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The impact of HIV prevalence, conflict, corruption, and GDP/capita on treatment cascades: data from 137 countries

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Abstract

Objective: In 2014, UNAIDS and partners set the 90-90-90 targets for the HIV treatment cascade. Multiple social, political and structural factors might influence progress towards these targets. We assessed how close countries and regions are to reaching these targets, and compared cascade outcomes with HIV prevalence, gross domestic product (GDP)/capita, conflict and corruption.

Methods: Country-level HIV cascade data on diagnosis, ART coverage and viral suppression, from 2010 to 2016 were extracted from national reports, published papers and the www.AIDSinfoOnline database, and analysed. Weighted least-squares regression was used to assess predictors of cascade achievement: region, HIV prevalence, GDP/capita, the 2016 Corruption Perceptions Index (CPI), which is an international ranking system, and the 2016 Global Peace Index (GPI), which ranks all countries based on three main categories: societal safety, militarisation and conflict.

Results: Data were available for diagnosis for 84 countries, ART coverage for 137 countries, and viral suppression for 94 countries. Regions with the lowest ART coverage were South-east Asia and Pacific (36%), Eastern Europe and Central Asia (17%), and Middle East and North Africa (13%). Lower HIV prevalence was associated with poorer cascade results. Countries with higher GDP/capita achieved higher ART coverage ($P<0.001$). Furthermore, countries with lower levels of peace and higher corruption had lower ART coverage ($P<0.001$). Countries with a GPI >2.5 all had ART coverage of <40%.

Conclusion: Only one country has reached the UNAIDS 90-90-90 targets. International comparison remains difficult due to heterogeneous data reporting. Difficulty meeting UNAIDS targets is associated with lower GDP/capita, lower HIV prevalence, higher corruption and conflict levels.

Keywords: antiretroviral therapy coverage, cascade of care, corruption, conflict and peace, prevalence, regional and national analysis

Introduction

The 90-90-90 targets set by UNAIDS and partners call for 90% of all people living with HIV to be diagnosed, for 90% of those diagnosed to be on antiretroviral therapy (ART), for 90% of those on treatment to achieve viral suppression, and to considerably reduce annual new infections to <500,000, by 2020 [1]. Furthermore, by 2030 the policy aims for 95% of all people living with HIV to be diagnosed, subsequently 95% on ART and a subsequent 95% of those on treatment to be virally suppressed, with fewer than 200,000 global annual new infections, as part of the 'Fast track to end the epidemic' [1]. Since these goals were first set, much has changed. While approximately 3.5 million deaths have been averted due to ART, the epidemic size has increased by about 1.9 million since 2014. However, the number of people on ART has increased comparatively more (by 3.3 million) [1].

When the 90-90-90 targets were first announced in October 2014, they were met with optimism and hope but some reservations [2]. It was proposed that global policy to dramatically scale up ART coverage could help to avert HIV/AIDS-related deaths and illnesses, reduce incidence and stigma, and by employing the concepts of universal test and treat (UTT), reduce new infections and bring the HIV/AIDS epidemic under control [1]. Eleven months later, WHO guidelines changed to recommend UTT – whereby all those diagnosed with HIV should immediately start ART, regardless of CD4 cell count [3] and the '15 by 15' target was met (15 million people on treatment by 2015) [4]. The cascade, or continuum of HIV care [5], illustrates progress towards these targets and the effectiveness of a country's healthcare system in terms of HIV pandemic control. It is now not only used to analyse HIV programmes but also hepatitis C [6], TB and other diseases [7].

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While funding for HIV quadrupled between 2000 and 2012, it then plateaued at US$19.5 billion and has actually reduced over the last 4 years [8]. Following the financial crash and subsequent stagnation in funding for HIV, PEPFAR and other programmes have refocused on cost-effectiveness. As a consequence they prioritise their funds towards high prevalence areas [9]. Countries with generalised, high prevalence epidemics may find it more cost-effective to run large testing and treatment campaigns. Globally, HIV prevalence is variable: from 0.1 to 7.1% between regions (<0.1 to 28.8% nationally [4]) and epidemics can be focal (within a specific population such as men who have sex with men [MSM]) or generalised.

High-income, geographically small countries in Western Europe with high GDP/capita such as Sweden [10] and Switzerland [11] have proved that these targets are achievable [12]. However, both these countries are wealthy and have small focused HIV epidemics. Unfortunately, disparity and inequality is inevitable; poorer regions, higher HIV-burden countries with generalised epidemics, lower-GDP/capita and disadvantaged high-risk populations may struggle more to reach the targets, especially as international aid funding has been reduced [8].

While we have seen promising and somewhat unpredicted successes in parts of sub-Saharan Africa (Rwanda and Botswana [6,13]), previous research analysing national cascades found countries in the Middle East and Eastern Europe in particular were struggling to test and treat successfully (Ukraine, Russia, Iran, Yemen, Afghanistan) [12]. Having a successful HIV treatment system requires infrastructure, healthcare workers and public health education programme. Importantly, an absence of structural barriers preventing key populations from accessing care. Countries with lower GDP/capita may lack funding to build these comprehensive healthcare systems.

With higher rates of poverty and illness in general [14], individuals living with HIV in poorer countries may experience increased structural and social barriers to accessing care [15]. It has been found that a low GDP/capita prevented poorer countries from achieving the health-related Millennium Development Goals owing to reduced spending on health and having fewer physicians per capita [14]. However, in lower-income settings, frugal innovation [16], activism [17,18], task-shifting, community resilience and leadership [19], have helped to fight stigma [17], reduce drug prices and provide generic medications to build highly cost-effective, horizontal HIV/AIDS programmes, allowing some poorer countries to succeed [13].

The Global Peace Index (GPI) and Corruption Perceptions Index (CPI) [20] have never before been compared directly with HIV treatment service outcomes. Corruption may prevent access to testing and care in particular settings where funds for public health and HIV/AIDS programmes may be misappropriated. Corruption has been found to be a factor in drug stock-outs [21], which impact ART coverage and viral suppression. Furthermore, individuals may become resentful, distrusting and therefore reluctant to engage with healthcare providers that are corrupt or negligent [22]. Other qualitative research has suggested that corruption in parts of Nigeria has had a detrimental effect on HIV/AIDS treatment programmes, via increasing inequality, worsening stigma, damaging access to prevention services and poor sexual health education [23,24].

Unsurprisingly, it has been proven that conflict greatly damages health services [25], while peace greatly improves national life expectancy [24]. Conflict may directly contribute to structural barriers to accessing HIV care, leading to reduced diagnosis rates and more drug stock-outs, resulting in unplanned interruptions of treatment, reducing ART coverage and viral suppression.

We have investigated which countries and regions are progressing towards these targets, and more importantly, why some countries and regions are being left behind. We analysed correlations between cascade progress and GDP/capita, HIV prevalence, corruption, and peace and conflict, in a comprehensive global, regional and national analysis of HIV treatment cascades.

Methods

We ran a systematic search of OvidSP, the UNAIDS AIDSinfo database and national reports for all HIV treatment cascades published between 2010 and September 2016. The search terms included 'HIV' or 'AIDS' and 'Treatment Cascade' or 'Continuum of Care' combined separately with 196 country names. We identified 841 titles, read 241 abstracts and 191 National UNAIDS data pages. Reliable and recently published data were available for 144 countries (Appendix Figure A1). Sub-national cascades or cascades of specific groups of the population (e.g. MSM-only cascades) were excluded.

For countries where both UNAIDS estimates and national reports (or published papers) were available, we found that UNAIDS generally tended to underestimate the total epidemic size (see Appendix Figure A2). We, therefore, used the published peer-reviewed research or national reports where possible, despite the UNAIDS estimates being less heterogeneous.

In this analysis we included only countries with available full cascade data, which involved four key stages:

(1) Total epidemic size: estimated by back calculation, using epidemiological models such as Spectrum, in combination with cross-sectional studies or anonymous unlinked seroprevalence surveys.

(2) Diagnosis: estimated using healthcare system databases, testing programme data and retrospective cross-sectional surveys.

(3) ART coverage: estimated using pharmacy and funding records, prescription data, retrospective patient interview surveys, government drug purchases, procurement and distribution records (adjusted for PEP and PrEP). Different ART regimens were not distinguished.

(4) Viral suppression: defined by UNAIDS, and most national cascades as a viral load <1000 RNA copies/mL [1]. However, many countries used lower cut-offs to define 'undetectable' as viral load test sensitivity varies. For example Rwanda, used <40 copies/mL as the cut-off [13].

We excluded subcategories such as 'linkage to care', 'retention in care', 'eligibility for treatment' and 'adherence' as they were not specific to UNAIDS targets and were too heterogeneously defined.

GDP/capita data were taken from the 2015 World Bank database. HIV prevalence and incidence data were taken from the UNAIDS database (calculated using the Spectrum model). If prevalence data were not available there, published reports in peer-reviewed journals or national reports were used (e.g. *MMRW* [26]).

We used the 2016 CPI to compare estimated levels of corruption across 176 countries [20]. The CPI score is mostly qualitative, calculated by Transparency International, using 13 different data surveys, which combine factors such as transparency, accountability, bribery, nepotism and corruption levels in the private sector and various public services such as the judicial system, government or police force [20]. Each data set is then standardised to be compatible with other available sources for aggregation to the CPI scale. The standardisation converts all the data sources, using a Z-score, to a scale of 0–100 where a 0=highest level of perceived corruption, and 100=lowest level of perceived corruption. More details are available in the CPI technical methodology notes [20].

We used conflict and peace data taken from the 10th Global Peace Index report 2016 [27]. The GPI is calculated from 23 weighted qualitative and quantitative indicators, which generally fall into three main categories. Each indicator is weighted (shown in parentheses), and contributes to an overall score from 1=least conflict to 5=most conflict. More details are available in the GPI 2016 report [27].

1. *Ongoing domestic and international conflict*
    1. Number and duration of internal conflict (5)
    2. Number of deaths from organised conflict (external) (5)
    3. Number of deaths from organised conflict (internal) (5)
    4. Number, duration and role in external conflicts (2.56)
    5. Intensity of organised internal conflict (3)
    6. Relations with neighbouring countries (5)
2. *Societal safety and security*
    7. Level of perceived criminality in society (3)
    8. Number of refugees and internally displaces people as a percentage of the population (4)
    9. Political instability (4)
    10. Political terror scale (4)
    11. Impact of terrorism (2)

 Journal of Virus Eradication 2018; **4**: 80–90

12. Number of homicides per 100,000 people (4)
13. Level of violent crime (4)
14. Likelihood of violent demonstrations (3)
15. Number of jailed population per 100,000 people (3)
16. Number of internal security officers and police (3)

3. *Militarisation*

17. Military expenditure (% of GDP) (2)
18. Number of armed services personnel per 100,000 people (2)
19. Volume of transfers of major conventional weapons as recipient (imports) per 100,000 people (2)
20. Volume of transfers of major conventional weapons as supplier (exports) per 100,000 people (3)
21. Financial contribution to UN peacekeeping missions (2)
22. Nuclear and heavy weapons capabilities (3)
23. Ease of access to small arms and light weapons (3)

Our nine chosen regions were adjusted from those used by UNAIDS to be in line with GDP/capita, prevalence and GPI regional data. (See Appendix for details)

Statistical methodology

Cascade achievement, as defined by diagnosis, ART coverage and viral suppression, was compared using weighted least-squares regression analysis with various predictors. These predictors included: geographical region, GDP/capita, HIV prevalence, CPI and GPI, controlling for African and non-African countries.

Results

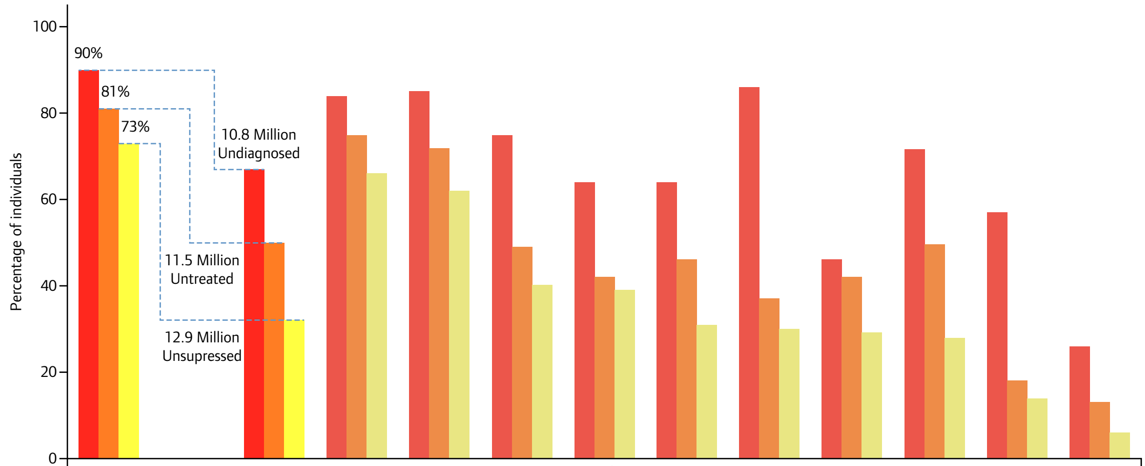
Global and regional findings

Figure 1 show the 90-90-90 targets, compared to the 2016 global cascade and each region ranked by percentage achieving viral suppression, illustrating the current estimated gaps in care. Globally, of all individuals living with HIV, an estimated 59%–67% were diagnosed, 46%–50% were on ART and approximately 29%–32% were estimated to have achieved viral suppression. Lower estimates were calculated using a weighted average of available national cascades and applied to the estimated total global epidemic size. Higher estimates were calculated by UNAIDS using Spectrum models.

Our regional analysis, using data from 84 countries, illustrates inter-country, inter-regional and intra-regional variation. Oceania, Western Europe and South America have the highest percentage of individuals living with HIV achieving viral suppression. Figure 1 shows that these three regions have similar cascade shapes, with the greatest breakpoints at diagnosis and ART coverage. Oceania is the only region to meet any individual target; where >90% of those on ART achieve viral suppression.

Sub-Saharan Africa and South-east Asia and Pacific (SEAP) have similarly shaped cascades, ending with 29% and 32% viral suppression overall respectively. In the USA however, despite the highest diagnosis rates (86%), ART coverage is lower than both sub-Saharan Africa and SEAP, and viral suppression is only marginally higher at 30%, despite having a much higher GDP/capita.

The Middle East and North Africa (MENA), where the average conflict level is highest, has the lowest percentage diagnosed (26%), on ART (13%) and virally suppressed (6%), but its greatest breakpoint is at diagnosis. The greatest breakpoint for Eastern Europe and Central Asia (EECA) is provision of ART to those diagnosed. Diagnosis rates in EECA are 57%, which is more than



Country/region	UNAIDS targets	Global disparity (2016)	Global average (2016)	Western Europe	Oceania	South America	South-east Asia and Pacific	Central America	USA	Sub Saharan Africa	Caribbean	Eastern Europe and Central Asia	Middle East and North Africa
Diagnosed (%)	90		67	84	85	75	64	64	86	46	72	57	26
Percentage **on ART**	81		50	75	72	49	42	46	37	42	50	18	13
Percentage **virally suppressed**	73		32	66	62	40	39	31	30	29	28	14	6
Prevalence			0.7–0.9	0.2–0.4	0.01	0.4–0.6	0.1–0.3	0.4–0.6	0.3	1.8–7.6	0.4–0.6	0.8–0.9	<0.1–0.2
Incidence			0.154	0.017	0.05	0.034	0.02	0.058	0.03	0.362	0.058	0.044	0.041
Global Peace Index			2.101	1.524	1.568	2.102	2.026	2.102	2.154	2.162	2.102	1.982	2.671
Sample size, *n*			36,900,000	687,720	30,695	1,301,200	4,696,578	327,825	1,201,100	25,532,002	286,338	1,758,146	654,340

Figure 1. Global and regional data: estimated regional cascades weighted by epidemic size and ranked by diagnosis. Note: incidence and prevalence data from UNAIDS except USA which is from CDC [28]

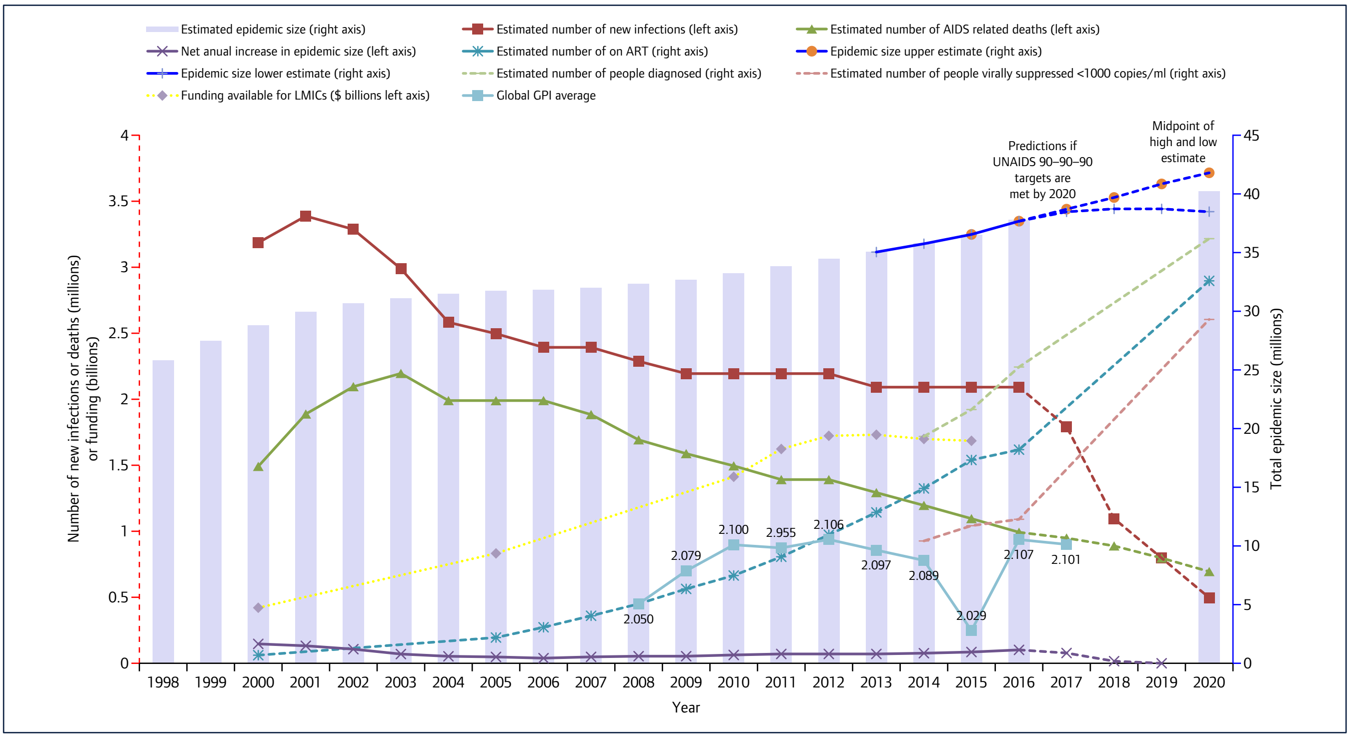


Figure 2. Global HIV cascade, new infections, deaths and funding 1998–2020

double that of the MENA region and similar to that of SEAP (64%) and sub-Saharan Africa (46%).

Figure 2 illustrates that the HIV epidemic is projected to grow by 1.95–6.30 million people by 2020, depending greatly on potential incidence and mortality reductions. New infections have been declining slightly over the last decade, but the drastic drop required to meet the <500,000/year target by 2020 looks unfeasible compared to the trend. Funding has also stagnated and has decreased since 2012, and global average GPI has marginally increased since records began, except for a drop in 2015.

As the number of new infections each year has only reduced from 2.5 million/year to 2.1 million/year over the last 13 years, unless drastic improvements occur in HIV prevention interventions, the upper limit seems more likely. Once all new infections are included, in order to meet the 90-90-90 targets by 2020, we must diagnose a further 12.6–17.6 million people, provide ART for 13.1–17.8 million and ensure that 14.4–19.6 million more people achieve viral suppression.

National cascade findings

National cascade data were available for 137 countries; however, only 86 countries had data for all four stages of the cascade. Figure 3a illustrates that for diagnosis rates across 69 countries, Sweden, Kazakhstan, Italy and Romania were the only countries that reported reaching the first overall 90% target, while Madagascar had the lowest percentage diagnosed. Figure 3b, with data from 126 cascades, shows that Sweden and the UK were the only countries found to reach the second overall 81% target for ART coverage, while Madagascar is the country with the lowest ART coverage. Figure 3c shows that for 86 countries with viral suppression data, Sweden and the UK again were the only countries known to meet the overall 73% target, while Pakistan had the lowest percentage of individuals living with HIV achieving viral suppression. Many countries in the MENA and sub-Saharan African regions lacked reliable data.

GDP/capita, ART coverage and HIV prevalence

Weighted least-squared regression analysis showed that countries with higher GDP/capita had higher rates of diagnosis, ART coverage and viral suppression (all $P<0.001$). Figure 4 shows the relationship between ART coverage and HIV prevalence, calculated using least-squares regression, weighted by epidemic size controlling for GDP/capita. Within Africa, countries with lower HIV prevalence had lower rates of ART coverage ($P<0.001$) and viral suppression ($P=0.0072$), and lower rates of diagnosis ($P=0.0261$) when controlling for GDP ($P<0.001$). Outside Africa, countries with lower HIV prevalence had lower diagnosis rates, ART coverage and viral suppression (all $P<0.001$).

GPI and CPI findings

As GPI score increases from 1 (more peaceful) to 4 (less peaceful), conflict has a negative impact upon diagnosis, ART coverage (Figure 5) and viral suppression for people living with HIV. GPI has a steeper correlation gradient with ART coverage than diagnosis or viral suppression, showing that conflict may have a more direct impact on access to treatment. No country with a GPI>2.5 achieved ART coverage >40%.

Figure 6 shows that as CPI score decreases from 100 (most corrupt) to 0 (least corrupt), ART coverage increases dramatically. Weighted least-squares regression analysis showed that countries with higher levels of corruption had lower ART coverage ($P=0.03394$). There may be a threshold whereby countries with a CPI<50 achieve relatively good ART coverage, but when CPI>50 there is a dramatic decrease in ART coverage. Figure 6 illustrates that many countries with high levels of corruption also have high levels of conflict (and vice versa).

Countries in the lower left quadrant of Figure 5, such as Madagascar, Mozambique, Indonesia and Bangladesh, perform poorly in the cascade, despite low conflict levels. However, all these countries have very high corruption (>60 CPI), which may explain their poor ART coverage.

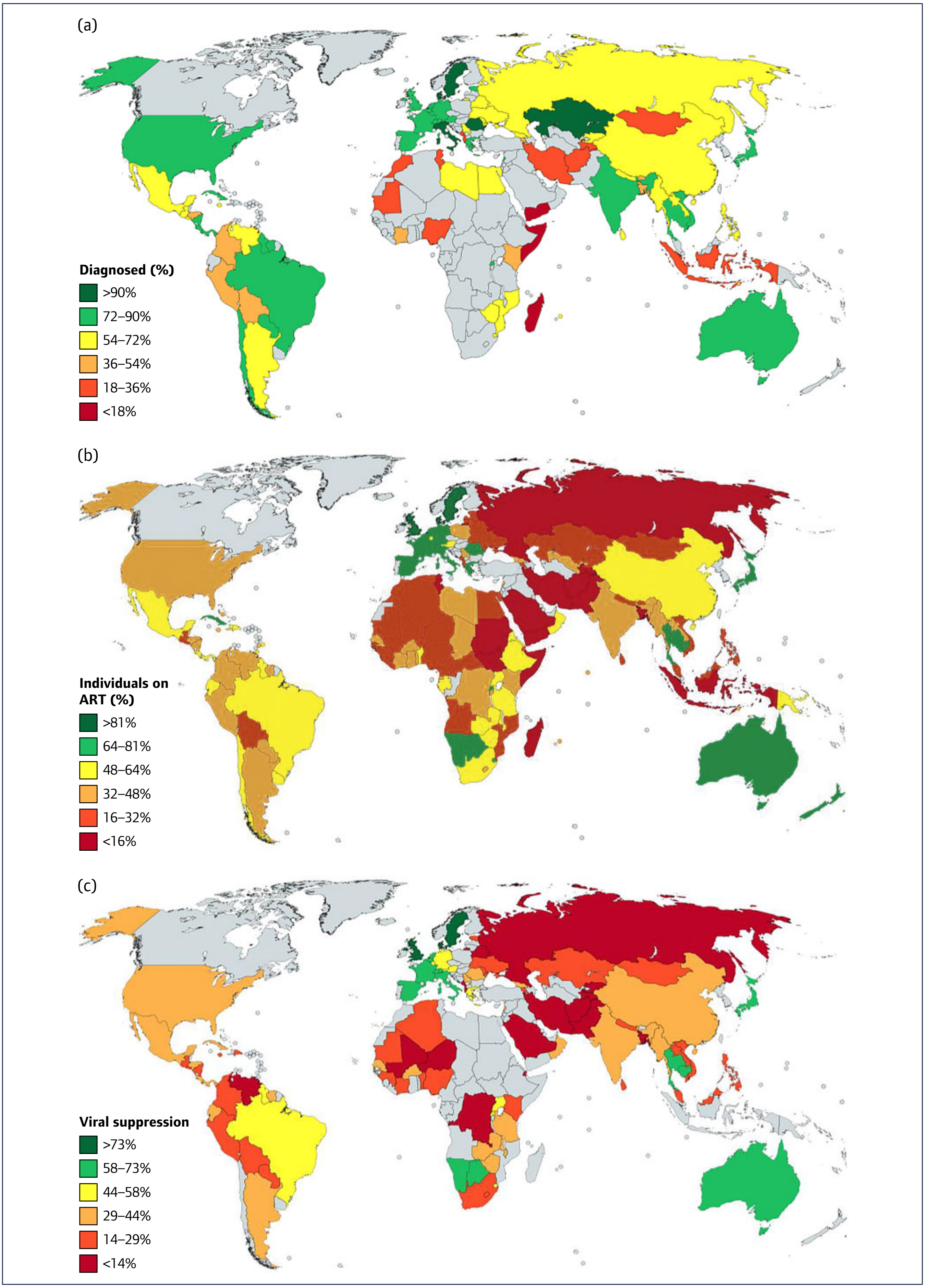


Figure 3. Maps of (a) diagnosis, (b) ART coverage and (c) viral suppression

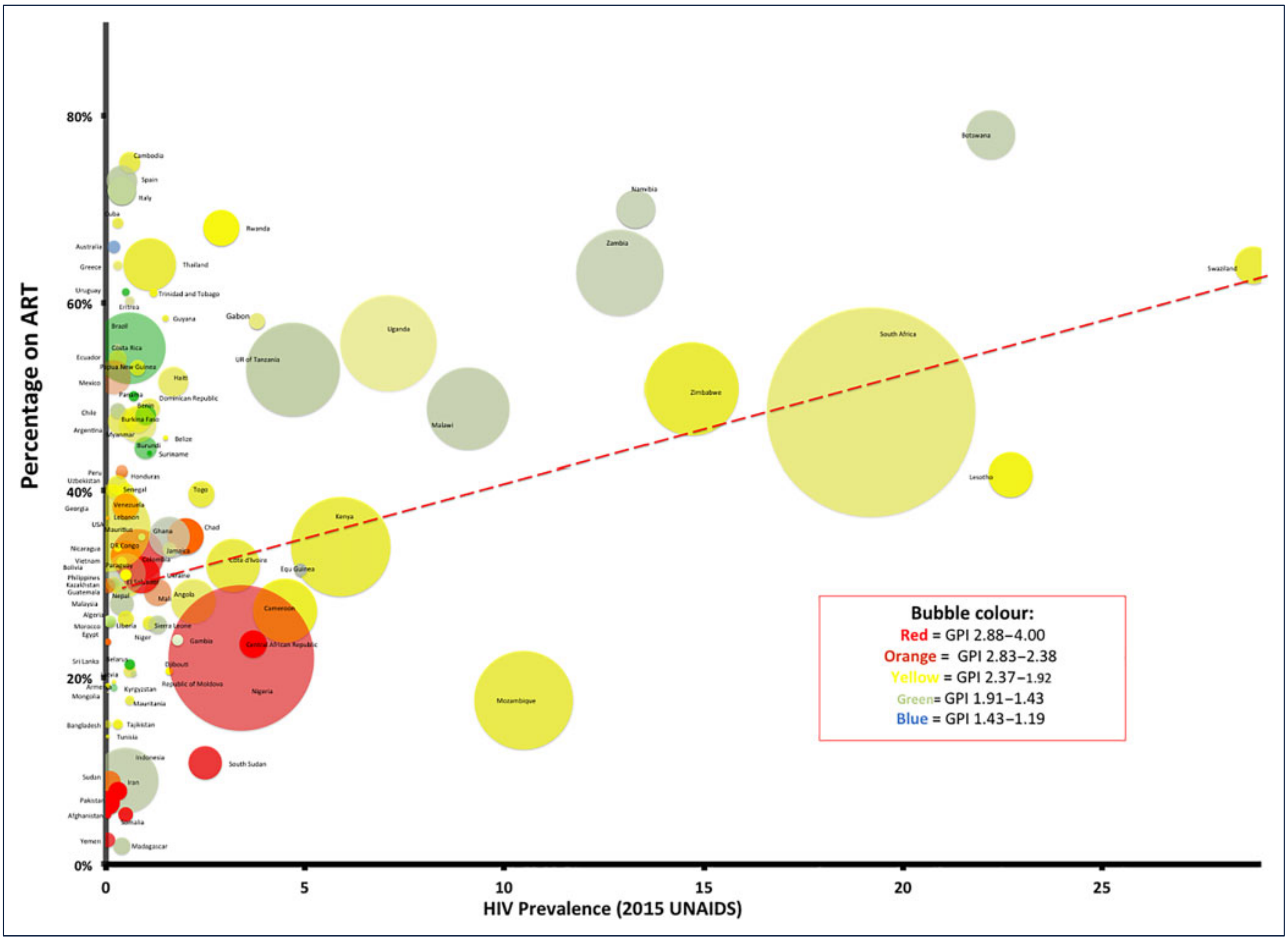


Figure 4. HIV prevalence in individuals aged 15–49 years per 100 population in 2015 compared with ART coverage controlling for GDP/capita. All circles are weighted by epidemic size and colour-coded for the level of increasing conflict. GPI: Global Peace Index

Discussion

This is the first time a direct global comparison has been made between HIV cascade targets and GDP/capita, HIV prevalence, conflict and corruption. We have shown that there may be a threshold of conflict and corruption levels, below which ART coverage is particularly compromised. We also found that countries with low HIV prevalence had poorer ART coverage. Reaching the global targets for diagnosis, ART coverage and viral suppression appears feasible, but international inequality is widespread.

Furthermore, funding available for lower- and middle-income countries (LMICs) stagnated around 2012 and has since decreased [8]. More research is urgently needed to examine if expanded treatment access is impacting incidence [29]. With planned funding scale-back, mathematical models predict that in 10 years projected incidence may increase by 0.5%–19.4% and deaths by 0.6%–39.1% [30]. Other models show that meeting the 90-90-90 targets may still be insufficient to significantly impact incidence, especially if key populations are missed and continue to drive incidence [31]. It is crucial to consider the demographics of the 10% being subsequently lost at each cascade stage.

An important new finding compared to previous analyses is that now one country, Sweden, has achieved all three targets, while several other countries are close. Another improvement is that cascade data are available for many more countries. While other high-income countries are likely to follow Sweden before 2020, we still have a long way to go for many higher-burden, lower-income countries. Sweden has relatively very high levels of GDP/capita and peace (GPI) and low corruption levels (CPI). Seven of the eleven countries with the lowest ART coverage have the highest levels of conflict: Afghanistan, Pakistan, Russia, Nigeria, Somalia, Yemen and Sudan.

The US, one of the largest donors for HIV treatment in LMICs via PEPFAR, performs poorly amongst high GDP/capita countries, as measured by cascade achievements. The greatest breakpoint in the US was from diagnosis to ART coverage as the US lacks universal healthcare coverage. Furthermore, other regional research found adherence (amongst adolescents) in the US was worse (53%) than in Europe, South America (62%–63%), Africa and Asia (both 84%) [32]. Additionally, the US has a high conflict level for its GDP/capita, owing to high military spending, gun crime and various conflicts abroad, these issues may detract from public health spending internally [27].

Multiple challenges to meeting the 90-90-90 targets have been noted in addition to political, social and structural barriers. Reduced funds and the rising 'double burden' of NCDs [33,34], may both distract from 'political will' and also cause comorbidities in people living with HIV. While some estimates found current drug resistance had remained stable at around 5%–8% in resource-limited settings [35], others found worrying levels of 29%, [36] and this could become a challenge in the future [34]. In the Trump era, global health researchers are worried that the US and other countries will suffer from the de-prioritisation of public health and a shift away from an evidence-based approach to HIV prevention and treatment access [36,37].

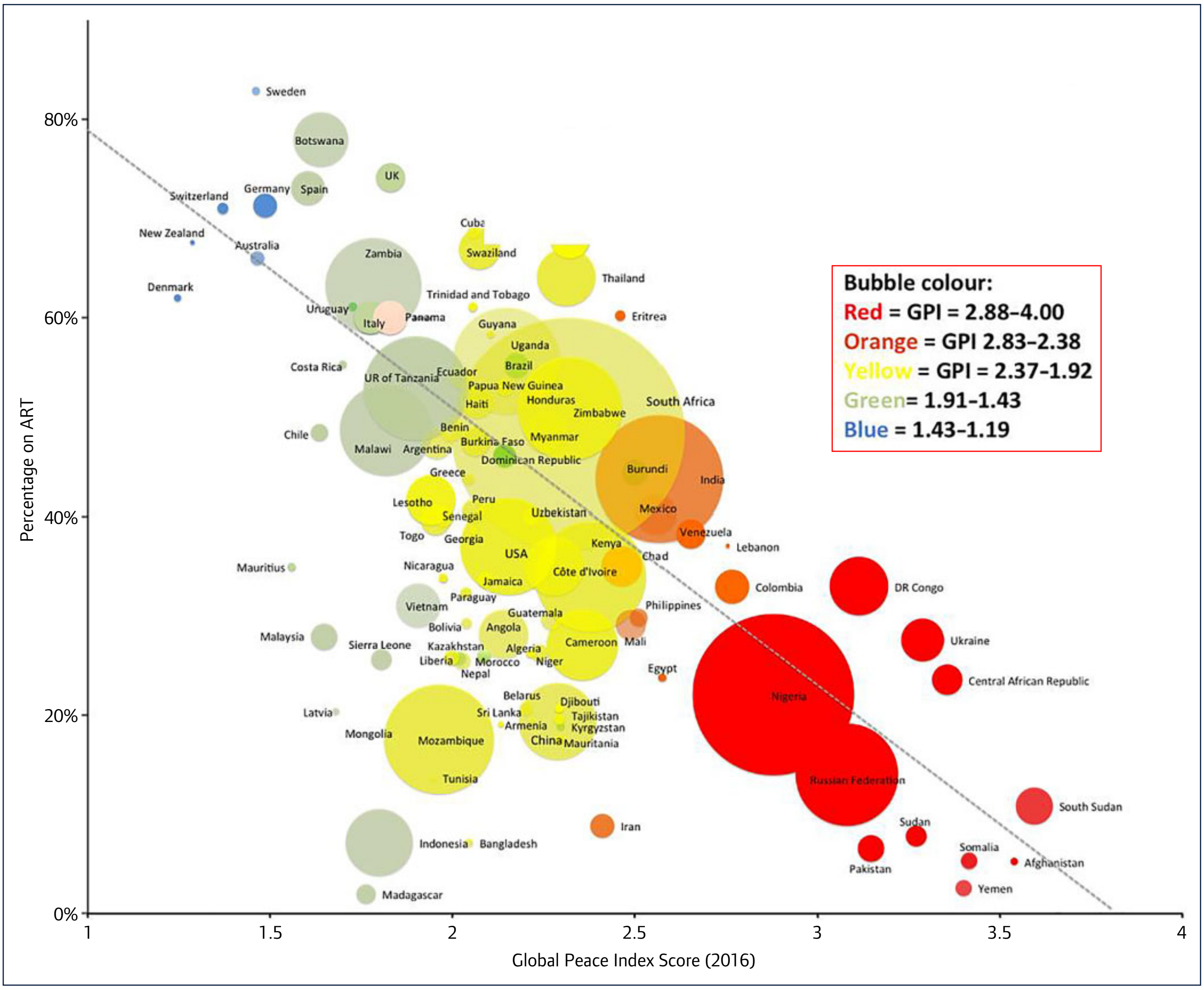


Figure 5. Comparison of estimated total number of people living with HIV on ART and Global Peace Index weighted by epidemic size and shaded according to Global Peace Index (GPI)

Prevalence

Countries with high-prevalence, generalised epidemics had better cascades than those with low-prevalence, generalised epidemics. This may seem counterintuitive, but as prevalence increases, it may become easier and more cost-effective to develop specialised services to diagnose and successfully treat individuals living with HIV. Furthermore, higher-prevalence countries may have more political momentum to push HIV higher up the agenda. This may reduce stigma, encouraging higher testing rates and allow purchasing of medicines and testing technologies at discounted bulk production prices. Therefore, high-prevalence countries may use relatively fewer resources per capita to successfully diagnose, treat and suppress the virus in those living with HIV. This may be further compounded by the global strategy to prioritise aid and resources to high-prevalence settings [9]. Prioritising high-prevalence areas may make sense in terms of immediate programme cost-effectiveness; however, the long-term financial savings of a healthier generation (both to the health system and to individuals living with HIV) should not be forgotten [38].

Other research found that higher national HIV prevalence had a negative effect on a country's economic and health-related development. Their model showed that every 1% decrease in HIV prevalence was equivalent to a 40% rise in GDP in terms of facilitating progress towards the UN Millennium Development Goals [14]. Conversely, amongst high-burden countries with generalised epidemics, countries with lower HIV prevalence have relative difficulties providing effective prevention of vertical transmission services [39].

Conflict

Conflict leads to displacement of people, who are more difficult to track and may slip through the monitoring of the HIV cascades [40]. This may skew the data, as the impact that conflict has upon people living with HIV would be underestimated. Additionally economic migration can have a detrimental impact on HIV coverage [41]. Globally, GPI has slightly increased since records began and there has been a recent marked rise in the number of externally displaced people and even more so, internally displaced people [27].

Other researchers have found that conflict did not directly increase HIV incidence or HIV prevalence in specific communities of displaced people in sub-Saharan Africa [42]. It was found in Kenya that a healthcare system without a back-up plan in case of an emergency/conflict, was more likely to struggle to provide HIV care [43]. Médecins Sans Frontières also found that HIV service provision in areas of conflict and post-conflict can be effective, as long as planning and effective responses are co-ordinated [44]. Refugees and migrants living with HIV may be less likely to be diagnosed, linked to care, on ART and virally suppressed [40], and may unfairly receive lower-quality care, and have comorbidities

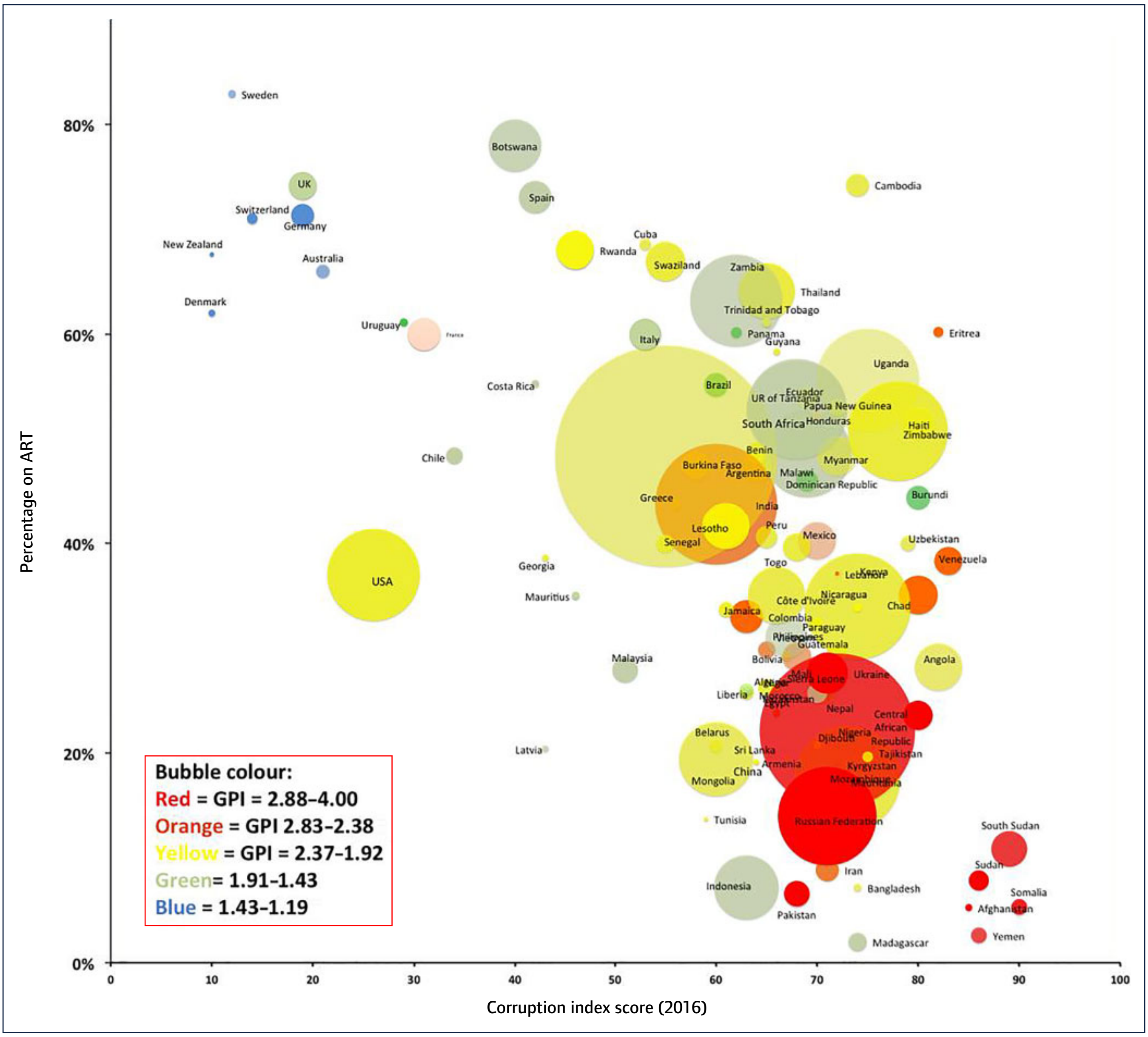


Figure 6. Comparison of estimated total number of people living with HIV on ART and Corruption Index, weighted by epidemic size and shaded according to Global Peace Index (GPI)

such as PTSD [45]. Displaced people are generally at a higher risk of HIV than non-displaced people; however, it is a common stigmatising misconception that refugees increase HIV rates in host communities [45,46].

Despite better stage definitions, national cascades continue to be heterogeneous and lack standardisation [28] making comparison difficult [12,28]. Most available cascade data were cross-sectional rather than longitudinal showing just a snapshot in time. Longitudinal data is more realistic as it shows change over time as people flow between different cascade stages, which was a limitation in this study.

Another limitation was that neither CPI nor GPI show the full picture, as some types of corruption or conflict will be more damaging to the HIV cascade than others. GPI scores only include violence variables where reliable data were available. Factors excluded from analysis included: domestic violence, household out-of-pocket spending on safety and security, the cost of crime to business, intimate partner violence, self-directed violence, and cost of intelligence agencies and judicial system expenditures [27]. These excluded factors may increase stigma or provide structural barriers to accessing care and further affect the HIV cascade.

Conclusion

Higher ART coverage was associated with higher GDP/capita, higher HIV prevalence, lower corruption levels and lower conflict levels. Many countries with a low HIV prevalence need to increase rates of HIV diagnosis, treatment and viral suppression. Therefore, current global strategies prioritising high-prevalence areas may leave behind key populations. We have identified a potential threshold of conflict and CPI – below which ART coverage is significantly impaired. Some countries are not reaching targets for ART coverage due to conflict or low GDP, while others may be struggling due to corruption; however, these factors are interrelated. Reaching the 90-90-90 target is possible, although more research is urgently needed to assess the impact that ART coverage, corruption and conflict and other factors are having upon incidence.

Acknowledgements

Conflict of interest

The authors declare that there are no conflicts of interest.

Authors' contributions

Andrew Hill, Anton Pozniak and Jacob Levi designed the project. Jacob Levi collected the data and wrote the manuscript. Katherine Heath and Jacob Levi analysed the data.

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Appendix

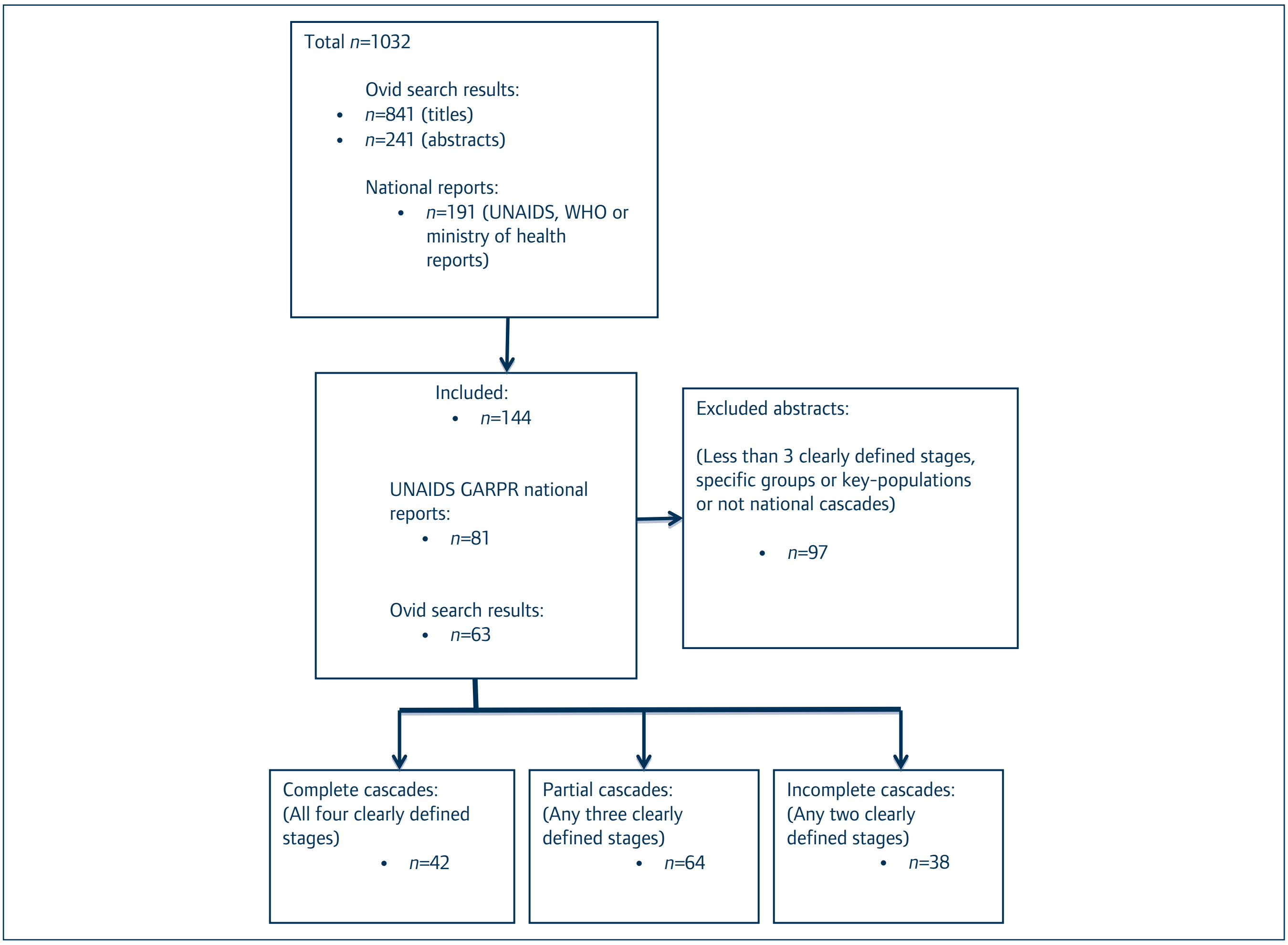

Figure A1. Search method flow chart. GARPR: global AIDS response progress report

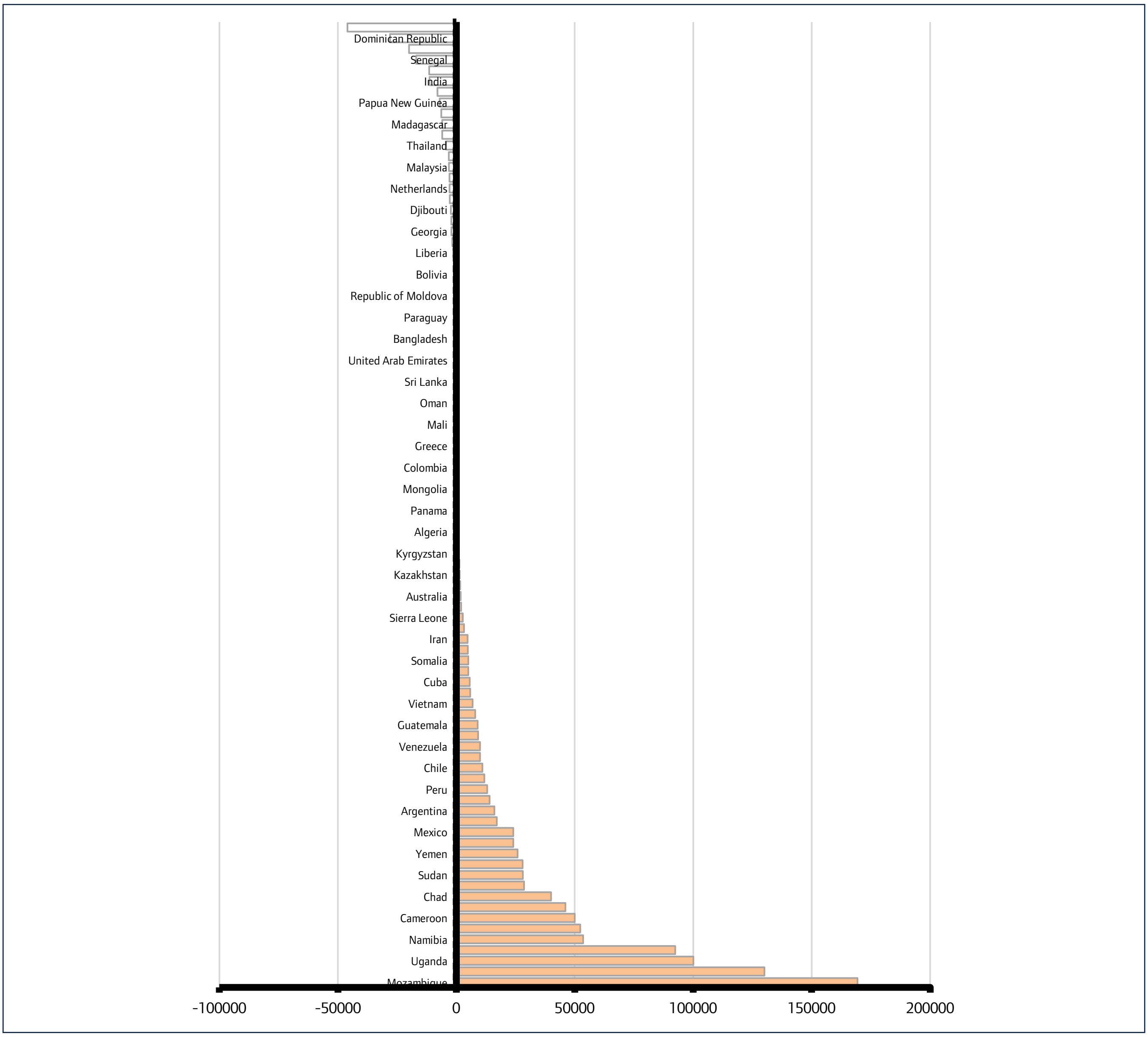

Figure A2. Difference between national report or published article estimate of total number of people living with HIV compared to UNAIDS estimation for the same year

Regions with available data to calculate averages

Western Europe

Austria, France, Germany, Greece, Italy, Luxembourg, Netherlands, Spain, Sweden, Switzerland, UK.

Oceania

Australia, Fiji.

South America

Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela.

South-east Asia and Pacific

Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Mongolia, Myanmar, Nepal, Papua New Guinea, Philippines, Sri Lanka, Thailand, Vietnam.

Central America

Belize, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama.

USA

Nationwide Canadian cascade data was not available so North America is USA.

Sub-Saharan Africa

Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sierra Leone, South Africa, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

Caribbean

Cuba, Dominican Republic, Haiti, Jamaica, Trinidad and Tobago.

Eastern Europe and Central Asia

Albania, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Russian Federation, Serbia, Tajikistan, Ukraine, Uzbekistan.

Middle East and North Africa

Afghanistan, Algeria, Djibouti, Egypt, Iran, Lebanon, Mali, Morocco, Pakistan, Somalia, South Sudan, Sudan, Tunisia, Yemen.