

Trends of HIV/AIDS Highlighted the Progresses and Challenges in Prevention and Control From 1990 to 2019

Zejin Ou

Southern Medical University

Huan He

Southern Medical University

Danfeng Yu

Guangdong Women and Children Hospital

Yongzhi Li

Southern Medical University

Yuanhao Liang

Southern Medical University

Wenqiao He

Southern Medical University

Yuhan Gao

Southern Medical University

Fei Wu

Southern Medical University

Qing Chen (✉ qch.2009@163.com)

Southern Medical University <https://orcid.org/0000-0002-8450-9300>

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Abstract

Background HIV/AIDS is a critical public health concern worldwide. This article aimed to demonstrate the trends of HIV/AIDS burden from 1990 to 2019.

Methods Data was extracted from the Global Burden of Disease study (GBDs) 2019. Estimated annual percentage change (EAPC) and age-standardized rate (ASR) were estimated to quantify the trends at global, regional and national levels.

Results During the period 1990-2004, the trend in incidence of HIV/AIDS was stable globally. Whereas the trends in prevalence, death and disability-adjusted life years (DALYs) had pronounced increasing trends, with the respective EAPCs were 7.47 (95%confidence interval [CI]: 5.84 to 9.12), 10.85(95%CI: 8.90 to 12.84), and 10.40(95%CI: 8.47 to 12.36). Meanwhile, the pronounced increasing trends were seen in low-resource settings, particularly that of death in Oceania and South Asia, in which the respective EAPCs were 44.76 (95%CI: 40.81 to 48.82) and 40.82 (95%CI: 34.31 to 47.64). However, the global trends in incidence, death and DALYs of HIV/AIDS pronouncedly decreased from 2005 to 2019, with the respective EAPCs were -2.68(95%CI: -2.82 to -2.53), -6.73(95%CI: -6.98 to -6.47) and -6.75(95%CI: -6.95 to -6.54). Whereas prevalence showed increasing trend (EAPC: 0.71, 95%CI: 0.54 to 0.87). Decreasing trends of HIV/AIDS were observed in most regions and countries, particularly that of death and DALYs in Burundi respectively were -15.28 (95%CI: -16.08 to -14.47) and -15.07 (95%CI: -15.79 to -14.33).

Conclusions Decreasing trends of HIV/AIDS were observed worldwide over the past 15 years. However, HIV/AIDS remains one of the most critical causes of health loss worldwide, which emphasized the effective prevention and control strategies.

Introduction

Human immunodeficiency virus infection/acquired immune deficiency syndrome (HIV/AIDS) is one of the most important infectious diseases worldwide. Great achievement has achieved in the HIV/AIDS controlling, but it remains an important health problem¹.

Epidemiological patterns of HIV/AIDS had transited dramatically over the past decades. There were 1.94 million new cases of HIV/AIDS worldwide in 2017, with a decrease annualised rate of 3.0% from 2007 to 2017². The global number of HIV/AIDS deaths peaked in 2006, and had decreased from 1.91 million in 2006 to 1.03 million in 2016³. The achievement of anti-HIV was mainly due to the widespread use of antiretroviral agents in the treatment and prevention of HIV/AIDS^{4, 5}. Especially, early antiretrovirals and isoniazid combined therapies were demonstrated as effective preventions in high-risk population⁶. Meanwhile, United Nations launched the Millennium Development Goals (MDGs), and invested more than 500 billion US dollars in the prevention and control of HIV/AIDS worldwide during the period 2000–2015⁷. Other prevention interventions including early preventive intervention, official funding, enhancement in HIV/AIDS testing and education, were advocated to reduce the risk of HIV/AIDS

transmission⁸⁻¹². Despite the considerable achievements had made, the burden of HIV/AIDS remains a substantial challenge to global public health.

The Joint United Nations Programme on HIV/AIDS (UNAIDS) launched a target of ending the AIDS epidemic by 2030¹³. Therefore, it is necessary to track the trends of HIV/AIDS using the latest data from the Global Burden of Disease study (GBDs). In this study, the authors aimed to investigate the trends of HIV/AIDS from 1990 to 2019, which would inform the strategies of HIV/AIDS control.

Methods

Data source

Data on the HIV/AIDS incidence was derived from the Global Health Data Exchange (GHDx) (<http://ghdx.healthdata.org/gbd-results-tool/>). The disease burden of HIV/AIDS including incidence, prevalence, death, and disability-adjusted life years (DALYs), were extracted by sexes, age, socio-demographic index (SDI) areas, geographic regions, and countries from 1990 to 2019. According to the socio-demographic index (SDI), the world was categorized into low, low-middle, middle, high-middle, and high. The data was available in multiple geographic dimensions, including 21 geographic regions (e.g. East Asia, Oceania, and Caribbean), and 204 countries/territories (e.g. China, Brazil, and South Africa). Data on Human Development Index (HDI) was downloaded from the United Nations Development Program ([http://hdr.undp.org/en/ data](http://hdr.undp.org/en/data)).

Statistical analysis

Estimated annual percentage change (EAPC) and age-standardized rate (ASR) were estimated to quantify the changing trends of disease. When involving discrepancies in the age structure of multiple populations over time, the ASR is a necessary and representative index. The ASR was calculated as the following formula:

$$ASIR = \frac{\sum_{i=1}^A a_i w_i}{\sum_{i=1}^A w_i} \times 100,000$$

In the above formula, a_i is the age-specific rate in the i^{th} age group, w is the number of people in the corresponding i^{th} age group among the selected reference standard population, and A is the number of age groups. Estimated annual percentage changes (EAPC) is a widely accepted method for describing the magnitude of the trends in ASR^{14,15}. A regression line is fitted to the natural logarithm of the ASR. EAPC and its 95% confidence interval (CI) was calculated using the linear regression model using the following formula:

$$y = \alpha + \beta x + \varepsilon$$

$$EAPC = 100 \times (\exp(\beta) - 1)$$

where y : \ln (ASR), and x : calendar year. When both EAPC value and its 95% CI > 0 meant an increasing trend, and both EAPC value and 95% CI < 0 meant a decreasing trend. While others signified that trend was stable over time. In order to detect factors influencing EAPCs, a Pearson correlation analysis was used to analyzed the association between the EAPC and ASR in 1990, and HDI in 2019, respectively. Data was calculated using an R program (Version 3.6.2).

Results

Trends in incidence of HIV/AIDS

Globally, the incident number of HIV/AIDS increased 28.62% since 1990. During the period 1990-2004, the overall age-standardized incidence rate (ASIR) of HIV/AIDS was relatively stable (**Table 1**, and **Figure 1A**). Compared to males, females had higher incident number in 2004 (1434.95×10^3) (**Table 1**). The highest incident number was observed in the age group of 25 to 29 years (487.92×10^3) and under 5 years (408.96×10^3) in 2004, and the largest increasing percent in number occurred in those aged under 5 years (124.05%) (**eTable 1** and **eFigure 1A in the Additional file**). Pronounced decreasing trend was observed in low SDI area (EAPC = -5.43 , 95%CI: -5.97 to -4.89), but increasing one occurred in middle SDI area (EAPC = 7.21 , 95%CI: 4.03 to 10.49). At regional level, increasing trend of HIV/AIDS were observed in 11 regions, particularly Oceania and Eastern Europe, with the respective EAPCs were 27.38 (95%CI: 18.38 to 37.07) and 12.94 (95%CI: 9.97 to 15.99). Conversely, decreasing trends were seen in 8 regions, and the highest decreasing one was Eastern Sub-Saharan Africa (EAPC = -6.10 , 95% CI: -6.79 to -5.40), followed by Central Sub-Saharan Africa and Caribbean (**Table 1**, and **eFigure 1B-C in the Additional file**). At the national level, increasing trends of HIV/AIDS were observed in 104 countries/territories, especially Nepal, Estonia and Lao People's Democratic Republic, in which the respective EAPCs were 48.02 (95%CI: 37.33 to 59.55), 42.80 (95%CI: 39.60 to 46.08) and 36.94 (95%CI: 32.01 to 42.04). On the other hand, decreasing trends were seen in 61 countries/territories, and the most pronounced ones occurred in Burundi and Spain, with the respective EAPCs were -13.92 (95%CI: -14.61 to -13.21) and -13.51 (95%CI: -16.10 to -10.84) (**Figure 2A**, and **eTable 3**, **eFigure 5A** and **7A in the Additional file**).

The incident number of HIV/AIDS declined 22.77% during the period 2005-2019, and it was 1989.28×10^3 (95%UI: 1760.91×10^3 to 2259.35×10^3) in 2019. The ASIR decreased by an annual average of 2.68% (EAPC = -2.68 , 95%CI: -2.82 to -2.53) (**Table 1**, and **Figure 1B**). From 2005-2019, a decreasing trend in ASIR of HIV/AIDS was more obvious in females than that of males, with the EAPC of -3.14 (95%CI: -3.30 to -2.98) (**Table 1**). Among age groups, the highest increase in number of HIV/AIDS cases was observed in age group above 60 years (19.83%), and the highest decrease was in group aged under 5 years (-67.8%) (**eTable 2** and **eFigure 1A in the Additional file**). Downward trend of ASIR were observed in low, low-middle, and middle SDI areas, particularly the first one (EAPC = -5.29 , 95%CI: -5.61 to -4.98). However, increasing trends were seen in high-middle and high SDI areas. At regional level, the trends declined in 8 geographic regions, and the largest ones were seen in Eastern Sub-Saharan Africa and East

Asia, with the respective EAPCs were -5.66 (95%CI: -5.97 to -5.35) and -5.35 (95%CI: -6.31 to -4.37). However, increasing trends occurred in 13 geographic regions, particularly Eastern Europe (EAPC= 12.31 , 95%CI: 10.38 to 14.28) (**Table 1**, and **eFigure 1B-C in the Additional file**). Among 204 countries/territories, the ASIR presented downward trends in 72 countries, and the largest one was in Burundi (EAPC = -12.93 , 95%CI: -13.23 to -12.63), followed by Cambodia and Democratic Republic of the Congo. On the other hand, the ASIR showed increasing trends in 100 countries, particularly Kazakhstan (EAPC = 13.00 , 95%CI: 11.52 to 14.50), followed by Russian Federation and Ukraine (**Figure 3A**, and **eTable 3**, **eFigure 6A** and **8A in the Additional file**).

Trends in prevalence of HIV/AIDS

From 1990 to 2004, the number of HIV/AIDS prevalence increased 258.90%, and the ASR showed a significant upward trend globally, with the EAPC was 7.47 (95%CI: 5.84 to 9.12) (**Figure 1A**, and **eTable 4 in the Additional file**). Compared with the males, females had more prevalence number and pronounced increasing trend, in which the EAPC of 8.06 (95%CI: 6.23 to 9.91) (**eTable 4 in the Additional file**). Percentages in prevalence number of HIV/AIDS increased in all age groups, particular the group of 10-14 (15030.00%) (**eTable 1** and **eFigure 2A in the Additional file**). Increasing trends of prevalence occurred in most SDI areas and geographic regions, particularly Oceania and South Asia, in which the respective EAPCs were 39.48 (95%CI: 34.22 to 44.95) and 25.27 (95%CI: 19.18 to 31.68) (**eTable 4** and **eFigure 2B-C in the Additional file**). With regard to national level, from 1990 to 2004, the rising trends were observed in 179 countries/territories, and the largest one was Nepal (EAPC = 64.97 , 95%CI: 52.41 to 78.57), followed by Papua New Guinea and Lao People's Democratic Republic. However, the trends of prevalence decreased only in 13 countries/territories, particularly Burkina Faso (EAPC = -6.21 , 95%CI: -6.93 to -5.50) (**Figure 2B**, and **eTable 5**, **eFigure 5B** and **7B in the Additional file**).

Globally, the prevalence number of HIV/AIDS increased 30.31% from 2005 to 2019, and it was 36848.15×10^3 (95% UI: 35149.00×10^3 to 38856.67×10^3) in 2019. Increasing trend of HIV/AIDS prevalence was demonstrated with a EAPC of 0.71 (95% CI: 0.54 to 0.87) (**Figure 1B**, and **eTable 4 in the Additional file**). During 2005 and 2019, the ASR in prevalence of HIV/AIDS showed increasing trends in both sexes, especially female (EAPC = 0.76 , 95%CI: 0.58 to 0.94) (**eTable 4 in the Additional file**). During the period 2005-2019, percentages in prevalence number of HIV/AIDS increased in most age group, particularly the group of >80 (263.55%), while the largest decreasing was in those aged <5 years (-55.79%) (**eTable 3** and **eFigure 2A in the Additional file**). Trends of prevalence declined in low and low-middle SDI areas, but increased in other areas, particularly High-middle one (EAPC = 4.42 , 95%CI: 3.78 to 5.06). The upward trends of prevalence occurred in most regions, especially Eastern Europe and Central Asia, in which the EAPCs were 11.81 (95%CI: 11.00 to 12.62) and 5.96 (95%CI: 5.13 to 6.81) (**eTable 4** and **eFigure 2B-C in the Additional file**). Among 204 countries/territories, decreasing trends of prevalence were observed in 44 countries from 2005 to 2019, particularly Sao Tome and Principe (EAPC = -6.98 , 95%CI: -8.23 to -5.71), followed by Burundi and Somalia. While the rising trends occurred in 157 countries, and the largest ones were in Georgia, Armenia, and Russian Federation, with the EAPCs were 17.14 (95%CI:

14.11 to 20.25), 15.49 (95%CI: 14.33 to 16.67), and 14.88 (95%CI: 14.29 to 15.47) (**Figure 3B**, and **eTable 5**, **eFigure 6B** and **8B in the Additional file**).

Trends in death of HIV/AIDS

The age-standardized death rate (ASDR) of HIV/AIDS had a rising trend worldwide from 1990 to 2004 (EAPC = 10.85, 95%CI: 8.90 to 12.84) (**Figure 1A**, and **eTable 6 in the Additional file**). Compared with the males, females had more death number and pronounced increasing trend, in which the EAPC of 11.89 (95%CI: 9.76 to 14.06) (**eTable 6 in the Additional file**). During the period 1990-2004, percentages in death number of HIV/AIDS increased in all age groups, particular the group of 10-14 (3480.81%) (**eTable 1** and **eFigure 3A in the Additional file**). Increasing trends of ASDR occurred in most SDI areas and regions, except high SDI area (EAPC = -9.09, 95%CI: -11.88 to -6.20). The most pronounced increasing trends were found in Oceania and South Asia, in which the respective EAPCs were 44.76 (95%CI: 40.81 to 48.82) and 40.82 (95%CI: 34.31 to 47.64) (**eTable 6**, and **eFigure 3B-C in the Additional file**). At national level, decreasing trends were documented in 28 countries/territories from 1990 to 2004, and the largest ones were in New Zealand (EAPC = -12.99, 95%CI: -14.98 to -10.96), followed by France and Australia. On the other hand, increasing trends in ASDR were observed in 157 countries, particularly Nepal (EAPC = 95.37, 95%CI: 76.31 to 116.49), followed by Lao People's Democratic Republic and Papua New Guinea (**Figure 2C** and **eTable 7**, **eFigure 5C** and **7C in the Additional file**).

During the period 2005-2019, the death number of HIV/AIDS decreased 52.89%, and it was 863.84×10^3 (95% UI: 786.07×10^3 to 996.04×10^3) worldwide in 2019. Globally, the ASDR showed an obvious downward trend from 2005 to 2019, with the EAPC was -6.73 (95%CI: -6.98 to -6.47) (**Figure 1B**, and **eTable 6 in the Additional file**). Decreasing trends of HIV/AIDS were observed in both sexes (**eTable 6 in the Additional file**). In age groups, percentages in death number of HIV/AIDS decreased in all age groups, except for aged >80 years (0.01%). The highest decreasing percentage changes occurred in those aged <5 years (-76.53%) (**eTable 2** and **eFigure 3A in the Additional file**). The ASDR had downward trends in all SDI areas and most regions, and the largest decreasing trends were seen in South Asia (EAPC = -11.20, 95%CI: -12.03 to -10.36), followed by Eastern Sub-Saharan Africa and Southern Sub-Saharan Africa. Whereas increasing trends were observed in East Asia, Eastern Europe and North Africa and Middle East (**eTable 6** and **eFigure 3B-C in the Additional file**). At the national level, decreasing trends were seen in 128 countries/territories, particularly Burundi, Malawi, and Zimbabwe, with the respective EAPCs were -15.28 (95%CI: -16.08 to -14.47), -13.51 (95%CI: -14.15 to -12.87), and -13.34 (95%CI: -14.31 to -12.35). Conversely, increasing trends occurred in 45 countries/territories, and the most pronounced ones were in Georgia and United Arab Emirates, in which the respective EAPCs were 28.87 (95%CI: 18.33 to 40.35) and 16.60 (95%CI: 14.66 to 18.57) (**Figure 3C**, and **eTable 7**, **eFigure 6C** and **8C in the Additional file**).

Trends in DALYs caused by HIV/AIDS

Pronounced increasing trend was observed in DALYs caused by HIV/AIDS from 1990 to 2004, with an EAPC was 10.40 (95%CI: 8.47 to 12.36). During the period 1990-2004, increasing trends of DALYs occurred in males and females (**Figure 1A**, and **eTable 8 in the Additional file**). The DALYs number of HIV/AIDS increased in all age groups, particular those aged 10-14 (3587.85%) (**eTable 1** and **eFigure 4A in the Additional file**). Increasing trends of DALYs occurred in most SDI areas and regions, particularly Oceania and South Asia, in which the EAPCs were 43.06 (95%CI: 39.14 to 47.09) and 37.95 (95%CI: 32.07 to 44.10). Whereas decreasing trends were seen in high SDI area and other regions, and the largest ones were observed in Australasia (EAPC = -12.30, 95%CI: -14.98 to -9.53), followed by High-income North America and Western Europe (**eTable 8** and **eFigure 4B-C in the Additional file**). At national level, increasing trends of DALYs were observed in 158 countries/territories, with the most pronounced one being in Nepal (EAPC= 86.23, 95%CI: 69.87 to 104.17), followed by Papua New Guinea and Lao People's Democratic Republic. However, decreasing trends were seen in 28 countries, particularly France and Australia, with the respective EAPCs were -12.60 (95%CI: -15.93 to -9.14) and -12.32 (95%CI: -15.17 to -9.38) (**Figure 2D**, and **eTable 9**, **eFigure 5D** and **7D in the Additional file**).

Globally, the number of DALYs due to HIV/AIDS was 47632.18×10^3 (95%UI: 42630.99×10^3 to 55650.04×10^3) in 2019, with a decrease of 54.03% since 2005. The ASR of DALYs had a decreasing trend worldwide from 2005 to 2019 (EAPC = -6.75, 95%CI: -6.95 to -6.54) (**Figure 1B**, and **eTable 8 in the Additional file**). Compared with the males, females had higher decreasing trend, in which the EAPC of -7.44 (95%CI: -7.65 to -7.22) (**eTable 8 in the Additional file**). During the period 2005-2019, percentages in DALYs number of HIV/AIDS decreased in all age groups, except for aged ≥ 80 years (19.37%) (**eTable 2** and **eFigure 4A in the Additional file**). Meanwhile, downward trends of DALYs were observed in all SDI areas and most regions, and the largest decreasing ones were observed in South Asia and Eastern Sub-Saharan Africa, in which the EAPCs were -10.99 (95%CI: -11.75 to -10.22) and -9.45 (95%CI: -9.69 to -9.20), respectively (**eTable 8** and **eFigure 4B-C in the Additional file**). At national level, decreasing trends were observed in 127 countries/territories, particularly Burundi (EAPC = -15.07, 95%CI: -15.79 to -14.33). Conversely, increasing trends occurred in 46 countries/territories, and the largest ones were seen in Georgia (EAPC= 24.30, 95%CI: 15.87 to 33.34), followed by Pakistan and Micronesia (**Figure 3D**, and **eTable 9**, **eFigure 6D** and **8D in the Additional file**).

Analysis on the influential factors of EAPC

During the period 1990-2004, EAPCs had negative associations with the ASR in 2004 in incidence, prevalence of HIV/AIDS ($\rho = -0.28$, $p < 0.001$; $\rho = -0.17$, $p = 0.018$, respectively). On the other hand, EAPCs had negative associations with the HDI in 2004 in prevalence, death, and DALYs of HIV/AIDS ($\rho = -0.25$, $p < 0.001$; $\rho = -0.49$, $p < 0.001$; $\rho = -0.51$, $p < 0.001$, respectively).

During the period 2005-2019, EAPCs had negative associations with the ASR in 2005 in incidence, prevalence, death, and DALYs of HIV/AIDS ($\rho = -0.38$, $p < 0.001$; $\rho = -0.25$, $p < 0.001$; $\rho = -0.37$, $p < 0.001$; and $\rho = -0.40$, $p < 0.001$, respectively) (**Figure 4A-D**). Whereas EAPCs had positive associations with the

HDI in 2019 in incidence, prevalence, death, and DALYs of HIV/AIDS ($\rho = 0.50, p < 0.001$; $\rho = 0.43, p < 0.001$; $\rho = 0.28, p < 0.001$; and $\rho = 0.34, p < 0.001$, respectively) (Figure 5A-D).

Discussion

In this study, the distributions of ASR of HIV/AIDS burden presented parabolic during the period 1990–2019, which peaked around 2004, and the lowest values were in 1990 and in 2019, respectively. Therefore, the year 2004 was selected as the time cut-off point to describe its trends in two periods, including 1990–2004, and 2005–2019. Trends in ASR of HIV/AIDS burden, including incidence, death, and DALYs, significantly increased during the period 1990–2004, but declined from 2005 to 2019, which objectively reflected the changing trends of HIV/AIDS.

During the period 1990–2004, trends of HIV/AIDS burden, particularly prevalence, death and DALYs rapidly increasing globally. In the early 1990s, The HIV/AIDS epidemic was closely associated with poverty, poor Health infrastructure, lack of control policies, and the high prevalence of injection drug use and sexual transmission^{16–19}. Increasing trends were mostly seen in the low and low-middle SDI areas, where existed poverty, drug use, low-levels education, and limited health systems²⁰. Among geographic regions, Oceania, East Asia, and South Asia showed the largest increasing trends of HIV/AIDS, where the ART coverage was only 25.9%, far lower than that in global (40.6%) and low SDI countries (37.9%)²¹. At national level, Nepal, Papua New Guinea, and Lao People's Democratic Republic had the most pronounced increasing trends of HIV/AIDS burden. Furthermore, the situation had been exacerbated by tuberculosis co-infection and drug resistance²². In these countries, there were many obstacles to the control of HIV/AIDS, including shortage of capital investment, poor health infrastructure and education^{23, 24}. Whereas decreasing trends of HIV/AIDS were generally observed in developed region and countries, e.g. New Zealand and Australia, where had the early response to HIV/AIDS prevention in high-risk groups, high-level awareness, and the robust healthcare systems^{25–27}.

However, decreasing trends of HIV/AIDS were observed worldwide over the past fifteen years (2005–2019), which might be due to the effective prevention and control strategies established in recent years, such as poverty reduction, improvement in health infrastructure, and intensive international cooperation²⁸. In 2000, HIV/AIDS was identified as one of the top health priorities, and had attracted considerable international funding or organizations²⁹. International assistance of financial and physical resources continued to support the poor countries with the main purpose of improving health and eliminating poverty³⁰. For example, 19 billion US dollars was invested in HIV/AIDS prevention in countries with low income level in 2015⁸. By 2014, there were 40% of eligible HIV-infected individuals having received ART globally³¹. With the increasing coverage of ART, the survival rate of people infected with HIV/AIDS has dramatically increased³². The above reasons also explained the pronounced decreasing trends in low and low-middle SDI areas. For example, Sub-Saharan Africa and South Asia had the most pronounced decreasing trends, which partly reflected that the great progress in the prevention and treatment of HIV/AIDS by the efforts of governments and multilateral organizations^{12, 33–35}. The most

pronounced decreasing trends were found in Sub-Saharan Africa countries included Burundi, Malawi, and Zimbabwe, probably due to the secondary education, medical circumcision in adolescents and children^{36–38}. However, increasing trends of HIV/AIDS occurred in Eastern Europe and Central Asia, which was due to underdeveloped economy, unsound health system, and high risks of infectious diseases^{39–41}. In the former Soviet countries, tuberculosis, drug use, and HIV infection were major public problems^{42, 43}, which probably generated the pronounced increasing trends in Georgia, Armenia, and Kazakhstan. Considerable progress had been achieved in the prevention and control of HIV/AIDS, but there are neither cure nor an effective and safe vaccine for HIV/AIDS⁴⁴, and the emergence of anti-HIV drug resistance brought substantial challenges^{45, 46}.

Serval limitations should be interpreted in this study: 1. Estimates of disease burden of GBD studies depended on the quality and quantity of data, as well as the potential for misdiagnosis and/or miscoding of diseases in different countries, including unreported cases, poor test technology, and incomplete reporting, which might affect the accuracy and robustness of the results. 2. Developments in diagnostic techniques of HIV/AIDS also varied from country to country and over time, which could generate potential biases. 3. Due to the limitations of the ASR formula, although age was an important factor, only percentage changes in the number of events across age groups were used in this study to estimate trends.

Conclusions

Trends of HIV/AIDS burden dramatically increased during the period 1990–2004, whereas decreased from 2005 to 2019. The results objectively reflected that considerable progress had made in the HIV-related burden worldwide, particularly in the high-risk settings. However, HIV/AIDS remains an enormous global health problem, and require more effective prevention and control strategies.

Abbreviations

HIV/AIDS: Human immunodeficiency virus infection/acquired immune deficiency syndrome;

GBD: Global Burden of Disease;

DALYs: Disability-adjusted life years;

ASR: Age-standardized rate; UI: Uncertainty interval;

CI: Confidence interval;

EAPC: Estimated annual percentage change;

GHDx: Global Health Data Exchange;

SDI: Socio-demographic index.

Declarations

Ethical approval and consent to participate:

Not applicable.

Consent for publication:

All authors consent for publication of the manuscript.

Availability of supporting data:

All data during this study are included in this published article and its supplementary information files.

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The authors declare no competing interests.

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Authors' contributions:

Zejin Ou, Huan He: Project administration and drafting.

Danfeng Yu, Yuanhao Liang: Data analysis and validation.

Wenqiao He, Yuhan Gao: Data analysis and visualization.

Yongzhi Li, Fei Wu: Data collection and collation.

Qing Chen: Supervision and drafting and editing.

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Table

Table 1 is not available with this version.

Figures

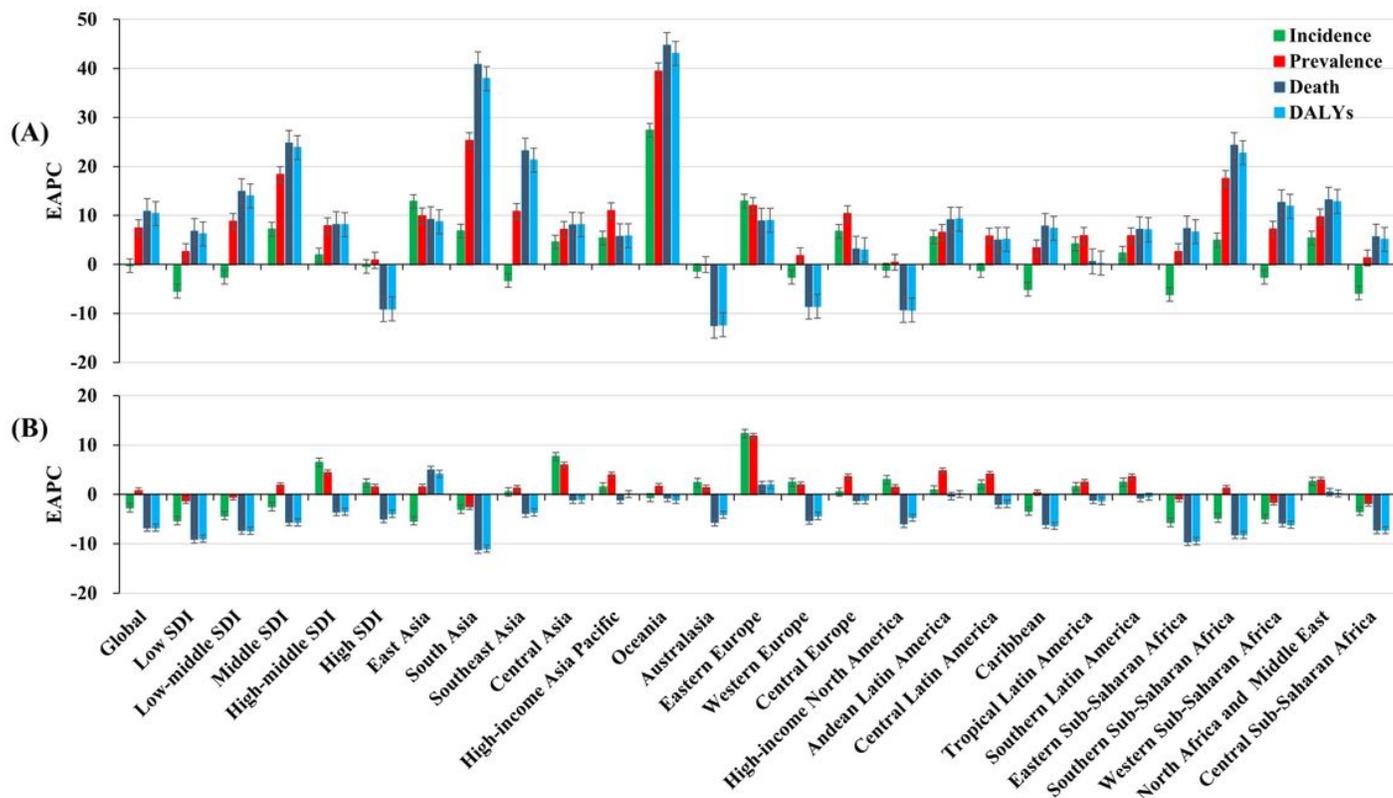


Figure 1

Trends in HIV/AIDS, 1990-2019. Trends of HIV/AIDS burden including incidence, prevalence, death, and DALYs worldwide, and in SDI areas and geographic regions. (A) the distribution of EAPCs of HIV/AIDS from 1990 to 2004; (B) the distribution of EAPCs of HIV/AIDS from 2005 to 2019.

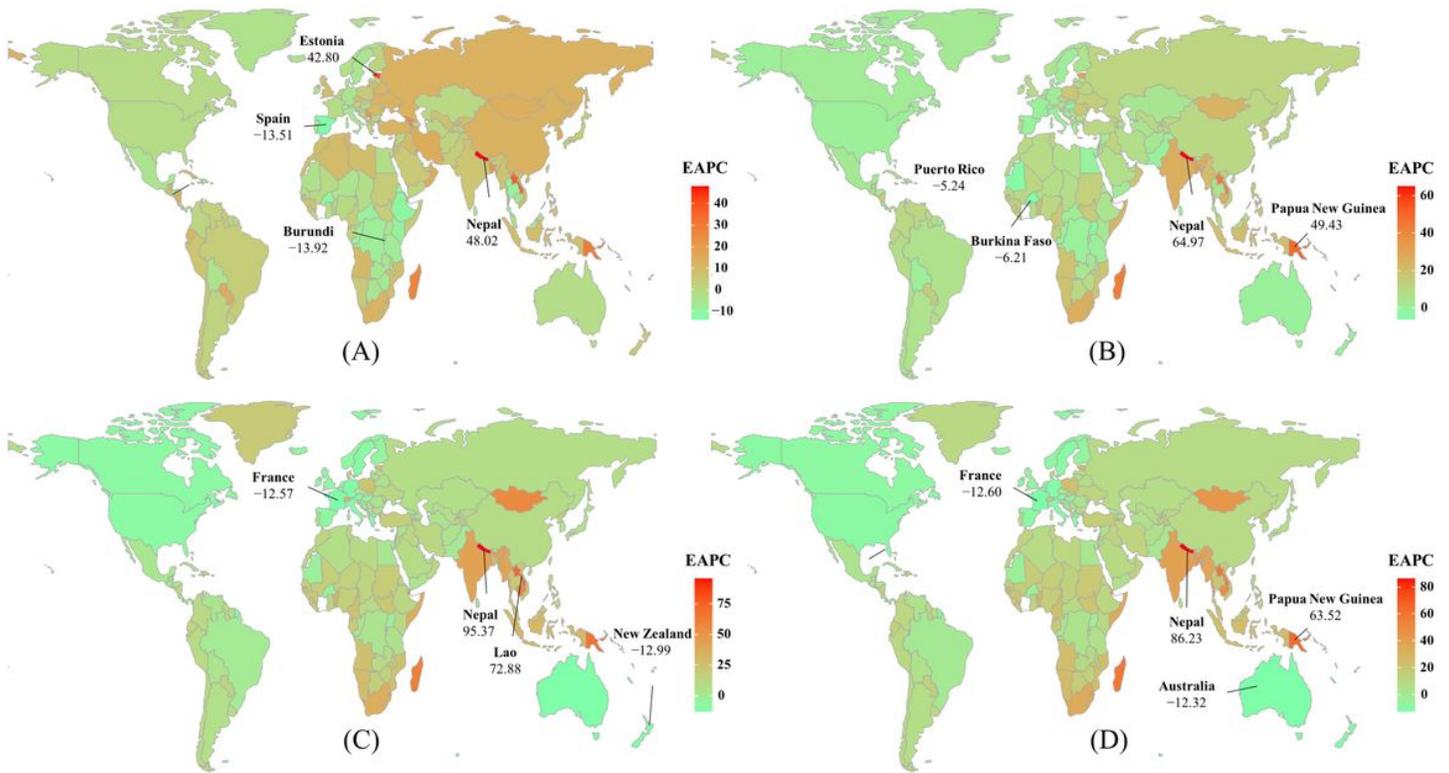


Figure 2

The distribution of EAPCs of HIV/AIDS burden at a national level during the period 1990-2004, including incidence (A), prevalence (B), death (C), and DALYs (D) Countries/territories with an extreme value were annotated. ASR, age-standardized rate; EAPC, estimated annual percentage change; DALYs, disability-adjusted life-years. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

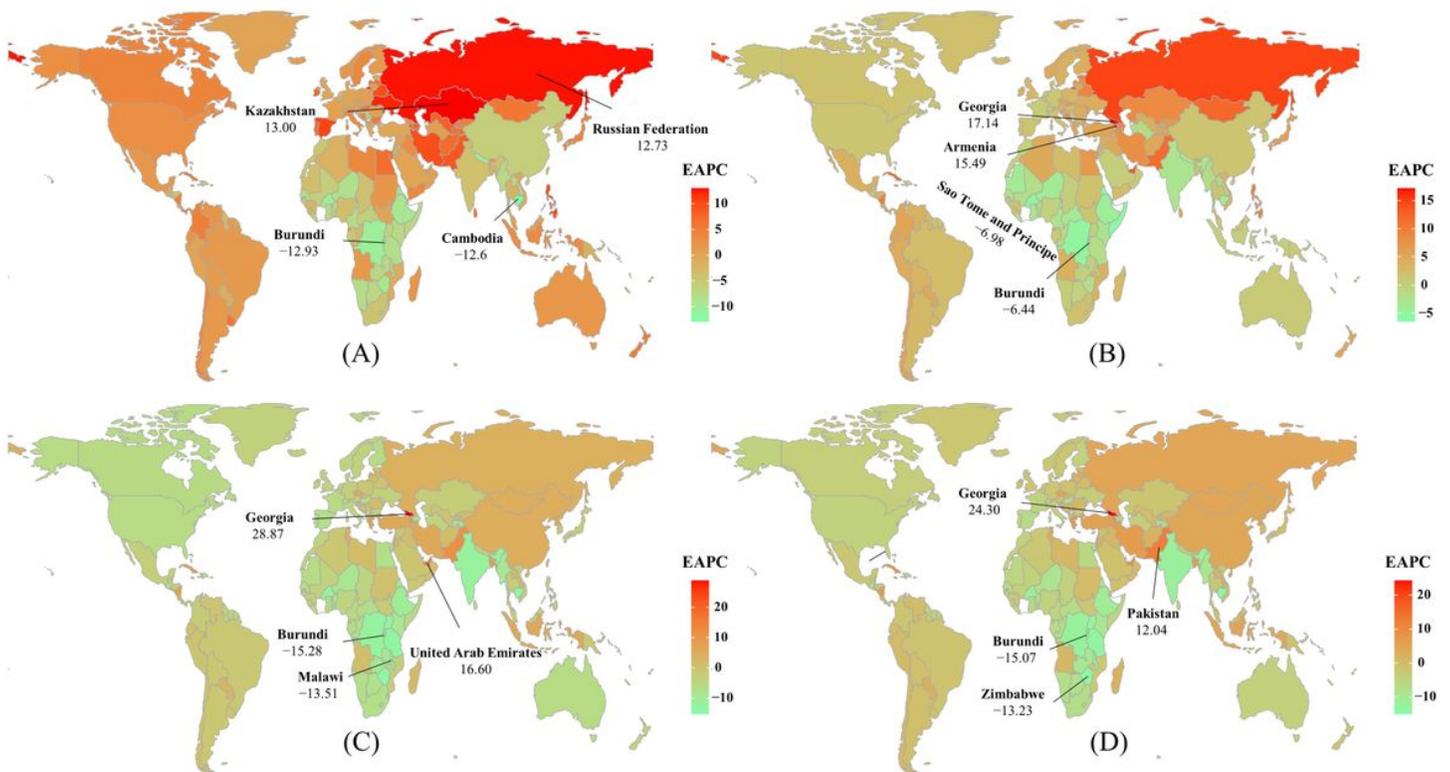


Figure 3

The distribution of EAPCs of HIV/AIDS burden at a national level during the period 2005-2019, including incidence (A), prevalence (B), death (C), and DALYs (D) Countries/territories with an extreme value were annotated. ASR, age-standardized rate; EAPC, estimated annual percentage change; DALYs, disability-adjusted life-years. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

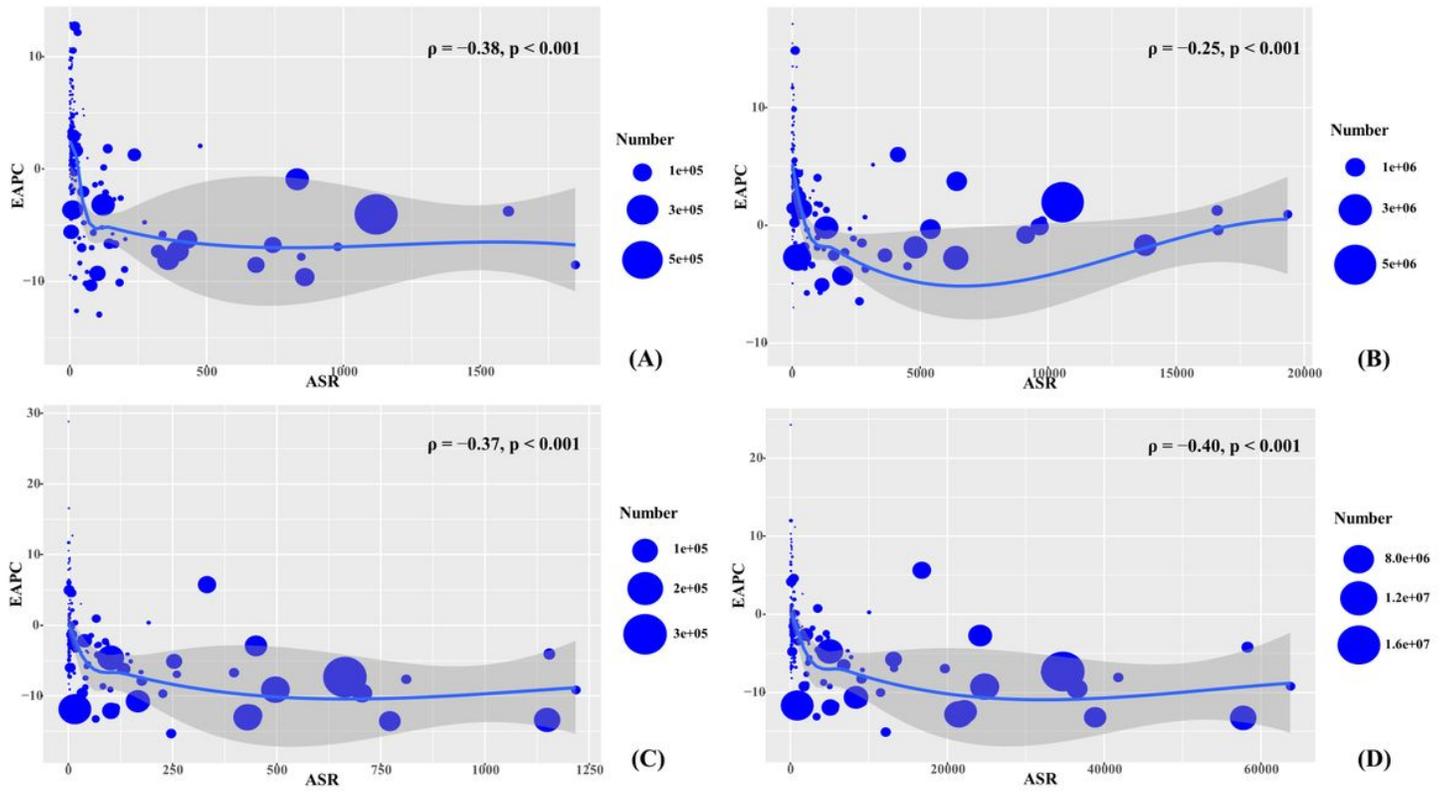


Figure 4

The association between EAPCs and ASR in 2005 at a national level during the period 2005-2019. The EAPCs of HIV/AIDS including incidence (A), prevalence (B), death (C), and DALYs (D) had a negative association with the corresponding ASR in 2005. The associations were calculated with Pearson correlation analysis. The circles represent countries that were available on HDI data, and the size of circle changed with the number of HIV/AIDS in the corresponding countries in 2005. ASR, age-standardized rate; EAPC, estimated annual percentage change; DALYs, disability-adjusted life-years.

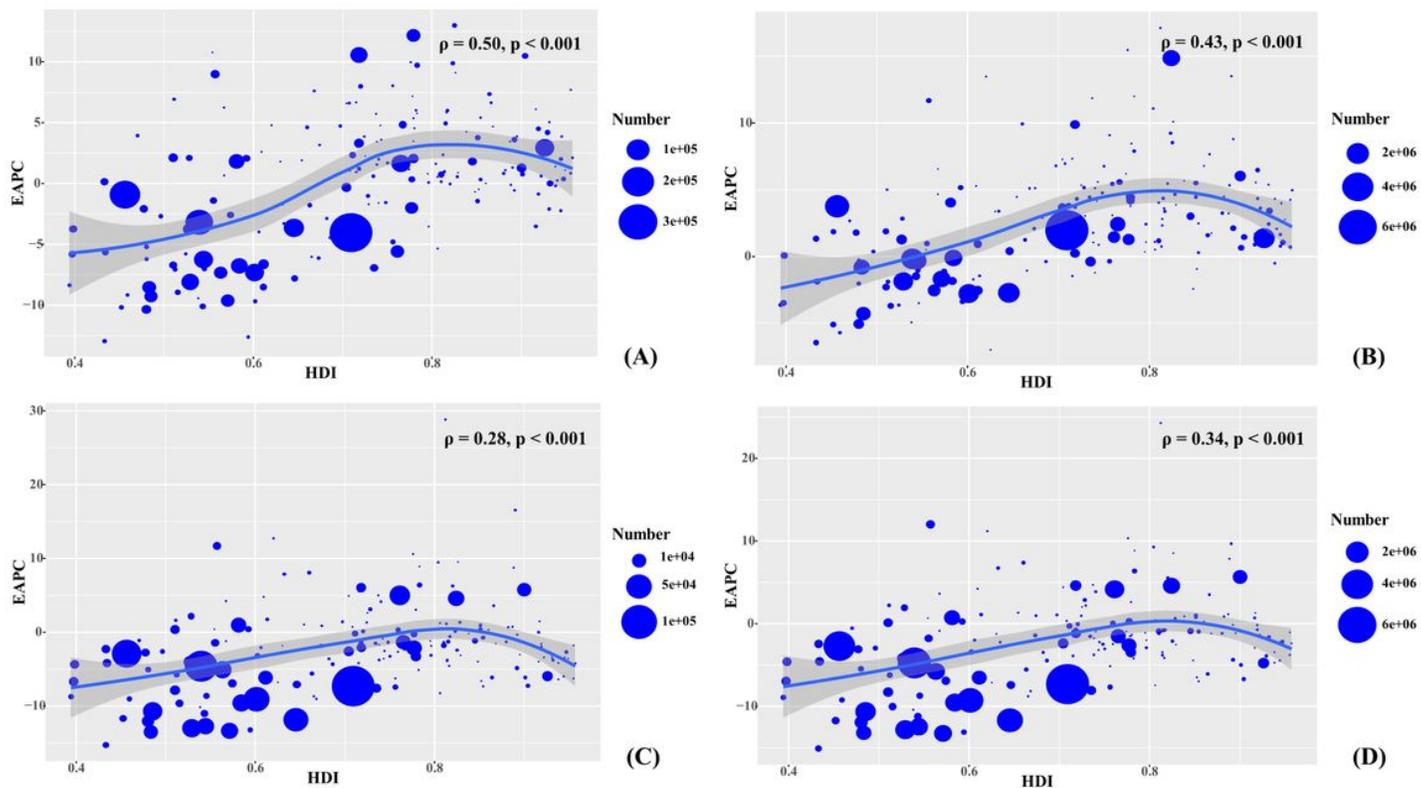


Figure 5

The association between EAPCs and HDI in 2019 at a national level during the period 2005-2019. The EAPCs of HIV/AIDS including incidence (A), prevalence (B), death (C), and DALYs (D) had a positive association with the corresponding HDI in 2019. The associations were calculated with Pearson correlation analysis. The circles represent countries that were available on HDI data, and the size of circle changed with the number of HIV/AIDS in the corresponding countries in 2019. EAPC, estimated annual percentage change; HDI, human development index.

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