Most new HIV infections, vertical transmissions and AIDS-related deaths occur in lower-prevalence countries

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Abstract

Objectives: The Joint United Nations Programme on HIV/AIDS (UNAIDS) targets aim to reduce new HIV infections below 500,000 per year by 2020. Despite targeted prevention programmes, total new infections remained in 2016 and 2017 at 1,800,000 cases. We have aimed to analyse data from 2017 and to compare HIV incidence, AIDS-related deaths and provision of antiretroviral therapy (ART) to adults, pregnant women and children living with HIV in lower- and higher-prevalence countries. Vertical or mother-to-child transmission (MTCT) and early infant diagnosis (EID) rates were also investigated.

Methods: UNAIDSinfo data use the Spectrum model to represent country-level HIV data. Countries with epidemics over 40,000 HIV cases were separated into higher prevalence (≥4.5%) and lower prevalence (<4.5%). Least squares linear regression, weighted by epidemic size and controlled for gross domestic product/capita, was used to compare HIV prevalence with estimated ART coverage in adults (≥15 years), children (0–14 years), pregnant women, and EID rates and MTCT rates. Data were then compared between higher- and lower-prevalence groups, including numbers of new HIV infections and AIDS-related deaths.

Results: Data were available for 56 countries. Twelve higher-prevalence countries accounted for 16.7 million and 44 lower-prevalence ones for 15.1 million people living with HIV, altogether making up 87.5% of the global estimate. Lower-prevalence countries had less ART coverage for adults, pregnant women and children, lower EID rates and higher AIDS-related death levels. There were more new HIV infections in adults and children in lower- than higher-prevalence countries.

Conclusions: Most new HIV infections, MTCTs and AIDS-related deaths occurred in countries with an HIV prevalence rate below 4.5%. Many of these countries are not targeted by access programmes, such as the President' Emergency Plan for AIDS Relief. More intensive programmes of diagnosis and treatment are needed in these countries in the effort to reduce global new HIV infections below 500,000 per year by 2020.

Keywords: new HIV infections, prevalence, antiretroviral therapy, early infant diagnosis, mother-to-child transmission

Introduction

The Joint United Nations Programme on HIV/AIDS (UNAIDS) and partners launched in 2014 the 90–90–90 targets. The aim was to diagnose 90% of all HIV-positive individuals, provide antiretroviral therapy (ART) for 90% of those diagnosed and achieve viral suppression for 90% of those treated by 2020 [1].

In 2016, key prevention targets were added to reduce HIV incidence and HIV/AIDS-related deaths by 2020, such as reductions in the number of new infections to below 500,000 per year and below 100,000 for adolescent girls and young women; to have 3 million people treated with HIV pre-exposure prophylaxis (PrEP) worldwide; to provide 90% of key populations with access to combined HIV prevention; and to reduce total HIV/AIDS-related deaths to below 500,000 per year [1,2].

In order to reach these targets, UNAIDS echoed the 2011 Global Plan to eliminate new childhood infections by 2015 by emphasising the need to focus on 'treatment as prevention' and core prevention strategies, such as elimination of vertical or mother-to-child-transmission (MTCT) [3], alongside condoms, PrEP, male circumcision, needle exchange and public health education methods [4]. They also set specific targets for accessing key populations.

Programmes of prevention of mother-to-child transmission (pMTCT) have indeed been credited with contributing to a reduction in childhood HIV incidence, as ART coverage for pMTCT increased from 50% to 77% between 2010 and 2015 [5]. In 2015, World Health Organization (WHO) guidelines for pMTCT settled on option B+, which involves lifelong ART for all pregnant HIV-positive women and all children born to HIV-positive mothers given nevirapine or zidovudine daily from birth to 4–6 weeks. The option B+ success can be measured with early infant diagnosis (EID), without which treatment of the newborn may not take place. For this reason, EID is increasingly emphasised as a means of measuring levels of care in newborns at potential risk of HIV infection [1]. Considered alongside EID, option B+ would be expected to further contribute to decreased HIV incidence as seen between 2010 and 2015.

With renewed emphasis on treatment as prevention and therefore ART coverage and pMTCT, it would be expected that AIDS-related deaths, MTCT and total new HIV infections would continue to fall. Whilst AIDS-related deaths and total new infections have fallen by 34% and 18%, respectively, since 2010, worldwide new infections in 2016 and 2017 have remained constant at 1.8 million cases, 180,000 of whom are children [6–8]. At the current reduction rate of new HIV infection, the 2020 target of fewer than 500,000 new cases per year remains out of reach. This suggests a need for a new approach [9].

Initiatives such as the Global Fund and the United States President's Emergency Plan for AIDS Relief (PEPFAR) have consistently had regional focuses. Similarly, the 2011 Global Plan has worked in 22 priority countries selected on the basis of HIV prevalence in pregnant woman and country–income classifications. Here there was a 60% decrease in new HIV infections in children. As the

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US aid and the Global Fund budgets are reduced [10], the trend has intensified to focus on higher-prevalence settings, following increased pressure for programme cost-effectiveness. Last year, PEPFAR announced that it would now focus efforts on just 13 priority countries [11]. This resource allocation strategy raises the question of whether there is a difference in treatment levels in lower-prevalence *vs* higher-prevalence countries and, if so, is this difference reflected in incidences and outcomes for these HIV-positive populations?

In this analysis, we have aimed to investigate whether there was a prevalence bias in ART provision for people living with HIV (PLWHIV) in 2017, looking more specifically at adults, pregnant women and children. We have explored a potential difference in the number of AIDS-related deaths and new HIV infections between lower- and higher-prevalence countries. To gain insight into HIV-positive pregnant women and children outcomes, we have also examined EID and MTCT rates. We have compared estimates amongst 56 higher- and lower-prevalence countries with an epidemic size above 40,000 cases. We have used for the year 2017 the UNAIDSinfo database, which is the most extensive and detailed dataset for these variables.

Methods

The UNAIDSinfo database provides estimates for a wide variety of epidemiological data, including HIV prevalence, epidemic size, ART coverage for adults, children and pregnant women, as well as numbers of new HIV infections and HIV/AIDS-related deaths and MTCT and EID rates [7]. This study has analysed UNAIDSinfo data from within the year 2017.

Countries included in this study had an epidemic size of over 40,000 PLWHIV. Those in the regions of North America, Oceania and Western Europe were excluded due to significant differences in epidemic demographic and national income levels compared with the rest of the world. We have excluded four further countries, Colombia, Thailand, Vietnam and China, due to a lack of information in terms of numbers of new infections.

Countries included in the analysis were categorised as higher or lower prevalence, with ≥4.5% considered as higher or <4.5% as lower. This threshold split the global HIV-positive population into two, such that each group accounted for a similar proportion, with the higher-prevalence group accounting for 52% and the lower-prevalence group accounting for 48%.

Data on MTCT rates, defined as the percentage of children born to HIV-positive mothers who were themselves infected by 12 months of age, were taken from the UNAIDS Spectrum model and were cross-referenced with WHO country reports for countries whenever available. A new child infection was defined as a new HIV diagnosis made before 14 years of age, as the vast majority of these new infections are vertical transmissions and only a small minority are horizontal ones (sexual or blood product related) [12]. We defined pMTCT as the estimated percentage of pregnant women undergoing ART to prevent HIV vertical transmission.

Least squares linear regression, weighted by total adult HIV epidemic size and controlling for gross domestic product per capita, was used to correlate HIV prevalence with estimated rates of EID, MTCT and ART coverage for children, adults and pregnant women. Comparisons were made for lower- and higher-prevalence groups on numbers of new adult and child infections, ART coverage for adults, children and pregnant women, as well as numbers of AIDS-related deaths for adults and children, and rates of MTCT and EID as defined as an HIV test within 2 months of delivery.

Results

A total of 56 countries were included in our analysis. Twelve higher-prevalence countries accounted for 16.7 million and 44 lower-prevalence countries accounted for 15.1 million PLWHIV. These countries made up for 87.5% of the global epidemic size, 87% of global new infections and 89% of global AIDS-related deaths. There were 4.1 new infections per 100 PLWHIV in higher-prevalence countries *vs* 5.8 per 100 PLWHIV in lower-prevalence countries. Tables 1 and 2 show the countries included in this analysis in decreasing order of the number of new infections. Estimates

Table 1. Total new infections and ART coverage in adults living with HIV by region: (a) higher prevalence and (b) lower prevalence

			a		
Country	Epidemic size	HIV prevalence (%)	Total new infections (*n*)	% ART coverage for PLWHIV	AIDS-related deaths
Eastern and Southern Africa	16,610,000		674,400		304,200
South Africa	7,200,000	18.80	270,000	61	110,000
Mozambique	2,100,000	12.50	130,000	54	70,000
Kenya	1,500,000	4.80	53,000	75	28,000
Uganda	1,300,000	5.90	50,000	72	26,000
Zambia	1,100,000	11.50	48,000	75	16,000
Zimbabwe	1,300,000	13.30	41,000	84	22,000
Malawi	1,000,000	9.60	39,000	71	17,000
Lesotho	320,000	23.80	15,000	74	4900
Botswana	380,000	22.80	14,000	84	4100
Namibia	200,000	12.10	7400	84	2700
Swaziland	210,000	27.40	7000	85	3500
Central Africa	53,000		4100		1900
Equatorial Guinea	53,000	6.50	4100	38	1900
Total	16,663,000	—	678,500	—	306,100
Weighted average	—	14.45	—	67	—

Table 1. Total new infections and ART coverage in adults living with HIV by region: (a) higher prevalence and (b) lower prevalence (continued)

		b			
Country	Epidemic size	HIV prevalence (%)	Total new infections (*n*)	% ART coverage for PLWHIV	AIDS-related deaths
Western and Central Africa	5,972,000		370,200		263,400
Nigeria	3,100,000	2.80	210,000	33	150,000
Côte d'Ivoire	500,000	2.80	30,000	46	24,000
Cameroon	510,000	3.70	28,000	49	24,000
Ghana	310,000	1.70	19,000	40	16,000
DRC	390,000	0.70	15,000	55	2600
Mali	130,000	1.20	9900	32	6300
Guinea	120,000	1.50	8100	35	5100
Congo	100,000	3.10	7900	29	4900
Central African Republic	110,000	4.0	7700	32	5200
Chad	110,000	1.30	5800	45	3100
Togo	110,000	2.10	4900	57	4700
Burkina Faso	94,000	0.80	4300	65	2900
Benin	70,000	1.0	4000	55	2500
Sierra Leone	61,000	1.40	3200	39	2600
Burundi	78,000	1.10	3100	77	1700
Gabon	56,000	4.20	3100	59	1300
Guinea-Bissau	40,000	3.40	2300	30	1900
Liberia	40,000	1.40	2300	29	2500
Senegal	43,000	0.40	1600	54	2100
Asia and the Pacific	3,370,000		170,690		128,700
India	21,000,000	0.20	88,000	56	69,000
Indonesia	630,000	0.40	49,000	14	39,000
Pakistan	150,000	0.10	20,000	8	6200
Malaysia	87,000	0.40	7800	45	4400
Papua New Guinea	48,000	0.90	3000	55	1100
Philippines	68,000	0.10	1200	36	1000
Myanmar	220,000	0.70	1100	66	6700
Cambodia	67,000	0.50	590	87	1300
Eastern Europe and Central Asia	1,292,000		119,400		10,900
Russia	1,000,000	1.20	100,000	36	nd
Ukraine	240,000	0.90	13,000	40	9000
Uzebekistan	52,000	0.30	6400	29	1900
Latin America	1,382,000		74,600		24,100
Brazil	860,000	0.60	48,000	64	14,000
Mexico	230,000	0.30	15,000	62	4000
Argentina	120,000	0.40	6,500	66	2000
Peru	72,000	0.30	2,800	67	2100
Guatemala	46,000	0.40	2,300	39	2000
Eastern and Southern Africa	2,820,000		129,400		75,100
Tanzania	1,500,000	4.50	65,000	66	32,000
Angola	310,000	1.90	27,000	26	13,000
Ethiopia	610,000	0.90	16,000	71	15,000
South Sudan	180,000	2.40	14,000	13	12,000
Rwanda	220,000	2.70	7400	83	3100
Carribean	217,000		10,000		7300
Haiti	150,000	1.90	7600	64	4700
Dominican Republic	67,000	0.90	2400	52	2600
Middle East and Northern Africa	111,000		9400		6100
Sudan	51,000	0.20	4700	15	2600
Iran	60,000	0.10	4700	19	3500
Total	15,110,000	—	883,690	—	530,000
Weighted average	—	1.81	—	47	—

…: countries supported by PEPFAR. ART: antiretroviral therapy; PLWHIV: people living with HIV.

Table 2. Total new child infections, MTCT rates, EID and ART coverage by region: (a) higher prevalence and (b) lower prevalence

a

Country	New child infections (n)	MTCT rate (%)	% EID 2017	% ART coverage for pMTCT	% ART coverage for children	Child AIDS-related deaths
Eastern and Southern Africa	66,050					39,590
Mozambique	18,000	15	50	86	51	9800
South Africa	13,000	5	95	95	58	8600
Kenya	8000	12	51	76	82	4300
Uganda	7600	8	48	95	68	3800
Zambia	7300	10	46	92	64	3400
Malawi	4900	9	52	92	63	3000
Zimbabwe	4300	7	65	95	89	4300
Lesotho	890	7	51	90	60	890
Swaziland	850	10	81	90	75	500
Botswana	610	5	50	90	68	500
Namibia	600	6	95	95	76	500
Central Africa	540					500
Equatorial Guinea	540	23	nd	64	17	500
Total	66,590	—	—	—	—	40,090
Weighted average	—	8	71	91	64	—

b

Country	New child infections (n)	MTCT rate (%)	% EID 2017	% ART coverage for pMTCT	% ART coverage in children	Child AIDS-related deaths
Western and Central Africa	65,800					41,460
Nigeria	36,000	23	12	30	26	23,000
DRC	4800	21	34	59	58	100
Cameroon	4500	15	51	77	25	3300
Côte d'Ivoire	3800	15	40	70	27	3100
Ghana	3400	19	30	66	23	2900
Mali	2000	27	11	31	23	980
Congo	1700	27	3	11	18	1200
Guinea	1500	24	11	38	18	720
Chad	1300	17	5	68	18	850
Togo	1200	20	36	66	30	870
Central African Republic	1100	22	23	56	25	700
Burundi	690	14	20	85	38	500
Benin	660	14	32	83	27	540
Burkina Faso	660	12	16	92	28	500
Sierra Leone	560	13	7	89	18	500
Guinea-Bissau	510	23	36	65	16	500
Gabon	500	17	4	64	50	200
Liberia	500	28	nd	86	18	500
Senegal	500	22	23	53	25	500
Eastern and Southern Africa	24,660					14,900
Tanzania	11,000	12	36	85	46	6000
Angola	5500	26	1	34	14	3300
Ethiopia	5500	17	38	59	34	3600
South Sudan	1800	20	10	60	9	1500
Rwanda	860	9	85	92	76	500

Table 2. Total new child infections, MTCT rates, EID and ART coverage by region: (a) higher prevalence and (b) lower prevalence (continued)

Country	New child infections (*n*)	MTCT rate (%)	% EID 2017	% ART coverage for pMTCT	% ART coverage in children	Child AIDS-related deaths
Asia and the Pacific	**9400**					**6630**
India	3700	16	23	60	nd	2600
Indonesia	3100	26	1	13	25	2200
Pakistan	950	31	1	6	13	530
Philippines	200	40	5	11	13	100
Myanmar	750	13	28	78	91	500
Cambodia	100	10	64	95	95	100
Malaysia	100	20	95	95	95	100
Papua New Guinea	500	29	35	41	40	500
Carribean	**1050**					**4000**
Haiti	950	15	40	70	50	600
Dominican Republic	100	10	80	95	34	3,400
Latin America	**1920**					**1280**
Brazil	720	8	45	85	45	680
Guatemala	500	42	17	21	42	200
Mexico	500	23	nd	49	69	200
Argentina	100	6	66	90	95	100
Peru	100	10	78	84	78	100
Middle East and Northern Africa	**660**					**600**
Iran	100	20	31	55	53	100
Sudan	560	29	nd	7	19	500
Eastern Europe and Central Asia	**500**					**500**
Ukraine	500	17	48	81	54	500
Russia	nd	nd	84	nd	nd	nd
Uzebekistan	nd	nd	56	62	nd	nd
Total	104,070	—	—	—	—	69,370
Weighted average	—	17	30	53	29	—

…: countries supported by PEPFAR. ART: antiretroviral therapy; EID: early infant diagnosis; MTCT: mother-to-child transmission; nd: not detected; pMTCT: prevention of mother-to-child transmission.

for new HIV infections, epidemic size, HIV prevalence, MTCT and EID rates, ART coverage and AIDS-related deaths are included.

All higher-prevalence countries were located in sub-Saharan Africa, as shown in Figure 1. Table 1a shows that 43% of PLWHIV in higher-prevalence countries lived in South Africa.

Within lower-prevalence countries, 63% of the epidemic occurred in Western and Central Africa, 24% in Eastern and Southern Africa, and 9% in Asia and the Pacific, with the remaining 4% made up of the Caribbean, Latin America, the Middle East, Northern Africa, and Eastern Europe and Central Asia combined.

Adult population

Adult ART coverage was greater in higher-prevalence countries. Weighted average ART coverage was at 67% in higher-prevalence countries *vs* 47% in lower-prevalence ones. As shown on Figure 2a, as HIV prevalence decreased, so did ART coverage (*P*=0.00325). More AIDS-related deaths amongst adults occurred in lower-prevalence countries (*n*=530,000) than in higher-prevalence ones (*n*=306,100).

Table 3 shows a summary of HIV data. In the 56 countries analysed, there were a total of 1,562,190 new infections, with 57% of these occurring in the lower-prevalence countries. More specifically, more than 24% of these new infections in lower-prevalence countries occurred in Nigeria (210,000) and 11% (100,000) occurred in Russia.

Pregnant women and children

Vertical transmission transmission

The coverage of pMTCT increased as national HIV prevalence increased (*P*=0.028), as shown on Table 3. The pMTCT rate was 53% for pregnant women living in lower-prevalence countries and 91% in higher-prevalence ones. As national HIV prevalence increased, so did national MTCT rates (*P*=0.005). Rates of MTCT were 17% in lower-prevalence countries and 8% in higher-prevalence ones.

The majority of higher-prevalence countries had an MTCT rate at 10% or below, with the lowest rates found in Botswana and South Africa. Within the lower-prevalence category, Rwanda, Brazil

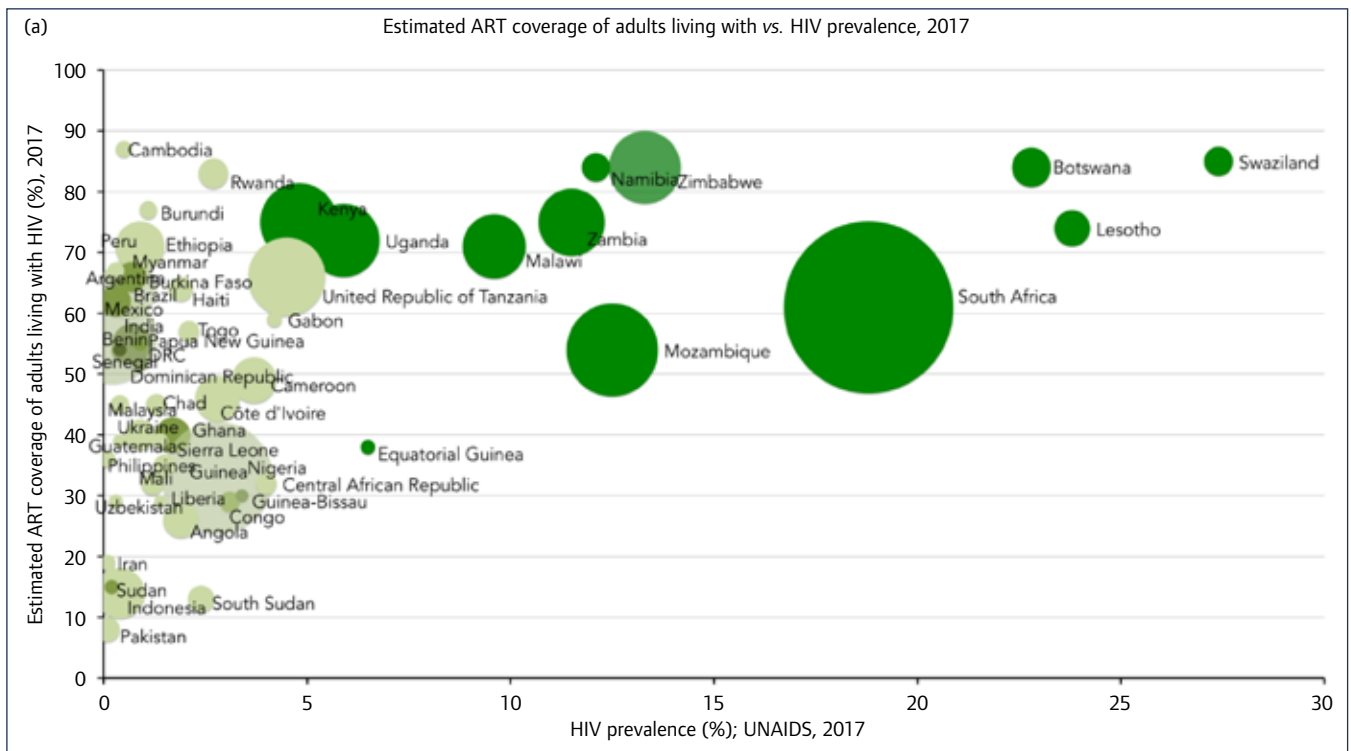**Figure 1.** Map of the countries included in this analysis split by HIV prevalence

Figure 2. (a) ART coverage against HIV prevalence weighted by epidemic size. (b) ART coverage in pregnant women against HIV prevalence weighted by epidemic size. (c) Early infant diagnosis coverage (%) against HIV prevalence weighted by epidemic size. (d) ART coverage in children against HIV prevalence weighted by epidemic size. ART: antiretroviral therapy; EID: early infant diagnosis; pMTCT: prevention of mother-to-child transmission; UNAIDS: Joint United Nations Programme on HIV/AIDS

Figure 2. continued.

Figure 2. continued.

(d) Estimated ART coverage in children vs. HIV prevalence, 2017
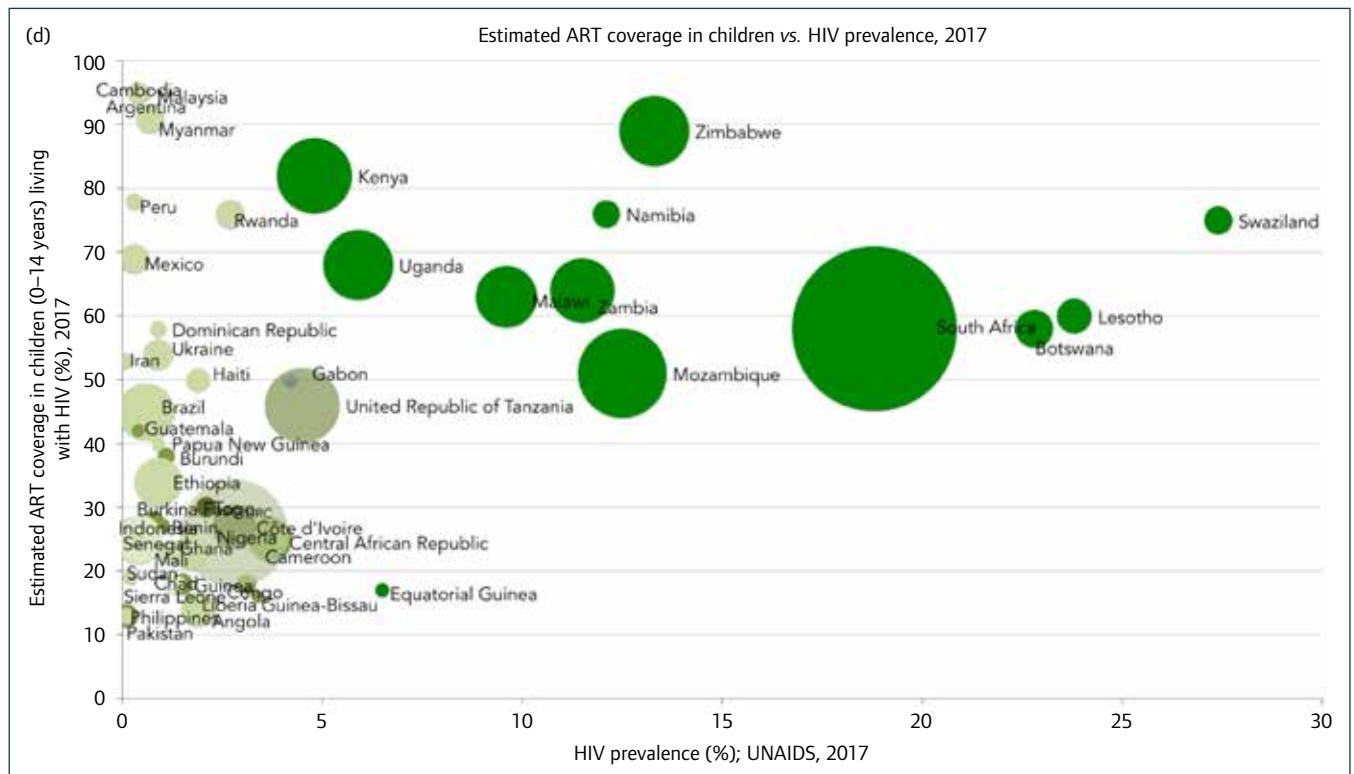
Figure 2. continued.

Table 3. Summary of HIV data for 2017 showing weighted averages by HIV prevalence, UNAIDS

	Higher prevalence (>4.5%)	Lower prevalence (≤4.5%)
No. of countries	12	44
Epidemic size (n)	16,663,000	15,110,000
Prevalence (%)	14.45	1.81
% MTCT	8	17
% EID	71	30
% ART coverage for pMTCT	91	53
% ART coverage for PLHIV	67	47
% ART coverage for children	64	29
New child infections	66,590	104,070
New total infections	678,500	883,690
Child AIDS-related deaths	40,090	69,370
Total AIDS-related deaths	306,100	530,000

ART: antiretroviral therapy; EID: early infant diagnosis; MTCT: mother-to-child transmission; PLWHIV: people living with HIV; pMTCT: prevention of mother-to-child transmission; UNAIDS: Joint United Nations Programme on HIV/AIDS.

and Argentina achieved an MTCT rate below 10%. Nearly half of lower-prevalence countries had an MTCT rate of 20% or greater. Nigeria was found to have the highest number of new child infections (36,000) and an MTCT rate at 23%.

Early infant diagnosis

As national HIV prevalence increased, EID rates also increased ($P=0.027$). EID was on average 30% *vs* 71% in the lower- and higher-prevalence countries, respectively. Figure 2c illustrates the poor EID coverage in lower-prevalence countries, particularly

Angola, Chad and Sierra Leone at 1%–2%, 5% and 7%, respectively. Rwanda, Peru and Malaysia all showed a higher EID coverage above 75%. Higher-prevalence countries, such as South Africa, Namibia and Swaziland, all achieved an EID coverage above 80%.

Children living with HIV

Figure 2d shows that childhood ART coverage increased with HIV prevalence. Two important anomalies involve Equatorial Guinea in the higher-prevalence category and Rwanda in the lower-prevalence one, with a child ART coverage of 18% and 76%, respectively. ART coverage was higher in higher-prevalence countries (average of 64%) compared with lower-prevalence ones (29%).

There was a total of 170,660 new childhood infections in the 56 countries analysed, with 61% ($n=91,470$) in lower-prevalence countries. Furthermore, more childhood AIDS-related deaths occurred in lower-prevalence countries ($n=69,370$; 8% of HIV-positive children) compared with higher-prevalence ones ($n=40,090$; 4% of HIV-positive children), with death rates twice as high for these children in lower-prevalence countries *vs* higher-prevalence countries.

Discussion

We have found in the present analysis that 205,190 more new HIV infections occurred in lower-prevalence countries compared with higher-prevalence ones, despite the fact that they accounted for 48% of the global epidemic size and that 63% of AIDS-related deaths took place in lower-prevalence countries. Four key factors may explain these results, such as a lower adult ART and pMTCT coverage and higher MTCT rates, as well as lower EID and childhood ART coverage in lower-prevalence countries. However, different types of distributions of key populations in lower-prevalence countries may also contribute to this higher number of new infections [13]. Lower ART coverage in lower-prevalence countries was seen alongside a greater number of AIDS-related deaths, with almost

twice as many in lower-prevalence countries as compared with higher-prevalence countries. Our results highlight an increasing need for effective preventative and treatment programmes in lower-prevalence countries.

There are several strategies used in higher-prevalence settings that could potentially be applied in lower-prevalence ones, including healthcare system decentralisation [14], task shifting, ART distribution by community health workers and mobile technology [15,16], adherence clubs, support networks and adoption of WHO guidelines to test and treat [17,18]. Other ground-breaking advances in ART delivery expansion include home-based, point-of-care testing [19,20], and active recalling and community-based self-testing, especially in groups of men who have sex with men [21,22]. Improved access to testing can also be made possible by lower cost testing kits [23,24]. The international community has galvanised large amounts of funding and grassroots action in higher-prevalence countries, which could be replicated with political will in lower-prevalence countries, which often have unique epidemiological, technical and social challenges in ART delivery [25]. These include lower levels of both community and healthcare professionals' awareness and understanding of HIV prevention. The absence of dialogue and of HIV testing can lead to increased stigmatising opinions about HIV [26,27] compounded by the difficulty in obtaining monitoring laboratory treatment tools and access to treatment centres. Recent success in Tanzania with the use of drones may suggest one of the ways forward to reach remote areas [28]. Reducing stigma remains crucially important in these lower-prevalence settings [29–31].

Other research exploring the relationship between successful HIV treatment programmes and the national Global Peace Index, Corruption Index and HIV prevalence found that a country with high levels of conflict and of corruption and a lower HIV prevalence was more likely to have a less effective HIV treatment programme [32]. There may be many other complex inter-related factors that explain the correlation between lower HIV prevalence and higher new infection rates.

Factors such as subnational prevalence rates may need further attention [33]. For example, regional prevalence in South Africa ranges from 13.9% to 27%. The Arc Geographic Information System shows that some hotspots have a prevalence of up to over 35%, whilst others have a prevalence of less than 1.6% HIV [34]. Therefore, if we look at lower-prevalence countries with poor national ART coverage, we may find that small hotspot areas, which may include the majority of new infections with high numbers of key populations, have very poor ART coverage, such as in Nigeria [35]. The role of geospatial analysis is increasing, but the level of detail assessed needs to be adjusted to the most relevant one for decision-making in HIV programme planning [36].

Challenges for testing and ART implementation in key populations are well recognised as these often do not disclose their current or former status as at-risk populations, particularly in countries with a high degree of stigmatisation or severe punishment. Furthermore, tracking these individuals and collecting data can be difficult as they may use a variety of services, with testing and treatment in different settings [37]. Lower-prevalence countries may face particular challenges with clusters of 'hard-to-reach' high-risk populations, and particular attention should be paid to improve their access to treatment [38].

When considering the populations of mothers and children, we have noted a great disparity in pMTCT between higher-prevalence (91%) and lower-prevalence (49%) countries, with a need for option B+ to be rolled out in the neglected countries. The pMTCT programmes are proving successful in some of the countries with

higher HIV prevalence. For example, both Botswana and South Africa are approaching a level below 5% of MTCT (for breast-feeding mothers) set by the WHO as a step towards elimination of mother-to-child transmission (eMTCT). Equatorial Guinea, however, has only 64% pMTCT coverage, with 23% MTCT rates, well above the 8% average with a huge variation in incidence and HIV information across the country [39]. Amongst lower-prevalence countries, Nigeria and Angola have an ART coverage below 35% and an ART coverage of pregnant women at 30% and 34%, respectively. Testing and treatment coverage for children in lower-prevalence countries needs attention, where EID rates are low. Point-of-care testing has not been available for infants and can be costly in areas where test volumes are low. Furthermore, interruption in drug supply and loss-to-follow-up rates can be high despite an aim for lifelong treatment for mothers [40,41]. Wide-scale EID testing is possible as shown in a pilot study in Kenya showing the impact of innovation using text-messaging services [42].

It has to be stressed that not all lower-prevalence countries are performing badly. Ethiopia, the Democratic Republic of Congo and Rwanda all show that improved EID and ART coverage is possible in these settings. Cuba, Belarus and Armenia, not included in the analysis because of small epidemic sizes, have achieved eMTCT [38]. There are clusters of poorly performing countries with ART coverage of less than 40%, EID below 30% and MTCT above 15% in lower-prevalence countries. These should draw on the successes in other low-prevalence countries to improve access to antenatal care, maternal screening, treatment and infant follow-up [38]. Further guidance might come from other successes in paediatric inpatient settings, nutrition centres, immunisation clinics and paediatric outpatient clinics, and triggered testing may have a similar yield to universal testing [43].

There are limitations in our analyses. The UNAIDSinfo database uses the Spectrum model. Given the limited availability of surveillance data across the HIV population, the data presented rely on modelling approaches to fill in the gaps and on modelled understanding of HIV transmission [44,45]. Although the 2017 data were produced by an updated model reflecting improved understanding of MTCT, overestimations and underestimations cannot be excluded [44]. The benefit of using UNAIDSinfo data rather than heterogeneous national reports or peer-reviewed published studies is that data for each country are calculated by the Spectrum model and used the same methodology and are relatively homogenous. Therefore, data for each country both benefit and suffer from the same modelling underestimations and overestimations.

Overall, HIV data remain incomplete, necessitating further estimates, such as for pregnant women with an unknown HIV status or for those not using antenatal services. We have assumed that most new children infections (between the ages 0 and 14) would originate from vertical transmission. Many women breastfeed their children up to the age of 5 years or even longer and may transmit after the 12-month definition, whilst other pregnant women who may have been HIV negative at the beginning of their pregnancy become HIV positive during pregnancy or just afterwards.

Our analysis shows only a part of the global picture. The rates of increase in new infections have been highest in the Eastern European and Central Asia regions (200,000 cases in 2017) [46]. As China did not have available data, it was excluded from our analysis. We are aware that other sources provide different estimates for some countries. For example, much of the WHO country profile data give different figures, although these are from 2016.

PEPFAR data also report different figures [24]. It is important to bear in mind that the country reports from 2016 when compared with UNAIDSinfo data from the same year showed variable results [47]. Thus, despite the fact that we have analysed the most up-to-date data on the UNAIDS website, providing a maximally homogenous dataset, estimates must be treated with caution.

In conclusion, higher MTCT rates and numbers of new HIV infections in adults and children, as well as increased HIV/AIDS-related deaths, were found in lower-prevalence rather than higher-prevalence countries, despite lower-prevalence countries accounting for 48% of the global epidemic. These lower-prevalence countries have significantly decreased rates of EID and ART uptake for adults and children. More intensive programmes of diagnosis and treatment are needed in these countries to reduce global new HIV infections to below 500,000 per year by 2020.

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