness-to-pay for reductions in mortality, we build on the generic model developed in Becker et al. [6] as modified and calibrated by Philipson and Soares [1] to assess the welfare gains from a hypothetical "No-AIDS"-scenario in sub-Saharan Africa. These hypothetical gains are the full social costs that HIV/AIDS imposes on the respective country or region. The model first determines the marginal willingness of individual persons to pay for lower mortality, essentially the present value of consumption in the additional years of life that the elimination of HIV/AIDS would generate, and then aggregates these values across different types of individuals to determine the social marginal willingness-to-pay. As an innovation, we incorporate survival probabilities that are contingent on a country-level measure of ART access, which varies substantially between our Eastern European sample countries. As part of the calibration, we fit both the generic model and the hypothetical "No-AIDS"-scenario to the actual situation in Eastern Europe at the beginning of the twenty-first century, using publicly available data for as many parameters as possible. The remaining parameters are determined endogenously using standard methods and kept constant when we calibrate the effects of the counterfactual changes in survival probabilities that define the "No-AIDS"-scenario.

The calibration offers two major insights. First, since countries throughout Eastern Europe have much higher per capita incomes, smaller mortality increases will suffice to generate welfare losses comparable in size to those suffered in Africa. By the same token, Eastern Europeans can expect to enjoy relatively large welfare gains from a given improvement in survival. Longevity and per capita income are complements in terms of utility because higher income allows people to consume more in any additional year of life. Second, Eastern Europe's much higher investments in human capital tend to increase the influence of age on the value of gaining additional years of life, albeit in a non-linear fashion. People typically build their stock of human capital until around age 35, both through formal schooling and from practical work experience, and tend to make merely maintenance investments at higher ages so that their human capital declines and becomes at least partly obsolete. Assuming the present value of individual stocks of human capital follows an inverted U-curve over the life cycle, people between 25 and 45 years of age will tend to place a greater value on improved survival than those below or above this interval. By implication, young people may rationally behave less risk-averse with regard to HIV/AIDS than those who already have developed their human capital. Moreover, mortality increases in the age groups that are the most human capital-intensive in Eastern Europe

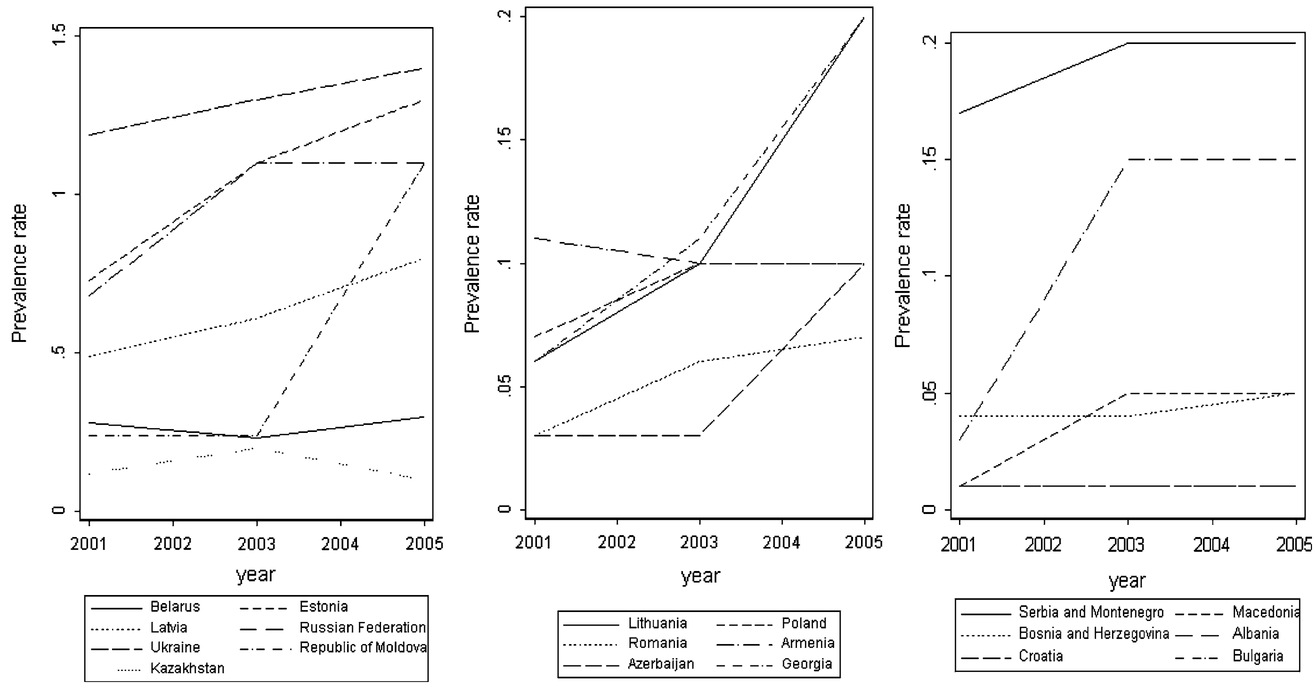


Fig. 2 Development of HIV-prevalence rates from 2001 to 2005. Source: UNAIDS/WHO (2004, 2006). Report on the global AIDS epidemic, Annex 2: HIV and AIDS estimates and data

will have a greater welfare impact there than they would have in countries where little or no investment in human capital takes place. In sum, even at lower HIV prevalence, Eastern Europe may already face social costs of the same order of magnitude as sub-Saharan Africa.

In the remainder of this paper, a section on "Theory" describes the model in more detail, "Data and empirical methods" discusses the quality of our data, measurement issues and novel aspects of our empirical methods, including specifics of the Eastern European context, "Results" presents our calibrations for the welfare costs associated with HIV/AIDS at the individual and social level, respectively, and the "Discussion and conclusion" section concludes with a brief discussion of policy implications and opportunities for further research to overcome the limitations of our study.

Theory

Willingness to pay for lower mortality

To identify the relevant measure of individual willingness to pay, we adopt the perspective of a statistical life, a person who does not yet know whether s/he will be infected with HIV at some point in the future. Placing a finite monetary value on a statistical life is compatible with the general ethical imperative to use all available means to save any identified life when it comes under acute threat, such as the life of a person suffering from AIDS. The key policy question is how much should be spent on making available the means, including diagnostic and treatment facilities, laboratory equipment and trained personnel, medical centres, hospital beds and medicines, that can be used in the event of disease or injury. The value of a statistical life (VSL) is found by studying how much lifetime consumption individuals would be willing to give up to live with lower mortality and with the expectation of a longer life [7]. This can often be inferred from revealed preferences, such as compensating wage differentials between jobs with different mortality risks.

The value-of-life methodology provides a consistent empirical approach to account for the intrinsic value of life, instead of merely counting a person's contribution to gross domestic output (GDP) and placing arbitrary weights on the lives of economically inactive persons. It seems well suited to inform resource allocation in HIV/AIDS prevention and treatment. The HIV/AIDS mortality risk for most susceptible individuals lies in the relatively small range on which traditional estimates of the statistical value of life are based. Moreover, the value-of-life methodology automatically includes the value of positive externalities, such as lower rates of HIV infection, that prevention and treatment generate and that are difficult to include in conventional cost-effectiveness analyses measuring the outcome of prevention and treatment in terms of non-monetary aggregates, such as gains in life expectancy, quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs).[1]

Formally, reductions in mortality that result from improvements in medical care, such as the eradication of HIV/AIDS, can be modelled as an exogenous shift factor θ in the survival functions, denoted $S(t, a)$, that serve as a measure of the cumulative probability to survive up to a given future time period t or of remaining life expectancy as of each individual's current age a. Our empirical calibration of the implied welfare gains assigns monetary value to changes in S that are induced by changes in θ, $S_\theta(t, a) = \partial S(t, a; \theta)/\partial\theta$, allowing for variations in survival probabilities contingent on the probability of becoming infected. The valuation must be based on a marginal analysis of people's willingness to substitute income for a lower rate of future mortality, quantifying the marginal willingness to pay for mortality reductions, at a given age a ($\mathrm{MWP_a}$). To this end, Philipson and Soares [1] provide an analytical expression that uses time series observations only for income $y(t)$ and consumption $c(t)$ and is derived from the maximisation of discounted utility over a person's remaining lifetime under the technical assumption of a complete contingent claims market:

$$\mathrm{MWP}_a = \mathrm{e}^{-r(t-a)} \int_a^\infty \{c(t)/\varepsilon[c(t)] + y(t) - c(t)\} S_\theta(t, a)\mathrm{d}t. \tag{1}$$

In addition, the constant rate of interest, r, at which the future is discounted, a key role is played by the elasticity of instantaneous utility, $u(\cdot)$, with respect to c at time t, denoted $\varepsilon[c(t)] = (\partial u(c)/u(c))/(\partial c(t)/c(t))$ with $\partial c(t)$ defined as the numéraire equal to unity. ε is always positive and must be smaller than c since $\varepsilon(\cdot)/c$ is equal to the ratio of marginal to average utility and the assumption of diminishing marginal utility of consumption implies that marginal utility is smaller than average utility. $\mathrm{MWP_a}$ rises as ε approaches 0. $c(t)/\varepsilon[c(t)]$ expresses the direct utility gain from a larger survival probability up to t while $y(t) - c(t)$ expresses an indirect gain, the income surplus in period t that can be used to purchase additional consumption in other periods. As the future is discounted, individuals are generally willing to pay more for a given distribution of increases in survival probabilities across biographical time, the closer they are to the age in which the increase is maximal.

[1] In this vein, Stover et al. [8] estimate the costs for prevention per infection averted in Eastern Europe at US $ 9,148 and compare this with an estimated net present value of lifetime treatment at US $ 11,203 to infer savings of US $ 2,055 per infection averted during the 2005–2015 period. The value-of-life methodology suggests these cost savings are only a small fraction of the total social value of lower HIV infection rates.

Aggregation and discretisation

Since the relevant variables are flow variables, only observed annually, we calculate the social value of eliminating HIV/AIDS by simply summing the individual age-specific values of $\mathrm{MWP_a}$ across a, weighting them by the size of population $P(a)$ in the respective age group in discrete time:

$$\mathrm{MWP_{social}} = \sum_{a=0}^{\infty} \mathrm{MWP}_a \cdot P(a). \tag{2}$$

This presupposes a time-invariant population distribution across a and ignores the hypothetical willingness of unborn future members of society to pay for the absence of HIV/AIDS. Moreover, since separate data on income and consumption at different points in people's biographical time are not available, we follow Philipson and Soares [1] and abstract from lifecycle-considerations, so that $r = \rho$, the rate of time preference, and per capita income is time-invariant and equal to per-period consumption, $y(t) = y = c$. This amounts to assuming that all individuals within a country share the same average material living standards and face the same cross-sectional mortality profile from a given age a onwards so that we can use standard measures for country-wide GDP per capita.

Discretisation further requires an inter-temporal utility function that is additively separable across periods and based on an instantaneous utility function that incorporates state dependence with respect to being alive or dead. This implies, as Rosen [7] first saw, a subsistence level of consumption c^* with $u(c^*) = 0$ at which people are indifferent to being alive or dead. Becker et al. [6] suggest the flexible functional form $u(c) = c^{1-1/\gamma}/(1 - 1/\gamma) + \alpha$, in which γ represents the elasticity of substitution in consumption between different periods of time and α normalises the utility of being dead to zero, irrespective of the level of c. The higher a person's γ, the better can they substitute longevity by current consumption and the lower their willingness to pay for a reduction in mortality. As α essentially determines the threshold of consumption $c^* = (\alpha/\gamma - \alpha)^{\gamma(1-\gamma)}$ below which an individual would prefer to be dead, α must assume a negative value if γ is larger than one. As Philipson and Soares [1, p. 322] show, these considerations lead to the following discrete-time expression for the social marginal willingness to pay:

$$\mathrm{MWP}_{\mathrm{social}} = \sum_{a=0}^{\infty}\left[P(a)\left(\frac{y}{1-1/\gamma}+\alpha y^{1/\gamma}\right) \times \sum_{t=a}^{\infty}(1+r)^{-(t-a)}S_{\theta}(t,a)\right], \qquad (3)$$

whose first term in brackets expresses the income value of being alive relative to that of being dead, and whose second term represents the aggregate of survival gains or losses over the remaining lifetime.

The influence of human capital on the income distribution across age groups

While our benchmark calibration assumes perfect consumption smoothing over the lifecycle, the model can easily be adapted to allow for age-dependence of per capita income and consumption as annual earnings typically rise with workers' age during the build-up of human capital, the acquired knowledge and skills that enable workers to be more productive and earn higher wages, and fall when the stock of human capital begins to become obsolete and to depreciate. In principle, investments in human capital have two primary effects in our context. On the one hand, they imply a higher average income and a higher average willingness to pay for the elimination of HIV/AIDS, which is reflected in countries' GDP per capita. On the other hand, they also affect the distribution of income across age groups and may thus imply that individual willingness to pay depends on age. At any given age, we take people's stock of human capital as an exogenous endowment and thus ignore the potential reverse causality from rationally expected mortality increases due to HIV/AIDS on the private incentives to invest in human capital. To focus on the second effect, we hold population-wide per-capita incomes constant, and calibrate a scenario in which individual income rises with age to reflect rising returns from a growing stock of human capital until age 35 and declines to reflect diminishing returns thereafter. Compared with our benchmark calibration, the human capital scenario differs only in terms of the distribution of incomes across age groups. Even our stylised human capital scenario can make a substantial difference in terms of the welfare costs as mortality from HIV/AIDS is particularly high at prime ages. The benchmark calibration is more likely to underestimate the true welfare costs of AIDS.

Data and empirical methods

Parameterisation

Besides countries' annual per-capita incomes, our calibrations require empirical estimates of three essential parameters: the rate of time-preference, ρ; the inter-temporal elasticity of substitution, γ; and the life-death indifference parameter, α. As the time-preference rate is assumed constant for all periods and equal to the market rate of interest, in our benchmark calibration we set r equal to 0.03, the rate that international organisations such as the World Bank commonly use to discount the future in advanced countries. For the sake of comparability with Philipson and Soares' [1] study on Africa, we also calibrate our model for r equal to 0.1 and perform sensitivity analyses to illustrate the influence of r on the welfare costs of HIV/AIDS in Eastern Europe. We find that the rate of time preference has a major impact on the values of longevity gains.[2]

Given the instantaneous utility function suggested by Becker et al. [6], both γ and α depend on the consumption elasticity of instantaneous utility, $\varepsilon[c(t)]$ and, ultimately, on the value people place on being alive. For a given level of c, a higher VSL implies a higher $\varepsilon[c(t)]$. The utility function implies $\varepsilon = u'(c)c/u(c) = c^{1-1/\gamma}/[c^{1-1/\gamma}/(1-1/\gamma)+\alpha]$ so that a higher value of $\varepsilon[c(t)]$ is associated with a lower value of α and a lower subsistence income at which the individual is indifferent between life and death. Empirical estimates of the VSL and the aggregate per-capita value of a change in mortality risk tend to vary with the characteristics of the population as well as with the type and level of that risk. Since the literature does not offer methodologically consistent VSL estimates for all countries of Eastern Europe, we follow Philipson and Soares [1] in using parameter values that are calibrated on the basis of United States data, as described in Murphy and Topel [9]. They estimate that individual workers would be willing to accept an increase of 1/10,000 in the probability of dying on the job in exchange for a US \$ 500 compensation. Since 10,000 workers would have to be employed for one person to die in a statistical sense, the VSL is given by $10{,}000 \times \$500 = \$5$ million. This confirms the estimate of an influential early study by Viscusi [13] and implies $\varepsilon = 0.346$.

Using this estimate of ε, and the conclusion from a meta analysis for γ by Browning et al. [14] suggesting a value slightly above 1, Philipson and Soares [1] set $\gamma = 1.25$ and calibrate the value for $\alpha = -16.16$. Our benchmark calibration adopts the same parameter values. Additional sensitivity analyses are based on several different values

[2] The health economics literature has not found a consensus on the correct discount rate. Viscusi and Moore [9] suggest a discount rate between 1% and 14%, yet newer estimates lie mostly below 10%. Based on contingent valuation, instead of revealed preferences as in wage compensations for occupational risks, Johannesson and Johansson [10] find discount rates for life years between 0 and 3%, Cairns and van der Pol [11] for health effects between 6 and 9%, whereas Ganiats et al. [37] find rates from negative to 116%. See also Frederick et al. [12].

for γ ranging from 1.25 to 1.1, to assess the implications of a lower substitutability between quality and quantity of life that is likely to characterise the situation in Eastern Europe compared with sub-Saharan Africa. The implied value for α ranges from -16.16 to -20.46, as shown in Table 3.

The distribution of HIV-infections

To calculate the economic gains from decreasing the risk of contracting HIV, we first need to estimate the distribution of HIV-incidence across age groups, and determine the survival probabilities of the infected conditional on the country-specific probabilities of access to effective ART treatment. We then calculate counterfactual survival probabilities using the "infra-marginal valuation formula" introduced by Becker et al. [6].

Table 1 provides a summary of the relevant information on treatment access, costs and the age-dependency of infections for the year 2002. To account for the stylised fact that HIV incidence rates are higher in younger populations between 15 and 30 years of age, and in specific subpopulations, we assume that infection occurs only in the age interval from 15 to 49 years and that, in the Commonwealth of Independent States (CIS-States), 70% of all HIV infections occur between 15 and 30 years of age. Assuming the distribution of HIV-incidence is proportional to the population distribution, 50% of the cumulative number of annual new HIV infections will occur in the population between 15 and 29 years of age. Pelletier [15] suggests a Weibull distribution for modelling the age-specific distribution of HIV incidence rates, and we adopt this model for the CIS-States, including Armenia, Azerbaijan, Georgia, Ukraine, Belarus, Russia, the Republic of Moldova and Kazakhstan, where a very young population is the main group with new infections. The Weibull distribution is defined by two parameters and assumes monotone hazard rates for new infections with rising age. We fit this distribution using the shape parameter $\delta = 1.96$, scale parameter $\beta = 1.7$ and a characteristic lifetime T of 20, defined as the point in time at which 63.2% of the cases are infected, since $1 - e^{-(T/T)^{\delta}} = 1 - e^{-1} = 0.632$. To calculate age-specific incidence rates, we determine the population at risk by subtracting the people already living with HIV/AIDS from the population in each age group, using prevalence rates reported by UNAIDS [2, 3]. We then multiply the population at risk by the incidence rate, as a percentage of the total population, to get the number of annual new infections in each age-group. The ratio of new HIV cases per age-group over the total population at risk gives us the age-specific incidence-rates with which we proceed to calculate the conditional survival probabilities.

For the survival probabilities, we make use of Philipson and Jena's [15, 16] estimation of HIV-survival curves conditional on the age of infection and subsequent access to treatment. Once infected, the individual is assumed to follow a survival curve resembling that of non-infected "healthy" individuals at some older age Y. The exact age Y is found by comparing the survival curves for HIV/AIDS-patients in the first 5 years after diagnosis with a similar stretch of "healthy" survival curves at a more advanced age. Philipson and Jena [16] use these comparisons to quantify improvements in survival from improvements in medical technology. For example, survival after a new HIV-diagnosis in the year 1984 was approximately equivalent to the survival of a non-infected 86-year-old, while in 2000 it was already equivalent to that of a 68-year-old.

We calculate "healthy" survival curves on the basis of survival probabilities during discrete age periods: $S(t+1, t) = 1 - N(t+1, t)/(P(t+1, t))$, where $N(t+1, t)$ represents the number of deaths between ages t and $t+1$, and $P(t+1, t)$ the population at risk between these ages. We next construct contingent survival probabilities in which we take into account the probability of being infected and the probability of getting access to treatment after an infection, $S_{HIV} = \eta \cdot [\psi \cdot S_{treat} + (1 - \psi) \cdot S_{notreatt}] + (1 - \eta) \cdot S$, where η is the age-specific incidence rate, ψ the probability of getting access to treatment, as a percentage of those in need, and S is the "healthy" survival probability for the case of not being infected. Because we only have age-specific population and death figures for the years 2000 and 2001, we make the simplifying assumption that population size and structure as well as HIV-incidence rates are constant over time. We note that this may result in an underestimation as incidence rates have actually been increasing over the past years.

Table 1 shows that access to fully developed HIV-treatment varies significantly across countries in Eastern Europe. We therefore assume that the countries find themselves at various distances in time, relative to the state of the art observed in the United States. Based on international surveys of the World Health Organization (WHO) that report for individual countries the year of introduction of ART and the extent of ART coverage in 2003 and 2005 [17], we assign ordinal numbers to classify the medical development status of each country, ranging from 1 for more than 80% coverage to 6 for less than 10% coverage. We then use this information to assign additional time lags relative to Philipson and Jena's [16, 18] estimate of age shifts according to the survival of HIV/AIDS-patients in the United States, with 1 indicating a 1-year lag behind the contemporaneous United States treatment technology and 6 indicating a 6-year lag. This is meant to capture the negative impact on survival prospects that reduced access to ART, compared with the United States, will have for an HIV-infected person in an Eastern European country. The Global Fund for the fight against HIV/AIDS has identified

Table 1 Country-level background information

Country	Average GDP during 1995–2000 PPP/adjusted for TT, in 1996 (US $)	Average pension in % of per capita GDP	Average pension as percentage of wage income	Estimates for the prevalence of university degrees: level of attainment in age-group				All	Estimated ART coverage (%)	Annual cost per patient (US $)	HIV prevalence rate (%)
				25–34	35–44	45–54	55–64	25–64			
Albania	3,041	36.4	–	0.091	0.096	0.089	0.073	0.089[a]	15		0.15
Armenia	2,503	18.7	24.0	0.091	0.096	0.089	0.073	0.089[a]	0	10,000	0.1
Azerbaijan	2,445	51.4	29.0	0.091	0.096	0.089	0.073	0.089[a]	0	11,000	0.03[b]
Belarus	6,647	31.2	43.0	0.550	0.580	0.540	0.440	0.54[a]	5	9,700	0.23[c]
Bosnia/Herzegovina	3,522	–	–	0.091	0.096	0.089	0.073	0.089[a]	10		0.04
Bulgaria	5,798	39.3	31.0	0.187	0.197	0.184	0.150	0.1835	44.5	8,400	0.01[d]
Croatia	8,005	–	48.6	0.187	0.197	0.184	0.150	0.1835[a]	98.7		0.01[e]
Cyprus	15,991	41.8		0.234	0.247	0.230	0.187	0.23	90	9,000	0.3[f]
Czech Republic	13,560	37.0	48.6	0.122	0.129	0.120	0.098	0.12	93.9	7,500	0.1
Estonia	8,578	56.7	25.0	0.258	0.272	0.253	0.206	0.253	17	15,000	1.1
Georgia	4,799	12.6	36.0	0.195	0.206	0.192	0.156	0.1918	49	10,000	0.11
Hungary	9,429	33.6	57.9	0.153	0.161	0.150	0.122	0.15	97	10,000	0.1
Kazakhstan	6,347	18.8	31.0	0.550	0.580	0.540	0.440	0.54[a]	15		0.2[g]
Latvia	6,746	47.6	62.8	0.167	0.176	0.164	0.134	0.164	31	6,500	0.61[h]
Lithuania	7,097	21.3	–	0.392	0.414	0.385	0.314	0.385	64		0.1
Poland	8,248	61.2	55.4	0.109	0.115	0.107	0.087	0.107	100	10,000	0.1
Republic of Moldova	2,214	–	43.1	0.091	0.096	0.089	0.073	0.089[a]	39		0.24[i]
Romania	4,745	34.1	–	0.091	0.096	0.089	0.073	0.089	64.4		0.06
Russian Federation	7,549	18.3	–	0.550	0.580	0.540	0.440	0.54	5		1.1[j]
Serbia and Montenegro	3,814	–	–	0.187	0.197	0.184	0.150	0.1835[a]	26.4	7,140	0.2
Slovak Republic	10,899	44.5	42.5	0.112	0.118	0.110	0.090	0.11	100	10,000	0.01
Slovenia	14,334	49.3	68.7	0.147	0.155	0.144	0.117	0.144	100	2,000	0.05
FYROM	4,753	91.6	63.5	0.187	0.197	0.184	0.150	0.1835[a]	20		0.05
Turkey	6,691	112.7	–	0.102	0.107	0.100	0.081	0.1	9	10,000	0.15
Ukraine	4,554	30.9	32.0	0.550	0.580	0.540	0.440	0.54[a]	7		1.3[k]
Whole region	6,892	–	–	0.219	0.231	0.215	0.175	0.215	44	9,083	0.26

Sources: Access to ART/annual treatment costs: WHO [17]; UNAIDS [4]

GDP Gross domestic product, *PPP* Purchasing power parity, *TT* terms of trade, *ART* antiretroviral therapy, *FYROM* Former Yugoslav Republic of Macedonia

[a] Based partly on gross enrolment ratios

[b] 45% of infections contracted outside the country, especially in Russia

[c] 60% of HIV infections in age group 15–24; 15% of HIV infections in group 25–29

[d] 48.6% of HIV-infections in males aged between 20 and 39

[e] Over 90% of HIV-positive men infected outside the country

[f] 3% of infections in 15–19 year olds; 80% of infections in 20–44 year olds; most HIV-infections in non-permanent residents

[g] 15.7% of infections in 15–19 year olds; 53.4% of infections in 20–29 year olds; 84% of registered infections caused by injecting drug use (IDU)

[h] 70% of infections caused by IDU

[i] 78% of infections caused by IDU

[j] 80% of all IDU-HIV-infections in under 30-year-olds

[k] 25% of infections in 15–24 year olds

Russia, Ukraine and Moldova as countries with particularly low treatment coverage.[3]

On this basis, we proceed to calculate survival probabilities conditional on being HIV-positive for two cases, namely with (case 1) and without (case 2) access to ART. For case 2, Rangsin et al. [19] estimate that the probability of death for an HIV-positive person without receiving ART is around 30% in the first 7 years after infection, which is ten times higher than the mortality of an HIV-negative person. Philipson and Jena [15] find improvements of 15 years in life expectancy between 1984 and 2000 due to earlier HIV diagnoses and progress in treatment technologies in the United States. We thus assume that any new HIV-patient not treated immediately faces the survival curve of an HIV-negative 86-year-old, equivalent to the survival prospects of an HIV-positive person in the United States in 1984.

The survival function conditional on age a is defined as the ratio of cumulative survival up to age t and the cumulative survival up to age a, i.e. $S(t, a) = S(t)/S(a)$ for all $t \geq a$. We calculate the hypothetical cumulative survival probabilities for people without HIV/AIDS for every age between 0 and 110, using the number of annually reported AIDS deaths in each country. The counterfactual change in survival probabilities from the elimination of the AIDS epidemic is then defined as $S_\theta(t, a) = S(t, a) - S_{\mathrm{HIV}}(t, a) = S(t)/S(a) - S_{\mathrm{HIV}}(t) \cdot S(t-1)/S(a)$. For $t \geq a$, these changes in survival probabilities are discounted and summed as shown in the latter part of Eq. 3, $\sum_{t=a}^{\infty} (1+r)^{-(t-a)} S_\theta(t,a)$, to obtain the aggregate losses from HIV/AIDS over the remaining lifetime.

Endowments with human capital

It is difficult to find comprehensive and internationally comparable measures of workers' human capital that account for both formal training and learning from experience. One readily available, albeit limited, indicator is the level of formal educational attainment. We therefore make use of the fact that before 1990 all countries of Eastern European were under the influence of the former Soviet Union and bound to follow, at least loosely, the Soviet Union's education system, which provided a relatively high percentage of the population with tertiary education. Using data on the absolute level of tertiary education from each country, we assume—for lack of more detailed data—that the relative distribution of educational attainment across age groups follows the distribution in Russia, for which we have data. In the case of countries without any data, we determined the absolute level according to similarities in GDP and gross enrolment ratios (GER), an index used by UNESCO to measure the percentage of the population in a given age group that was enrolled in a given level of education [20].

To measure the influence of educational attainment on workers' wage income in each relevant age group, we make further simplifying assumptions since most countries do not provide this information. We therefore assume that an academic degree generally allows workers to earn higher wages than those paid to other blue- and white-collar workers. This is well documented in the case of Russia, and we simply assume that all countries of the former Soviet bloc share basically the same income structure with regard to educational attainment. We thus ignore changes in the income structure that may have taken place more recently, as described in Simai [21]. Against this background, we conclude that workers aged between 25 and 65 earn the highest wages. We further assume that those younger than 20 and older than 65 earn wage or pension incomes in line with the average pension in the respective country. For the young, this seems appropriate because students generally have just enough income to finance food and the costs of living and therefore tend to have relatively low consumption. Widespread unemployment among the under 25s, about double the national average rates [21, p. 10], also constrains their income and consumption. Those between 20 and 50 years of age are assumed to earn at least the average income, with the income in this group being distributed normally about a mean of age 35. Those between 50 and 65 are assumed to have the country's per capita income. To determine the income distribution in the human capital scenario, we calculate the social income by multiplying per capita GDP by the total population. We then subtract the income that goes to under 20-year-olds and pensioners and the income earned by 50- to 65-year-olds. We assume the income between ages 20 and 50 to be normally distributed, peaking at age 35. This is because most skills and human capital are further built up on the job. Figure 3 shows the implied country-specific distributions of people's marginal willingness-to-pay for an AIDS-free life that we used in calibrating the human capital scenario.

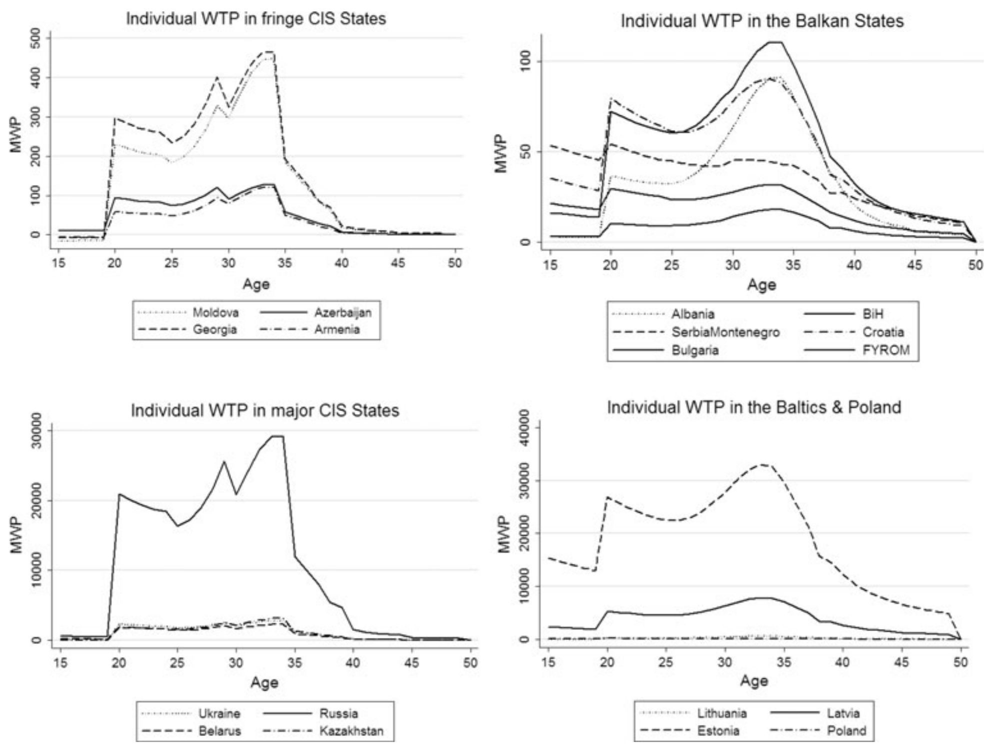
Results

Welfare losses from HIV/AIDS at the individual level

To assess the welfare losses from HIV/AIDS at the individual level, we compare survival probabilities with and

[3] For Albania, the Czech Republic and Slovenia, no original data on ART access are available. To obtain a rough estimate for these countries, we ran an ordinary least squares regression of ART coverage for HIV + persons in the other countries of our sample on real GDP per capita and a constant, yielding (absolute value of t-statistics in parentheses): ART cover = −0.064 (0.55) + 0.073 (4.85)** RGDP based on 22 observations with R2 equal to 51%. The slope coefficient is significant at the 1% level. Using data on real GDP per capita, we obtained predictions for the countries with missing information on ART coverage among HIV + persons.

Fig. 3 Individual willingness to pay (WTP) in human capital scenario. The curvature of the WTP also depends on the population density across age which peaks at around 15 and then again at about 40



without HIV. Based on the distribution of HIV-incidence across age-groups, we infer the expected life years lost to HIV/AIDS in case of an infection. These lost life years are "statistical" in the sense that they are conditional on the currently observed population-wide probabilities of becoming HIV-positive, and on getting access to treatment conditional on being infected. Our results are not meant to have predictive value for any identified individual whose particular milieu and behavioural incentives may deviate from the population average. Moreover, any non-infected individual may influence his or her susceptibility through preventive behaviour.

Due to limitations of space, we cannot report detailed estimates of individual willingness-to-pay for every age group included in our study. Instead, we highlight the influence of a person's age and some of the other relevant parameters by providing sample estimates for select age groups, namely for individuals aged 18, 25, 20 and 40 years. In this vein, the last two columns of Table 2 report the value of HIV/AIDS eradication for an 18-year-old person as implied by our benchmark calibration—assuming perfect consumption smoothing—with $r = 0.1$, $\alpha = -16.16$ and $\gamma = 1.25$, first in United States dollars and then as percentage of the respective country's per capita GDP. These estimates suggest that the value differs by several orders of magnitude across countries, from US \$6 in Bosnia and Herzegovina to US \$12,129 in Estonia. The preceding six columns of Table 2 show some relevant information on mortality from AIDS in our sample countries in order to make clear that the observed differences in mortality and life expectancy can only partially explain the large differences in welfare costs that we find.

To further illustrate our methodology, Table 3 reports the results of sensitivity analyses for a 25-year-old person, for whom the value of AIDS-eradication tends to be smaller than for an 18-year-old. The size of these differences can be gauged from a comparison of the first column of Table 3 with the penultimate column of Table 2. Our sensitivity analyses vary all three time-invariant parameters, r, α and γ. The results of these calibrations, reported in the last five columns of Table 3, show that a lower discount rate and a higher inter-temporal rate of substitution tend to increase individual welfare costs.

The first four columns of Table 4 report the results from further sensitivity analyses, including a comparison of our benchmark model with the human capital scenario. In the latter, people in the younger age-groups, most at risk of contracting HIV, are in the process of building their human capital, and those most affected by AIDS mortality tend to have higher than average levels of human capital, so that the welfare losses are larger. Table 4 shows that the individual valuation of the eradication of AIDS by a 20-year-old barely differs between the two scenarios, whereas a large difference is evident in the valuation by a 40-year-old. The relatively low value placed on an AIDS-free life by young people might go some way to explain why they often expose themselves to riskier behaviour than older people. We also believe that the accelerated increase in the

Table 2 AIDS mortality and welfare costs

Country	Life expectancy	Registered AIDS deaths	AIDS gross mortality rate (%)	Life expectancy (no AIDS)	HIV prevalence rate (%)	Life years lost to AIDS	Value of AIDS eradication for an 18-year-old[a]	
							Monetary value in US $	% of GDP per capita
Albania	68.6	0	0	70.7	0.15	2.0	22	0.7
Armenia	68.8	98	0.00458	70.2	0.1	1.4	22	0.9
Azerbaijan	62.5	97	0.00215	62.8	0.03	0.4	35	1.4
Belarus	67.7	0	0	70.8	0.23	3.1	493	7.4
Bosnia and Herzegovina	72.0	0	0	72.6	0.04	0.6	6	0.2
Bulgaria	70.7	0	0	70.9	0.01	0.1	30	0.5
Croatia	72.1	9	0.00040	72.2	0.01	0.1	35	0.4
Cyprus	76.1	0	0	81.0	0.3	4.9	586	3.7
Czech Republic	74.6	10	0.00020	76.1	0.1	1.5	279	2.1
Estonia	70.4	150	0.02138	88.2	1.1	17.8	12,129	141.4
Georgia	68.1	100	0.00365	69.6	0.11	1.5	86	1.8
Hungary	70.9	99	0.00198	72.3	0.1	1.4	42	0.4
Kazakhstan	62.1	306	0.00345	64.5	0.2	2.4	514	8.1
Latvia	69.9	150	0.01235	79.0	0.61	9.1	2,680	39.7
Lithuania	72.1	150	0.00789	73.6	0.1	1.5	135	1.9
Poland	73.2	0	0	74.7	0.1	1.5	84	1.0
Republic of Moldova	67.2	300	0.01282	70.3	0.24	3.2	92	4.2
Romania	70.3	358	0.00305	71.1	0.06	0.8	72	1.5
Russian Federation	64.4	8,969	0.01147	79.8	1.1	15.3	5,445	72.1
Serbia and Montenegro	68.8	50	0.00084	71.6	0.2	2.7	30	0.8
Slovak Republic	72.5	0	0.00000	72.7	0.01	0.1	11	0.1
Slovenia	75.1	50	0.00478	75.9	0.05	0.8	86	0.6
FYROM	70.8	50	0.00464	71.5	0.05	0.7	15	0.3
Turkey	68.2	0	0	70.2	0.15	2.0	29	0.4
Ukraine	66.9	14,000	0.05544	86.8	1.3	19.9	669	14.7
Total region	69.8	24,947	0.15107	73.6	0.26	3.8	945	12.3

[a] Calibrated conservatively, with $r = 0.1$, $\alpha = -16.16$ and $\gamma = 1.25$

value of an AIDS-free life with human capital points to an important difference between Eastern Europe and the situation in Sub-Saharan Africa.

Welfare losses from HIV/AIDS at the social level

The last four columns of Table 4 report our results for the full social welfare loss in the two scenarios, aggregating the individual values across all age groups using as weights each age group's population size according to Eq. 3. For the entire region, we estimate the social welfare costs of HIV/AIDS to be almost US $ 700 billion when people's consumption in each country is assumed independent of age as if they all earned their country's average income, and to be almost US $ 850 billion in the human capital scenario. However, even these figures may underestimate the true losses to society as they ignore costs that people incur through individual avoidance behaviour and preventive effort. Moreover, incidence rates have been rising rapidly in recent years and the number of reported HIV/AIDS cases has long been lower than the true prevalence in many countries.

Table 4 also shows that the per-capita welfare losses vary widely between countries in Eastern Europe. The most affected countries are Estonia, Russia, Latvia, Ukraine, Belarus, Kazakhstan and Moldova. In Russia, the social costs amount up to 20–70% of the country's annual GDP, in Estonia even up to 30–108% of GDP, depending on the underlying scenario. Another important case is Ukraine, where our estimates of the social costs are still much lower than in Russia, but the Ukrainian prevalence rate has been rising rapidly in recent years, just ahead of Estonia. Due to

Table 3 Sensitivity analysis—marginal willingness to pay (WTP) of a 25-year-old for different calibration parameters

Country	$\alpha = -16.16$[a]		$\alpha = -18.02$		$\alpha = -20.46$	
	$\gamma = 1.25$		$\gamma = 1.15$		$\gamma = 1.1$	
	$r = 0.1$	$r = 0.03$	$r = 0.1$	$r = 0.03$	$r = 0.1$	$r = 0.03$
Albania	14	43	11	33	9	28
Armenia	23	69	17	50	14	40
Azerbaijan	37	112	27	80	22	65
Belarus	522	1,567	459	1,376	425	1,276
Bosnia/Herzegovina	4	12	3	10	3	8
Bulgaria	23	70	20	60	18	55
Croatia	22	67	20	61	19	57
Cyprus	339	1,016	326	978	319	957
Czech Republic	241	722	228	685	222	665
Estonia	8,274	24,827	7,495	22,490	7,082	21,249
Georgia	89	267	74	223	67	201
Hungary	35	106	32	97	31	92
Kazakhstan	540	1,620	471	1,414	435	1,306
Latvia	1,741	5,223	1,531	4,595	1,422	4,266
Lithuania	94	283	83	250	78	233
Poland	48	145	44	131	41	123
Moldova	95	285	66	198	52	156
Romania	55	166	46	138	42	124
Russia	5,770	17,313	5,149	15,448	4,821	14,466
Serbia and Montenegro	21	62	17	50	15	44
Slovakia	7	22	7	20	7	20
Slovenia	61	183	58	174	57	170
FYROM	10	30	8	25	7	22
Turkey	20	60	18	53	16	49
Ukraine	708	2,123	587	1,761	526	1,577
Total region	18,794	56,392	16,797	50,399	15,748	47,250

[a] Value calculated by Philipson and Soares [1] on the basis of $\varepsilon = 0.346$, which Murphy and Topel [9] estimated on United States data using a consumption level of $c =$ US \$26,365. By varying the value of the intertemporal elasticity of substitution (γ) different values for α are obtained

their sheer size, Russia's and Ukraine's welfare losses alone add up to more than 95% of the entire region's welfare loss, both in our benchmark calibrations and in the human capital scenario. A ranking of countries according to their welfare loss from HIV/AIDS relative to their respective GDP is provided in Table 5.

Discussion and conclusion

With the results presented in this paper we hope to make a contribution towards answering the following questions regarding the current AIDS epidemic: Which countries should be invested in and by how much? Who should invest into fighting the AIDS epidemic? Should the EU help? What value might be created by using AIDS medication that does not cure the disease, but extends the lifetime of people infected with HIV? We think our focus on the quantitative implications of modern welfare economics is relevant to these questions; we also recognise that policy makers may be guided by additional social and ethical considerations and by other intellectual approaches to the prioritisation and allocation of healthcare resources, such as an extra-welfarist models. We therefore conclude with a brief discussion of the strengths and weaknesses of the value-of-life approach, with the goal of assessing the total willingness-to-pay for a hypothetical health improvement at a given level of social aggregation, rather than to determine the details of how the money is spent.

Based on the aggregation of individual willingness-to-pay for a statistical life, we have calibrated an intertemporal optimisation model for 25 Eastern European countries and find welfare losses for the region that come close to US \$ 1 trillion. If a smaller time preference rate is assumed, the welfare losses are even greater. The countries that would profit most from combatting the HIV/AIDS

Table 4 The welfare costs of HIV under the smooth consumption and human capital scenarios. Values obtained for $r = 0.03$, $\gamma = 1.1$ and $\alpha = -20.46$ and an uneven distribution of income over the lifecycle

Country	Individual value of HIV/AIDS eradication, in US $				Social value of HIV/AIDS eradication[c]			
	For a 20-year-old		For a 40-year-old		Human capital scenario[b]		With smooth consumption[a]	
	Smooth consumption[a]	Human capital scenario[b]	Smooth consumption[a]	Human capital scenario[b]	In million $	% of GDP	In million $	% of GDP
Albania	36	36	10	20	57.2	0.6	38.6	0.4
Armenia	59	59	2	5	75.5	0.8	51.2	0.5
Azerbaijan	94	95	4	7	233.7	1.2	179.1	0.9
Belarus	1,846	1,851	83	128	4,680.9	6.9	3,832.6	5.7
Bosnia/Herzegovina	10	10	4	6	18.7	0.1	15.1	0.1
Bulgaria	72	72	21	32	198.0	0.4	158.2	0.3
Croatia	79	79	21	29	111.0	0.3	99.5	0.3
Cyprus	1,380	1,383	382	573	372.5	3.0	319.8	2.5
Czech Republic	869	870	178	266	2,695.2	1.9	2,294.6	1.6
Estonia	26,856	26,891	9,365	12,281	12,819.4	108.6	11,568.7	98.0
Georgia	296	297	12	23	430.8	1.7	313.4	1.2
Hungary	125	125	26	39	372.0	0.4	304.3	0.3
Kazakhstan	1,902	1,908	82	157	9340.5	9.1	7,043.0	6.9
Latvia	5,311	5,320	1,969	2,705	4,688.4	28.9	4,122.1	25.4
Lithuania	283	283	93	156	457.5	1.7	335.3	1.3
Poland	188	188	42	56	2144.0	0.7	2,059.1	0.6
Moldova	230	231	9	18	297.5	3.1	216.4	2.3
Romania	169	169	40	68	1,428.3	1.3	1,090.4	1.0
Russian Federation	20,905	20,963	933	1,501	771,821.8	70.7	615,626.8	56.4
Serbia & Montenegro	54	54	22	24	211.0	0.5	205.8	0.5
Slovak Republic	29	29	6	9	48.0	0.1	43.2	0.1
Slovenia	236	236	60	79	142.5	0.5	128.2	0.5
FYROM	30	30	9	12	21.2	0.2	19.2	0.2
Turkey	67	68	14	20	1,921.3	0.4	1,498.7	0.3
Ukraine	2,283	2,288	102	162	26,872.9	12.0	22,061.2	9.9
Total region	63,409	63,535	13,490	18,374	841,460.0	10.2	673,624.5	8.7

[a] Assumes perfect consumption smoothing as if everybody received a country's average per capita income. This calculation may overestimate the welfare losses in younger age groups when many people earn relatively little and underestimate the losses of those at the peak of their lifecycle earnings capacity, typically in the middle of the lifecycle

[b] Takes into account people's investments in human capital during their younger years, which enables many to earn higher incomes later in life. Due to the lack of a complete set of internationally comparable data on income by age group, we use a simulated income distribution that assumes all people start earning income at 20, retire at 65, and that those below 20 and above 65 years of age receive income equivalent to the average pension. Between 20 and 65, income first rises and then falls, peaking at the age of 35. The accumulation of human capital raises people's willingness to pay for a life free from HIV/AIDS in the age groups where HIV tends to be particularly prevalent

[c] Sum of individuals' willingness to pay weighted by the number of individuals in each age group

problem, according to our assessment, are the Baltic States—above all Estonia, which suffers the highest per capita welfare loss from HIV/AIDS in the region. The fellow Baltics Latvia and Lithuania are not yet affected to the same degree, but they are particularly threatened by the further spread of the epidemic if policies are not changed in the near future. In line with previous studies by the WHO and UNAIDS, we find that Ukraine, Russia, Belarus, Kazakhstan and Moldova also suffer very high per capita welfare costs from HIV/AIDS. As a caveat, we note that even our study has probably underestimated the true welfare costs because we have included only the welfare losses from increased mortality, not the actual suffering of HIV-infected persons prior to death and the costly efforts of susceptible individuals aimed at avoiding an infection. We conclude that a much greater effort in prevention and

Table 5 Identification of HIV/AIDS hot spots in the smooth consumption and human capital scenarios. See footnotes to Table 4 for definitions

Country	Smooth consumption scenario		Human capital scenario	
	Million $	% of GDP	Million $	% of GDP
Estonia	11,568.7	98.0	12,819.4	108.6
Russian Federation	615,626.8	56.4	771,821.8	70.7
Latvia	4,122.1	25.4	4,688.4	28.9
Ukraine	22,061.2	9.9	26,872.9	12.0
Kazakhstan	7,043.0	6.9	9,340.5	9.1
Belarus	3,832.6	5.7	4,680.9	6.9
Cyprus	319.8	2.5	372.5	3.0
Republic of Moldova	216.4	2.3	297.5	3.1
Czech Republic	2,294.6	1.6	2,695.2	1.9
Lithuania	335.3	1.3	457.5	1.7
Georgia	313.4	1.2	430.8	1.7
Romania	1,090.4	1.0	1,428.3	1.3
Azerbaijan	179.1	0.9	233.7	1.2
Poland	2,059.1	0.6	2,144.0	0.7
Armenia	51.2	0.5	75.5	0.8
Serbia and Montenegro	205.8	0.5	211.0	0.5
Slovenia	128.2	0.5	142.5	0.5
Albania	38.6	0.4	57.2	0.6
Bulgaria	158.2	0.3	198.0	0.4
Turkey	1,498.7	0.3	1,921.3	0.4
Hungary	304.3	0.3	372.0	0.4
Croatia	99.5	0.3	111.0	0.3
FYROM	19.2	0.2	21.2	0.2
Bosnia and Herzegovina	15.1	0.1	18.7	0.1
Slovak Republic	43.2	0.1	48.0	0.1

treatment is needed to maintain long term economic growth and to reverse the size of the welfare losses that the Eastern European region is already incurring.

Critics of the value-of-life methodology might argue that its assumptions are too simple to provide more than an assessment of the problem's order of magnitude and that we cannot trust these estimates enough to use them as a detailed guide to government planning and investment prioritisation in the fight against HIV/AIDS. For example, critics might point out that individual marginal willingness-to-pay for an HIV/AIDS-free life can be different from society's marginal willingness-to-pay simply because of interdependencies and externalities such as altruism that makes people willing to pay for the lives of relatives, friends or other fellow human beings. In such a situation, society's marginal willingness-to-pay would not be a simple sum of individual willingness-to-pay.

Critics might also argue that distributional issues should play a much greater role in society's valuation of a hypothetical AIDS eradication than even our human capital scenario suggests. In contrast to Africa, where the AIDS epidemic is generalised and the probability of being infected is high throughout the population, the intensity of the epidemic in all Eastern European countries remains "low" or "concentrated in subpopulations," such as injecting drug users (IDUs) and commercial sex workers. As defined by the WHO and UNAIDS, in countries at a low level, HIV prevalence does not consistently exceed 5% in any pre-defined subpopulation; at the concentrated level, it is consistently above 5% in at least one defined subpopulation and below 1% in pregnant women in urban areas; and at the generalised level, it is consistently above 1% in pregnant women. Since the subpopulations at high risk in Eastern Europe tend to have low incomes and a low social status, the relevant willingness-to-pay for the absence of AIDS may be lower than estimates made on the basis of countries' average income might imply. In some countries, our relatively high estimates of willingness-to-pay for the eradication of AIDS would indeed be difficult to reconcile with the observation of persistent risky behaviour in a wide range of age groups, unless we take additional distributional aspects into consideration.

In defence against such criticism, we may say that our approach was never meant to explain risky behaviour of individuals, nor to provide an exhaustive rationale for society to act. The approach aims mainly to support those who have already decided to act. In this vein, the governments of individual countries may use our analysis, and the summary statistics provided in Table 5, to compare their own situation to other countries that are similar in some relevant aspect, such as geographical location, population size, or GDP per capita. Such comparisons can help to locate "hot spots" where measures need to be taken most urgently. Moreover, countries that neighbour on existing hot spots may decide on the basis of our analysis whether they need to make extra efforts to prevent rapidly rising infection rates from spilling over the border. Our findings suggest that Cyprus, Azerbaijan and Croatia, for example, owe a large percentage of their HIV-patients to the epidemic in other countries.

Individual countries may face different trade-offs between the need to adjust treatment and prevention strategies to local epidemiological, socio-economic and institutional conditions and the opportunity to exploit economies of scale through international cooperation in more standardised treatment and prevention schemes.[4] To fully exploit the potential insights that the value-of-life methodology might generate in this regard, our study would have required much more detailed data at the country level. If such data were available, one could for example adapt and calibrate the analytical framework that Bautista-Arredondo et al. [23] suggest for the optimization of resource allocation in HIV/AIDS prevention programs at the country, regional and local level. In a similar vein, Bertozzi et al. [24] review[5] the international lessons from the past two decades on how national HIV prevention programs can be better adapted and made to work more effectively at the country level, albeit against the background of a conventional cost-effectiveness framework.

The relationship between prevention and treatment remains an important issue that continues to be debated in the literature. Many have argued that prevention should be given priority, especially in resource-poor settings, because it is often more cost-effective than treatment [8, 25]. Needless to say, effective *prevention* can benefit from more international cooperation along many dimensions, including the identification of population subgroups most at risk, the social marketing of condoms, clean needles and drug dependency treatment for intravenous drug users (IDUs), as well as outreach programs that provide free testing for groups of people with particularly high social and geographical mobility. In a similar vein, international cooperation can help to better understand the rapidly changing opportunities and constraints in providing *treatment*, in particular improved access and better adherence of IDUs to ART, under real world conditions [26–28]. Most of the nearly 2 million people currently living with HIV in Eastern Europe and Poland have been infected by sharing contaminated injection equipment, although this seems to be a less important transmission route in the smaller Central European countries. Non-governmental initiatives, such as the member organisations of the European AIDS Treatment Group (EATG), have a special role to play in facilitating access by working against the stigma still often associated with IDUs, and by evaluating and disseminating information about successful strategies to improve adherence of IDUs to ART regimens. To overcome stigma and improve adherence, health services, education campaigns and outreach programs, including free substitution therapy for opioid users, may have to be kept strictly separate from law enforcement efforts against illegal drugs. In many places, active IDUs are still routinely excluded from ART although its effectiveness has been established for both active and former IDUs.

In this context, the value-of-life methodology can help to better understand and exploit the *complementarities* between prevention and treatment that make a more comprehensive strategy in the fight against HIV/AIDS desirable. Complementarities stem not only from the suppression of viral loads by antiretrovirals that makes patients under treatment less infectious even if they continue with risky behaviour. It also stems from the opportunity that successful treatment creates for medical practitioners to reach out and counsel carriers of the virus on preventive behaviour. And it also stems from the need to limit the rise in primary resistance to antiretroviral drugs that would result if their widespread use, breeding resistant strains of the virus and leading to the transmission of such strains, were not accompanied by an intensification of HIV prevention effort. Blower et al. [29] review the relevant evidence from developed countries and discuss insights from mathematical models for the evolution of drug-resistant HIV epidemics. The value-of-life approach could be used to provide microeconomic estimates of the prevalence and elasticity of the risky behaviour that spurs the spread of HIV as treatment is expanded. Future extensions of our study could also use the methodology to estimate the aggregate pan-European willingness-to-pay for the prevention of an increase in transmitted drug resistance that insufficient coordination of treatment and prevention might trigger, putting our common arsenal of drugs at risk of becoming ineffective in the fight against HIV/AIDS.

Priority setting and coordination has an international dimension not only because of cross-border disease

[4] A descriptive survey of national responses to HIV/AIDS in the Western Balkans and of recommendations for region-wide activities is provided in Godinho et al. [22].

[5] This review is the fifth in a series of six papers that Lancet published in 2008 about HIV prevention, surveying the state-of-the-art in biomedical, behavioural and structural approaches.

externalities, but also because the annual per-patient treatment costs in many countries exceed their average per capita income. This raises the question of whether international and supranational organisations, such as the World Bank, the European Bank for Reconstruction and Development, and the EU, should get more involved in helping to fight the AIDS epidemic in Eastern Europe. The recent EU-accession states are mostly still relatively little affected. The EU may therefore wish to prioritise countries outside its current borders whose HIV/AIDS epidemic already poses or could become a threat to the existing EU population as the mobility of people across borders increases. In addition to direct health benefits, external assistance that extends the lifetime of people infected with HIV may also generate important economic spillovers for the EU as HIV-positive individuals with access to the world's highest standard of medical treatment will have a greater incentive to invest in personal human capital and contribute to their country's economic growth.

Appendix

The WHO declared the following countries as belonging to Eastern Europe: Belarus, Bulgaria, Czech Republic, Hungary, Poland, Republic of Moldova, Romania, Russian Federation, Slovakia and Ukraine. We extend this list by adding countries from South Eastern Europe, i.e. Albania, the former Yugoslav Republic of Macedonia, Bosnia and Herzegovina, Serbia and Montenegro, Slovenia, and Croatia. Further, we include Cyprus and Turkey because of their geographic situation, the Baltic states Estonia, Latvia and Lithuania as well as the Caucasian countries Azerbaijan, Armenia and Georgia, which can be considered as Eastern Europe from a historical perspective. While Kazakhstan belongs to Central Asia, a small part of it lies on the outer border of Eastern Europe, which is why we also include this country. This leaves us with 25 countries in the list. The remainder of this appendix reports details of our data sources, how we handled missing observations and issues of data quality.

Income variables

We use the real gross domestic income adjusted for changes in the terms of trade (RGDPTT) from the Penn World Table 6.1 [30] as an indicator for per capita income, taking averages for the years from 1995 to 2000, and, in the case of missing data, the average from the available years. The RGDPTT measures domestic absorption in international price value for 1996 for a given country and year, but allows for current export and import prices in valuing the net foreign balance. It takes into account a country's changing ability to use its exports to buy imports, as its terms of trade change over time. This is particularly important for developing countries, which rely on a limited range of products for their overall export earnings. The "real" stands for purchasing power parity (PPP)-converted GDPL (gross domestic income after Laspeyres) with the impact of inflation already taken into account. This is done by using a weighted basket of goods and services according to the Laspeyres Index.[6]

Many Eastern European countries still have a narrow export base, i.e. only few primary export products, such as metal, steel, oil, or fruit.[7] Furthermore, some countries are very small, making them even more dependent on their exports and imports. The adjustment for changes in the terms of trade includes the impact of international price changes on the gross domestic income due to imports and exports, and therefore should be used for our purposes. For two countries (Bosnia and Herzegovina, and Serbia and Montenegro), the RGDPTT could not be obtained from the Penn World Tables 6.1. [30]. Therefore, we additionally use GDP in PPPs from the International Monetary Fund (IMF) economic outlook database [32]. The IMF-figures are higher for the Balkan region because these countries are all very import-intensive. For the purpose of our calculations, we carried out a regression for the Southern region to predicted RDGPTT for Bosnia and Herzegovina and Serbia Montenegro.

Number of AIDS deaths

The number of deaths is usually a reliable figure, but the number of reported AIDS-deaths is still very low. This is why our result is likely to underestimate the true welfare losses from HIV/AIDS. The annual number of reported AIDS deaths is obtained from the EuroHIV—HIV

[6] The Laspeyres-Index is the geometric mean of the price ratios for products characteristic of a base country, regardless of whether the products are representative or not of the other countries to be compared with. The Laspeyres Index produces a bias because it does not take into account the changes in relative prices, and hence, substitution effects in consumption. That is why in higher income countries, the costs of living still supersede those of countries with lower per-capita income. This could explain why, for countries with a higher income, the calculated life-death indifference parameter α is lower.

[7] Between 1990 and 1995, Hungary exported very much the same products (Hoekman and Djankov [31]), while Romania and Bulgaria changed their composition of exports significantly (especially with regard to the EU). Kazakhstan and Russia's principal exports are oil (which is why they owe their positive GDP growth to rising international oil and gas prices). Georgia's main export items are metals, wine and mineral water. The same applies to Moldova and to Ukraine, a metal and steel-exporter. All of these countries are vulnerable to changes in the external economic environment because of their narrow export base.

Surveillance report for Europe in 2004 [33]. We assume these deaths to be distributed proportionally to the population in each age group and then calculated counterfactual survival probabilities if no AIDS existed, calculated as described in the section "Data and empirical methods".

The estimated number of people living with HIV

Today, an HIV-infected person can survive for a long time and so his/her life will not become worthless after an infection. But this person still suffers utility reductions in having to protect others from being infected, loss of reputation or friends due to fear of potential infection etc. This utility reduction is difficult to determine empirically, but it can be incorporated if we assume that at a certain stage these HIV-infected people succumb to AIDS, and finally, to death.

The share of a population currently living with HIV is expressed by a prevalence rate. An HIV-incidence rate, on the other hand, counts only newly diagnosed cases of HIV per specified population in 1 year. The incidence rate is a measure of the speed at which the epidemic is spreading while the prevalence measures the overall burden at a given time. UNAIDS provides estimates[8] for the HIV-prevalence in adults between 15 and 49 years of age.

Age distribution of the total number of deaths

The distribution of actual deaths is available from the WHO life tables (see below, [34]) for the years 2000 and 2001 stating the total number of deaths per age-group.

Population

The population distribution for the years 2000 and 2001 is from the WHO life tables [34]. These state the actual population size for each country in the year 2000 and 2001 within different age groups of 5-year intervals. For Serbia and Montenegro, this data is not available, so that for this case, we found that the figures from the UN Population Division [35], providing the percentage of the total population in different age groups (0–4, 5–14, 15–24, 60+, 65+ and 80+) as well as the median age for 1995, 2000 and 2005, are very similar to the population distribution of Bosnia and Herzegovina. Hence, we assume the same distribution for both countries.

Incidence rates

The incidence rate is the rate of new HIV-infections in each year, while the prevalence rate is based on the number of people living with HIV. This means that a person infected with HIV in 1 year will be included in the prevalence rate for all following years until his/her death, while the incidence rate counts each HIV-infected individual only once. The incidence rate is calculated as the annual number of new infections divided by the population at risk in this period. The incidence rates for 1994–2001 were obtained from the EuroHIV HIV Surveillance report for Europe. For estimating the distribution of HIV-incidence across the population, we do not assign HIV/AIDS-mortality proportionally to each age group (as Philipson and Soares [1] did for Africa), because the HIV-prevalence in children under 15 is nearly zero in Eastern Europe. In Africa, due to a high infection rate in children, HIV-mortality can be assumed to show a more continuous trend than in Europe. For our study, we assume that the HIV/AIDS-prevalence in children is equal to zero and that there are no new infections beyond the age of 49, simply because there are no figures available for those over 50 years old.

Human capital/education

The level of educational attainment is one available indicator to approximate the amount of human capital that is already present in a country. This indicator gives the percentage of the population with a completed university degree and was obtained from the UN Economic Commission for Europe [36].

We also use an index of the number of people enrolled in a certain level of education to quantify the amount of human capital that is currently being built up in the country. Percentages of children in school are represented by GER. The GER is the number of pupils enrolled in a given level of education regardless of age expressed as a percentage of the population in the theoretical age group for that level of education [20].

Treatment

The survival of an HIV-infected individual depends on access to, and on the quality of, medical treatment. A low rate of HIV-treatment could pose a strong incentive for HIV-infected people to emigrate to countries providing better anti-retroviral treatment, leading to a lower prevalence rate in the affected countries. While in Western Europe basically every individual has access to ART, in

[8] The country-specific estimates were obtained by the UNAIDS/WHO [2–4] working group in two basic steps. First, point prevalence estimates for 1994 and 1997 were carried out and the starting year of the epidemic was determined for each country. In a second step, these estimates of prevalence over time and the starting date of the epidemic were used to determine the epidemic curve that best described the spread of HIV in each particular country. A simple epidemiological program (EPIMODEL) was used for the calculation of estimates on incidence and mortality from this epidemic curve.

Eastern Europe this medical treatment is still very limited. On the other hand, it could be argued that people who can afford to emigrate financially can also afford to access ART in their own country. Furthermore, the prices for ART are rapidly falling, from an initial price for a three-drug-ART regimen of US $10,000, to currently US $300 in sub-Saharan Africa (in Europe, the costs are still higher) with a falling trend. In Eastern Europe, access to treatment in a country is significantly correlated to the real GDP per capita. This implies higher survival probabilities for HIV-positive individuals in the richer countries in our sample.

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