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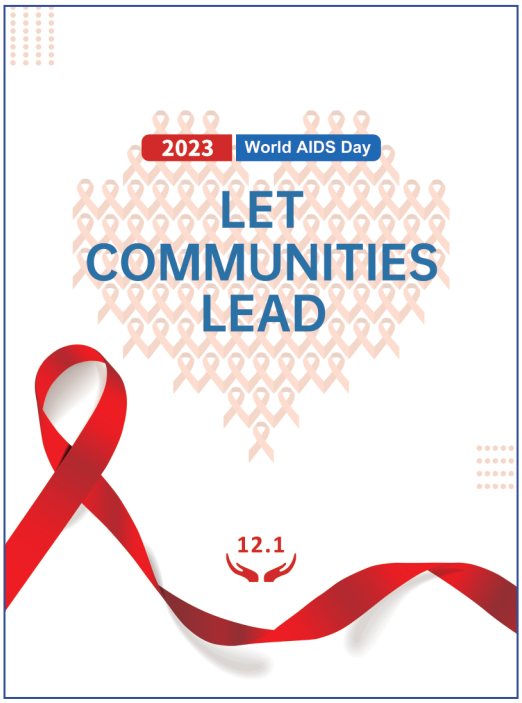

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This week's issue was organized by Guest Editor Mengjie Han.

Preplanned Studies

Economic Evaluation of the Comprehensive AIDS Prevention and Control Program — Tianjin Municipality, China, 2011–2022

Maohe Yu[1,2,&]; Jianping Wang[3,4,&]; Jinhua Zhao[3,4]; Yan Guo[1]; Jianyun Bai[1]; Zhongquan Liu[1]; Hui Gong[1]; Tielin Ning[1]; Minna Zheng[1]; Jinyu Hou[1]; Zhuang Cui[3,4,#]

Summary

What is already known about this topic?

Acquired immunodeficiency syndrome (AIDS) represents a significant public health challenge globally, not only inflicting harm on the health of individuals but also placing a considerable economic strain on society.

What is added by this report?

This study represents the inaugural report on the potential reduction in economic burden attributable to human immunodeficiency virus (HIV) prevention strategies in Tianjin. Between 2011 and 2022, it is estimated that effective measures could prevent 2,965 new HIV infections and avert 658 deaths, resulting in an economic benefit of approximately 14.437 billion Chinese Yuan.

What are the implications for public health practice?

The findings of this study offer valuable evidence to inform the development of localized HIV prevention and control strategies, as well as to guide public health policymaking.

Human immunodeficiency virus (HIV) infection and the resulting acquired immunodeficiency syndrome (AIDS) pose a significant global health crisis (*1*). The associated economic burden is substantial (*2–3*). In this study, using a Susceptible-Infected-Recovered-Deceased (SIRD) model and incorporating HIV epidemic surveillance data from Tianjin Municipality, China, we estimated the cumulative number of infections and deaths prevented, annual new infections, deaths, and the socioeconomic impact of HIV preventative and control measures in Tianjin from 2011 to 2022. The findings indicate that between 2011 and 2022, HIV prevention efforts may have averted a total of 2,965 infections and 658 deaths, leading to an economic benefit of approximately 14.437 billion Chinese Yuan (CNY). These outcomes underscore that effective prevention and control strategies have the potential to mitigate the spread of AIDS and lessen its economic impact.

The SIRD model was employed to segment the population into four distinct categories — susceptible (S), infected (I), recovered (R), and dead (D). This model was utilized to project the number of infections and deaths that would theoretically occur without the implementation of innovative and precise AIDS prevention and control measures. The simulations were based on transmission coefficients and mortality rates from 2010, which served as the baseline scenario. Following this, the actual outcomes were compared against the projections to estimate the annual number of new infections and deaths, as well as the aggregate reduction of infections and deaths, in Tianjin over the period from 2011 to 2022. Herein, 'S' represents the portion of the population who are healthy but lack immunity, while 'I' denotes individuals infected with HIV.

The model operates under the assumption that the transmission, recovery, and mortality rates remain constant over time. The system is described by the following set of differential equations.

$$\begin{aligned} dS/dt &= -\lambda \times S \times I/N \\ dI/dt &= \lambda \times S \times I/N - \mu \times I - \delta \times I \\ dR/dt &= \mu \times I \\ dD/dt &= \delta \times I \end{aligned} \quad (1)$$

Where N=8,730,300, is the total population aged 15 years and above in Tianjin in 2010, from the statistical yearbook. λ is the transmission coefficient, which is 0.25 (*4*). The recovery coefficient μ is 1–10, which we set to a very small value due to the fact that AIDS is almost incurable. δ is the mortality rate, which is 0.02 (*5–6*). Obtaining the baseline of AIDS in 2010 from the Networked Direct Reporting of Infectious Diseases (NDRID) system, where I(0)=786, R(0)=0, D(0)=2. The model assumes N=S+I+R+D.

Based on cost analyses conducted by real-world data measurements from designated medical institutions

and the literature (*7–8*), the average annual outpatient expense for treating an AIDS patient is approximately 3,400 CNY in the initial year, with subsequent annual costs averaging around 1,600 CNY. Furthermore, patients receive two complimentary CD4 tests annually at a cost of 360 CNY, a viral load test provided without charge for 1,300 CNY, and free antiretroviral therapy drugs estimated to cost about 1,679 CNY per patient per year. When hospitalization is required for the treatment of opportunistic infections, the cost averages 25,570.5 CNY per admission. Prior research and evaluations by the designated medical institutions suggest that the average treatment duration needed for an AIDS patient in Tianjin spans approximately 15 years (*9*).

The formula for calculating the cost of state financial support and the cost of health insurance, individual outpatient treatment, and treatment of opportunistic infections saved by the prevention of new infections are as follows (*10*).

$$E_{i1} = N_i \times 15\ years \times (2 \times CD4\ test + viral\ load\ test + antiretroviral\ therapy\ drugs) \quad (2)$$

$$E_{i2} = N_i \times (first\ year\ outpatient\ cost + 14\ years \times follow\ up\ outpatient\ cost + average\ hospitalization\ cost) \quad (3)$$

N_i was the cumulative prevention of infections.

The per capita GDP of Tianjin in 2011–2022 was 61,458.41 CNY, 66,517.25 CNY, 71,344.62 CNY, 74,960.34 CNY, 75,868.27 CNY, 79,647.47 CNY, 87,280.48 CNY, 95,688.65 CNY, 101,556.79 CNY, 101,614.21 CNY, 113,190.83 CNY, and 118,800.00 CNY. Concurrently, an analysis of the disability-adjusted life years (DALYs) per prevention in HIV infections was 31.05, 29.29, 30.78, 36.37, 41.80, 45.48, 46.76, 46.86, and 46.19 for 2011–2019 (*11*), and the 2020, 2021, and 2022 years using DALY 2019. The methodology utilized to calculate the economic benefits resulting from the reduction in new HIV infections E_{i3} is as follows (*12*).

$$E_{i3} = \sum_{t=2011}^{2022} \left(DALYs_t \times N_t \times (per\ capita\ GDP)_t\right) \quad (4)$$

t denotes the year. $DALYs_t$, N_t, $(per\ capita\ GDP)_t$ were the DALYs, reduced infections, and per capita GDP in year *t,* respectively.

Patients with AIDS and their families annually incur costs of 240.6 CNY for transportation, 88.44 CNY for accommodation, and 460.2 CNY for nutrition, respectively (*13*). The formula to calculate additional cost savings achieved by preventing new infections is provided in reference (*10*).

$$E_{i4} = N_i \times 15\ years \times (transportation\ cost + accommodation\ cost + nutrition\ cost) \quad (5)$$

The total economic benefit of reducing infections (E_i) is calculated as follows.

$$E_i = E_{i1} + E_{i2} + E_{i3} + E_{i4} \quad (6)$$

Between 2011 and 2022, the life expectancy of AIDS patients increased by an average of 12 years. The Health State Utility (HSU) for AIDS patients undergoing antiretroviral therapy is valued at 0.82 (*12*). The average per capita GDP in Tianjin during this timeframe was 87,327.28 CNY. To calculate the economic benefits derived from the prevented deaths, subtract the cost of treatment and additional expenses incurred during the extended survival period, including transportation, accommodation, and nutritional costs, according to the formula presented in reference (*10*).

$$E_{d1} = N_d \times average\ per\ capita\ GDP \times 12\ years \times DALY \quad (7)$$

$$E_{d2} = N_d \times 12\ years \times (Follow-up\ outpatient\ cost + 2 \times CD4\ test + viral\ load\ test + antiretroviral\ therapy\ drugs) \quad (8)$$

$$E_{d3} = N_d \times 12\ years \times (transportation\ cost + accommodation\ cost + nutrition\ cost) \quad (9)$$

N_d was the cumulative effect on the prevention of deaths.

The total economic benefit of reducing deaths (E_d) is calculated as follows.

$$E_d = E_{d1} - E_{d2} - E_{d3} \quad (10)$$

Considering the extended duration of the study, we conducted additional analysis on the economic advantages, applying an annual discount rate of 5% (*14*). All statistical analyses were conducted utilizing the Policy and Numpy packages in Python (version 3.8), complemented by the use of Microsoft Excel (version 2016, Microsoft Corporation, USA).

As shown in Figure 1, there is no significant difference in the number of infections per year during 2011–2013 compared to the actual situation. Infections prevented each year from 2014–2022 were 81, 147, 228, 337, 383, 442, 510, 213, and 612, respectively, with a total of 2,965 cases prevented from 2011–2022. Deaths prevented annually during the AIDS prevention and treatment program were 17, 22, 15, 11, 22, 34, 58, 68, 59, 87, 107, and 158, respectively, resulting in a cumulative prevention of 658 deaths over 12 years.

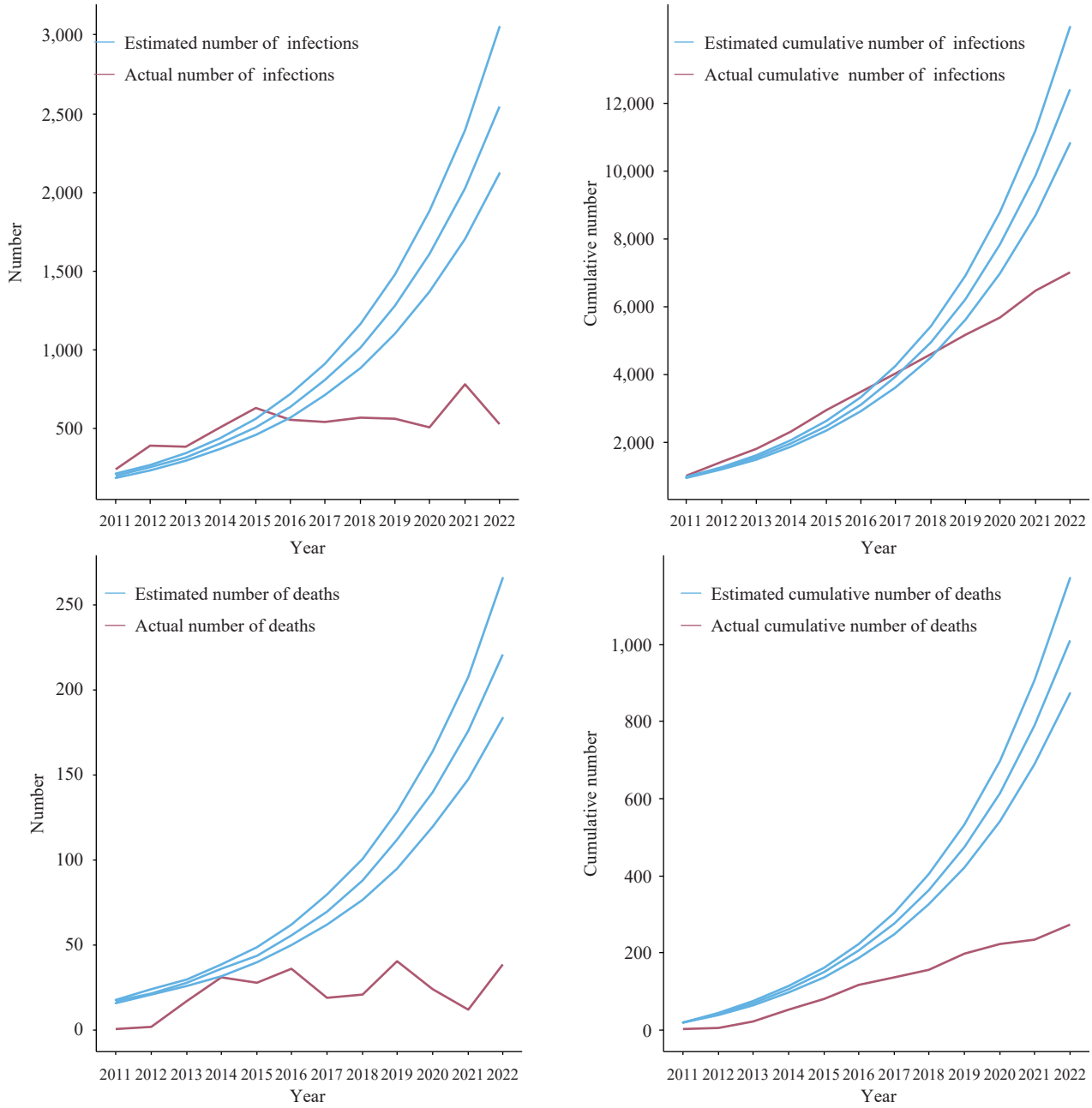

FIGURE 1. Annual prevention of infections and deaths and cumulative prevention of infections and deaths in Tianjin, 2011–2022.

As shown in Table 1, the economic benefits of prevented infections and deaths are valued at 13.920 billion CNY and 0.523 billion CNY, respectively.

DISCUSSION

Between 2011 and 2022, Tianjin's comprehensive HIV/AIDS prevention and control initiative has yielded significant outcomes. The program has averted 2,965 new infections, yielding an economic benefit of 13.920 billion CNY, and has prevented 658 deaths, which translates to an economic benefit of 0.517 billion CNY. The total economic benefit amounts to 14.443 billion CNY. These figures highlight that HIV/AIDS imposes a substantial economic burden, affecting both individuals and society. Other research corroborates the heavy disease burden attributed to AIDS (*13*). Consequently, maintaining and enhancing prevention and control efforts to stem HIV infection and mortality rates continues to be a priority for

TABLE 1. Economic benefits of HIV prevention measures in preventing infections and deaths with and without discounting in Tianjin Municipality, China, 2011–2022.

Sources of economic benefits	Economic benefits (billion CNY)	Discounting (billion CNY)
Infections		
E_{i1}	0.165	0.174
E_{i2}	0.152	0.160
E_{i3}	13.568	14.282
E_{i4}	0.035	0.037
Total	13.920	14.653
Deaths		
E_{d1}	0.565	0.595
E_{d2}	0.042	0.044
E_{d3}	0.006	0.006
Total	0.517	0.545

Abbreviation: HIV=human immunodeficiency virus; CNY=Chinese Yuan.

Tianjin.

The modeling of infectious disease dynamics relies on understanding the survival characteristics of a population, the incidence of diseases, and the laws governing the spread of infections. To quantitatively analyze the progression of infectious diseases and predict future trends, mathematical models are established and subjected to numerical simulation. This modeling provides a crucial quantitative foundation for sounding alarms in public health prevention and control efforts. Among the various models utilized, the susceptible-infected-recovered base model (SIR model) stands as the foundational and most significant approach in today's modeling landscape. Regarding the study area, the SIR model assumes that the total population remains constant, not accounting for changes due to births, deaths, mobility, and other factors. Nonetheless, when examining HIV/AIDS infection dynamics, the number of deaths attributable to AIDS and the number of individuals successfully treated are of profound public health importance. Consequently, we cannot simply group those exiting the system into a single category. Given that we have data on both the number of successful treatments (cures) and the number of deaths, we adapt our approach according to the specific characteristics of HIV/AIDS infections. In this paper, we employ a generalized form of the SIR model known as the SIRD model. The SIRD model presents certain advantages over traditional assessment methods in the domain of AI defense. First, SIRD is capable of modeling and forecasting the dynamic shifts in infectious diseases based on their transmission traits and influencing factors, something that classical assessment methods in AI defense struggle to undertake in terms of quantitative analysis and prediction. Second, SIRD assists policymakers in assessing the efficacy of various interventions on epidemic spread — a dimension that AI defense methods tend to overlook, focusing instead on system safety and robustness. Third, SIRD can integrate actual data for parameter estimation and model calibration, enhancing model accuracy and reliability. This stands in contrast to the AI defense field, where classical assessment methodologies tend to rely more heavily on simulation and emulation, making less use of empirical data (*15–17*).

Over the past ten years, the epidemiological landscape of HIV has undergone a significant shift. Sexual transmission has now become the predominant mode of infection, with men who have sex with men (MSM) facing a risk of HIV infection that is 22 times higher than that of the general population. This demographic has emerged as the fastest-growing segment among new HIV diagnoses in China (*18*). In response to these dynamics, Tianjin has adopted a pioneering approach labeled "innovative model, precise prevention and control" for AIDS management. This initiative has led to the establishment of China's inaugural pilot program for HIV intervention tailored to MSM in bathhouses and the creation of voluntary counseling and testing clinics with city-wide coverage. Additionally, Tianjin has implemented two phases of comprehensive HIV prevention and treatment demonstration areas and intensified efforts in nucleic acid monitoring and transmission testing among MSM. A cornerstone of infection source control is the policy of immediate treatment upon HIV detection. Since 2011, Tianjin has enforced free HIV testing in outpatient units of critical hospital departments, advancing early identification and management efforts. Collectively, these strategies have successfully maintained a low prevalence of AIDS within the Tianjin population.

Utilizing the aforementioned methodology enables the quantification of the economic burden alleviated within a specific region over a defined timeframe due to proactive HIV/AIDS prevention and treatment initiatives. This data serves as an integral reference point and foundation for judiciously assessing investments in HIV/AIDS prevention and treatment,

optimizing resource distribution, and refining policies and strategies. Such adjustments are essential for the effective realization of HIV/AIDS prevention and treatment objectives.

While the assessment of the economic benefits has accounted for numerous factors, it does not fully account for certain costs, including the treatment and care associated with opportunistic HIV infections and the prevention of mother-to-child transmission. This omission could lead to an underestimation of the economic benefits derived from preventive measures. Furthermore, the model does not reflect age-specific differences, thereby limiting the ability to ascertain the impact of preventive strategies on various population segments, which may compromise the accuracy of the estimated economic benefits. Additionally, due to limitations in the available data, this study provides point estimates without corresponding interval estimates. Although point estimates are unable to convey the possible range of outcomes, they offer valuable insight into the general trends and critical aspects of the issue at hand. Another limitation is the lack of precise data on total population figures or demographic shifts. Consequently, this study does not thoroughly examine the potential implications such changes may have on the model's accuracy and applicability. Future research will aim to enhance model precision by incorporating comprehensive data on population dynamics.

In conclusion, the HIV prevention and control strategies presently implemented in Tianjin have not only successfully curbed the incidence of HIV infections and associated mortality but have also yielded significant economic advantages. Maintaining and reinforcing these existing measures will continue to be of paramount importance for Tianjin in the ensuing years.

Acknowledgments: Designated medical institutions for supplying data regarding the costs associated with AIDS medical treatment.

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Preplanned Studies

Changing Mortality and Patterns of Death Causes in HIV Infected Patients — China, 2013–2022

Yan Zhao[1]; Lai Wei[1]; Zhihui Dou[1]; Decai Zhao[1]; Xiumin Gan[1]; Yasong Wu[1]; Mengjie Han[1,#]

Summary

What is already known about this topic?

The advent of antiretroviral therapy (ART) has markedly decreased mortality rates among patients infected with human immunodeficiency virus (HIV). Globally, there has been a 43% reduction in acquired immunodeficiency syndrome (AIDS)-related deaths from 2010 to 2022. Additionally, prior research indicates that the initiation of ART at an early stage within China has substantially lowered mortality rates.

What is added by this report?

Over the previous decade, following the implementation of China's universal ART access strategy, the patterns of mortality causes among HIV-infected individuals across the country have undergone significant alterations. In 2022, the all-cause mortality rate among this population was reported at 2.7%, with the non-AIDS-related mortality rate at 1.8%. However, it is important to consider that the accuracy of death reporting could contribute to potential misclassification of the underlying causes of death.

What are the implications for public health practice?

Efforts to enhance health outcomes should persist in emphasizing the advancement of ART strategies, with a particular focus on mitigating non-AIDS-related mortality in the future.

The advent of antiretroviral therapy (ART) has markedly increased life expectancy and decreased mortality rates in individuals living with human immunodeficiency virus (HIV). Before, or at the onset of, the ART era, the predominant causes of death were acquired immune deficiency syndrome (AIDS)-related illnesses, including defining opportunistic infections and malignant tumors. However, with the progression of the ART era, there has been a significant shift towards non-AIDS-related mortality. Data from the United Nations Programme on AIDS (UNAIDS) indicates a global reduction of 43% in AIDS-related deaths, falling from 1,100,000 in 2010 to 630,000 in 2022 (*1*). Within China, AIDS has emerged as a principal cause of death from infectious diseases in recent times. Earlier research emphasizes that initiating ART at early stages significantly diminishes the mortality rates (*2*). By 2020, ART coverage among those infected with HIV peaked at 92.9%. Over the past decade, China's implementation of a universal ART access strategy has occurred without a comprehensive analysis of mortality rates and changing patterns of cause of death among the national HIV-infected population. Utilizing data from the nationwide HIV/AIDS Comprehensive Response Information Management System (CRIMS), this retrospective analysis investigates mortality rates across the HIV-infected cohort from 2013 to 2022. The insights gained from this study are instrumental in pinpointing challenges and enhancing health outcomes moving forward.

Data for this study were obtained from the CRIMS database, administered by the National Center for AIDS/STD Control and Prevention (NCAIDS). The system mandates the reporting of all confirmed HIV-positive individuals, encompassing initial diagnosis and follow-up data. In the event of a patient's death, local healthcare workers must submit a specialized death registration form. Further, data specific to patients commencing ART should be entered into the ART database subsystem. This study implemented a multiple cross-sectional design to investigate changes in mortality rates and causes of death from 2013 to 2022. Data extraction for the manuscript occurred on June 30, 2023, allowing a six-month period to account for any reporting delays in death records. Due to modifications in the death registration system in 2012, consistent reporting of death causes only commenced in 2013. We calculated annual mortality rates using the total number of survivors and new diagnoses for the year as the denominator, and the total deaths in the same year as the numerator. The Cochran-Armitage trend test was employed to assess changes in the mortality rate, while the normal approximation method provided the 95% confidence intervals (*CI*) for

these rates. ART coverage rate was defined as the percentage of patients on treatment at year-end relative to all living HIV-positive patients, ascertained from historical data. We analyzed the correlation between ART coverage rate and mortality rate using Pearson's correlation coefficient.

During the study period, the eligibility criteria for initiating ART were modified: the threshold for CD4+T cell counts was raised from 350 cells/mm^3 to 500 cells/mm^3 in 2014 and then removed entirely in 2016, allowing initiation of ART regardless of CD4+T cell counts. These adjustments have potential implications for trends in ART coverage and mortality rates. Deaths related to AIDS and those not associated with AIDS were categorized based on the presence of specific diseases or events at the time of death, in accordance with the reporting guidelines of the system. AIDS-related diseases encompass pneumocystis pneumonia, cryptococcosis, tuberculosis, recurrent bacterial pneumonia, candidiasis, cytomegalovirus disease, AIDS-defining cancers (ADCs), toxoplasmosis, and HIV wasting syndrome, among others. Non-AIDS related events include cardiovascular and cerebrovascular diseases (CCVDs), non-AIDS defining cancers (NADCs), viral hepatitis, and various respiratory diseases, as well as fatalities due to accidents, which comprise suicide, drug overdose, and other non-disease related causes of death. China's geographical landscape is segmented into seven regions for the purposes of this research: northeastern China [comprising Heilongjiang, Jilin, and Liaoning provincial-level administrative divisions (PLADs)], northern China (including Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia PLADs), central China (Hubei, Hunan, and Henan PLADs), southern China (Guangdong, Guangxi, and Hainan PLADs), eastern China (encompassing Shanghai, Shandong, Jiangsu, Anhui, Jiangxi, Zhejiang, and Fujian PLADs), northwestern (Shaanxi, Gansu, Ningxia, Xinjiang, and Qinghai PLADs), and southwestern (Chongqing, Sichuan, Guizhou, Yunnan, and Xizang PLADs). Data analysis for this study was conducted using SAS software (version 9.4, NC, SAS Institute Inc., USA).

From 2013 to 2022, there was a marked decline in the all-cause mortality rate among Chinese HIV-infected patients, decreasing from 5.4% to 2.7% (P<0.05 for trend) (Figure 1). Simultaneously, ART coverage in China saw a substantial rise, from 58.4% to 92.8% (P<0.05 for trend), exhibiting a strong inverse relationship with the mortality rate (r=−0.964, P<0.05). Subgroup analyses based on ART status were carried out across various categories, including age, gender, transmission route, geographical regions, and CD4+T cell counts in 2022 (Table 1). In the same year, the subgroups with the highest all-cause mortality rates included individuals with CD4+T cell counts below 200 cells/mm^3 (7.5%), those aged 50 years or older (4.8%), people contracting HIV via heterosexual transmission (3.4%), residents of Southwest China (3.3%), and males (2.9%). Cause-specific mortality rates among ART recipients were lower compared to the overall patient population (all-cause mortality: 1.6% *vs.* 2.7%; AIDS-related mortality: 0.3% *vs.* 0.4%; non-AIDS related mortality: 1.1% *vs.* 1.8%; deaths

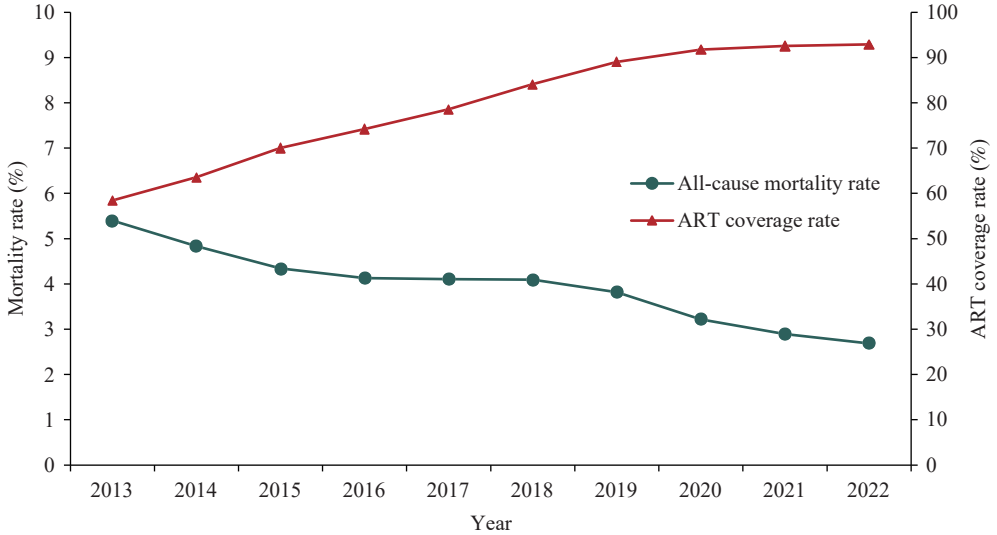

FIGURE 1. The trend of mortality rate and ART coverage among HIV-infected patients in China, 2013–2022.
Abbreviation: ART=antiretroviral therapy; HIV=human immunodeficiency virus.

TABLE 1. Cause-specific mortality rates among HIV-infected patients in China, 2022.

Characteristic	MR of total HIV infected patients (100.0%) % (95% *CI*)					MR of patients on ART (92.8%) % (95% *CI*)				
	Proportion	All cause	AIDS related	Non-AIDS related	Unknown cause	Proportion	All cause	AIDS related	Non-AIDS related	Unknown cause
Total	100	2.7 (2.66, 2.71)	0.4 (0.44, 0.46)	1.8 (1.78, 1.82)	0.4 (0.39, 0.41)	100	1.6 (1.62, 1.67)	0.3 (0.28, 0.30)	1.1 (1.08, 1.12)	0.3 (0.29, 0.31)
Current age, years										
<15	0.6	1.0 (0.76, 1.22)	0.3 (0.17, 0.41)	0.5 (0.36, 0.69)	0.2 (0.10, 0.30)	0.6	0.6 (0.42, 0.78)	0.2 (0.08, 0.27)	0.3 (0.18, 0.44)	0.1 (0.03, 0.17)
15–24	4.9	0.5 (0.46, 0.57)	0.1 (0.09, 0.15)	0.3 (0.25, 0.33)	0.1 (0.08, 0.12)	4.8	0.3 (0.22, 0.31)	0.1 (0.06, 0.11)	0.1 (0.10, 0.16)	0.0 (0.00, 0.00)
25–49	54.7	1.3 (1.30, 1.35)	0.3 (0.29, 0.31)	0.8 (0.79, 0.84)	0.2 (0.19, 0.21)	54.7	0.7 (0.72, 0.76)	0.2 (0.18, 0.20)	0.4 (0.43, 0.46)	0.1 (0.09, 0.11)
≥50	39.8	4.8 (4.79, 4.90)	0.7 (0.67, 0.72)	3.4 (3.31, 3.41)	0.8 (0.78, 0.82)	39.9	3.1 (3.01, 3.11)	0.5 (0.44, 0.48)	2.1 (2.09, 2.17)	0.5 (0.48, 0.52)
Gender										
Male	74.7	2.9 (2.88, 2.95)	0.5 (0.47, 0.50)	2.0 (1.93, 1.99)	0.5 (0.49, 0.51)	74.3	1.8 (1.77, 1.83)	0.3 (0.30, 0.33)	1.2 (1.19, 1.23)	0.3 (0.29, 0.31)
Female	25.3	2.0 (1.97, 2.07)	0.3 (0.32, 0.36)	1.3 (1.29, 1.37)	0.4 (0.38, 0.42)	25.7	1.2 (1.16, 1.24)	0.2 (0.20, 0.24)	0.8 (0.76, 0.82)	0.2 (0.18, 0.22)
Transmission route										
Heterosexual contact	65.4	3.4 (3.38, 3.46)	0.5 (0.53, 0.56)	2.3 (2.28, 2.35)	0.6 (0.58, 0.62)	65.3	2.1 (2.06, 2.13)	0.4 (0.34, 0.37)	1.4 (1.39, 1.44)	0.3 (0.29, 0.31)
Male-to-male sexual contact	26.0	0.8 (0.75, 0.81)	0.2 (0.18, 0.21)	0.5 (0.45, 0.49)	0.1 (0.09, 0.11)	26.4	0.4 (0.41, 0.46)	0.1 (0.11, 0.13)	0.3 (0.24, 0.28)	0.1 (0.09, 0.11)
Injection drug use	4.9	3.2 (3.05, 3.33)	0.5 (0.41, 0.52)	2.2 (2.09, 2.33)	0.5 (0.44, 0.56)	4.6	2.2 (2.07, 2.32)	0.3 (0.28, 0.38)	1.5 (1.41, 1.62)	0.4 (0.35, 0.45)
Blood receptor or donor	2.0	2.1 (1.97, 2.33)	0.5 (0.40, 0.58)	1.4 (1.29, 1.58)	0.2 (0.14, 0.26)	2.1	2.1 (1.88, 2.23)	0.5 (0.40, 0.58)	1.4 (1.21, 1.50)	0.2 (0.14, 0.26)
MTCT	0.8	0.8 (0.72, 0.91)	0.2 (0.19, 0.29)	0.4 (0.34, 0.47)	0.2 (0.15, 0.25)	0.8	0.6 (0.41, 0.72)	0.2 (0.09, 0.26)	0.3 (0.18, 0.40)	0.1 (0.03, 0.17)
Unknown	1.0	4.1 (3.73, 4.44)	0.7 (0.53, 0.82)	2.4 (2.17, 2.72)	1.0 (0.82, 1.18)	0.9	1.7 (1.41, 1.90)	0.3 (0.23, 0.46)	1.0 (0.79, 1.17)	0.3 (0.19, 0.41)
Geographical units										
Southern	16.3	3.2 (3.09, 3.24)	0.6 (0.59, 0.65)	2.0 (1.91, 2.03)	0.6 (0.57, 0.63)	15.7	1.6 (1.57, 1.69)	0.4 (0.33, 0.38)	1.0 (0.96, 1.05)	0.3 (0.27, 0.33)
Northern	5.9	1.1 (1.01, 1.16)	0.3 (0.26, 0.34)	0.6 (0.55, 0.66)	0.2 (0.17, 0.23)	5.9	0.6 (0.55, 0.67)	0.2 (0.12, 0.18)	0.4 (0.32, 0.42)	0.1 (0.08, 0.12)
Eastern	15.3	1.8 (1.73, 1.85)	0.4 (0.35, 0.40)	1.2 (1.15, 1.25)	0.2 (0.18, 0.22)	15.6	1.1 (1.01, 1.10)	0.2 (0.22, 0.27)	0.7 (0.65, 0.73)	0.1 (0.09, 0.11)
Central	12.6	2.7 (2.65, 2.81)	0.6 (0.52, 0.59)	1.8 (1.77, 1.90)	0.3 (0.27, 0.33)	12.7	1.8 (1.71, 1.85)	0.4 (0.37, 0.43)	1.2 (1.10, 1.21)	0.2 (0.18, 0.22)
Southwestern	38.5	3.3 (3.25, 3.35)	0.4 (0.39, 0.43)	2.3 (2.24, 2.33)	0.6 (0.58, 0.62)	39.1	2.1 (2.11, 2.19)	0.3 (0.27, 0.30)	1.5 (1.46, 1.53)	0.4 (0.38, 0.42)
Northwestern	7.4	2.2 (2.08, 2.26)	0.5 (0.43, 0.52)	1.5 (1.37, 1.53)	0.2 (0.17, 0.23)	7.1	1.3 (1.22, 1.38)	0.3 (0.27, 0.35)	0.9 (0.81, 0.94)	0.1 (0.08, 0.12)
Northeastern	4.1	1.5 (1.35, 1.56)	0.3 (0.21, 0.30)	1 (0.95, 1.13)	0.2 (0.16, 0.24)	4.0	0.8 (0.69, 0.84)	0.1 (0.11, 0.18)	0.5 (0.47, 0.60)	0.1 (0.07, 0.13)
Current CD4+T cell counts, cells/mm^3										
≥200	81.5	0.7 (0.70, 0.73)	0.1 (0.07, 0.08)	0.5 (0.52, 0.55)	0.1 (0.10, 0.11)	85.8	0.6 (0.57, 0.60)	0.1 (0.06, 0.07)	0.5 (0.43, 0.45)	0.1 (0.07, 0.08)
<200	10.7	4.7 (4.63, 4.85)	1.3 (1.25, 1.37)	2.7 (2.62, 2.79)	0.7 (0.69, 0.78)	10.9	3.6 (3.51, 3.71)	1.0 (0.91, 1.02)	2.1 (2.00, 2.16)	0.6 (0.52, 0.61)
Missing	7.8	20.5 (20.25, 20.76)	3.1 (3.03, 3.25)	13.9 (13.63, 14.06)	3.5 (3.41, 3.64)	3.3	23.1 (22.65, 23.50)	4.0 (3.81, 4.21)	15.3 (14.95, 15.68)	3.8 (3.56, 3.95)

Abbreviation: ART=antiretroviral therapy; AIDS=acquired immunodeficiency syndrome; HIV=human immunodeficiency virus; MTCT=mother-to-child transmission of HIV; MR=mortality rate; *CI*=confidence interval.

from unknown causes: 0.3% *vs.* 0.4%). Between 2013 and 2022, pneumocystis pneumonia remained the most frequent cause of AIDS-related deaths, accounting for 15.4% to 19.9% of cases. Tuberculosis and recurrent bacterial pneumonia, both trending downward, were the second and third most common causes, respectively. Among non-AIDS causes of death, respiratory diseases, CCVDs, and NADCs were predominant from 2013 to 2018, but by 2019 CCVDs had emerged as the leading cause (Figure 2). Notably, the proportion of deaths attributable to CCVDs increased from 16.3% in 2013 to 26.1% in 2022.

DISCUSSION

The scale-up of ART has played a critical role in the reduction of mortality among individuals infected with HIV. The all-cause mortality rate has exhibited a downward trend. In 2022, the all-cause mortality rate decreased to 2.7%. A study from 2013 revealed that in the top 30 countries with the most significant AIDS-related mortality burden, rates varied from 22 per 1,000 to 91 per 1,000 HIV-infected individuals, in contrast to North America and Western Europe, where the rates were between 4.6 per 1,000 and 15 per 1,000 HIV-infected individuals (*3*). In the United States, AIDS-related deaths decreased to 4.7 per 1,000 HIV-infected patients in 2017 (*4*). Research indicates that factors such as viral replication, a lower CD4 count, advanced clinical stage, and injection drug use are consistently associated with increased all-cause mortality (*5*). To mitigate early mortality, comprehensive strategies, including expanded screenings, management of opportunistic infections, and expeditious initiation of ART, are imperative. Concurrently, non-AIDS-related deaths are almost four times greater than those related to AIDS. The mortality rate in 2022 was higher among individuals over 50 years of age, those infected through heterosexual contact or injection drug use, and those with a CD4 count below 200 cells/mm^3. Regional disparities in mortality rates may be attributable to variations in medical infrastructure, professional capacity, and patient demographics.

In the era following the widespread adoption of ART, there has been an observable increase in mortality attributed to non-AIDS-related causes (*6*). Persistent inflammation and immune activation, consequences of chronic HIV infection, are now acknowledged as primary contributors to the pathogenesis of non-AIDS-related mortality. The risk factors for these conditions include a range of comorbidities, adverse effects associated with ART, the aging process, and lifestyle choices (*5*). Consequently, routine medical examinations, consistent adherence to ART regimens, lifestyle adjustments such as a nutritious diet, regular exercise, and smoking cessation, as well as proactive management of underlying health conditions, particularly cancer and cardiovascular diseases, are instrumental in decreasing the risk of both AIDS-related and non-AIDS-related deaths. Indeed, cancer constitutes a significant factor in mortality rates, with NADCs showing increased fatality rates, partly due to the advancing age of the HIV-infected population. One of the foremost challenges for clinicians treating HIV-infected individuals is to devise and apply efficacious strategies for the early detection, treatment, and prevention of cancers in this demographic (*7*).

China has made commendable progress in the expansion of ART and subsequent reduction in mortality rates. Nevertheless, challenges persist. A primary concern is the continued prevalence of late HIV diagnosis. Within Asia, it is estimated that between 34% and 72% of individuals diagnosed with HIV present late (*8*). Late presentation is associated with an elevated risk of treatment failure, higher mortality, and significant economic impacts. To bridge the diagnostic gap for all people living with HIV, China has launched significant initiatives geared towards early detection. These efforts include implementing anonymous urine testing for HIV, distributing HIV testing kits within MSM communities, advocating the use of novel rapid and self-testing methods among high-risk groups, and mandating health facilities to extend HIV testing to clinical attendees. Additionally, the issue of an aging population among HIV-positive individuals is more pronounced than ever. Between 2015 and 2022, a total of 221,621 cases of HIV-infected individuals aged 60 and older were reported (*9*). HIV infection may exacerbate the aging process due to sustained inflammatory responses, chronic immune activation, and prolonged use of ART. Older HIV-positive patients are at higher risk of cardiovascular events, opportunistic infections, malignancies, frailty, and mental health disorders compared to their younger and middle-aged counterparts (*10*). It is incumbent upon healthcare providers from various sectors to integrate management of age-related comorbidities within the regular HIV care framework.

This study presents certain limitations. First, the

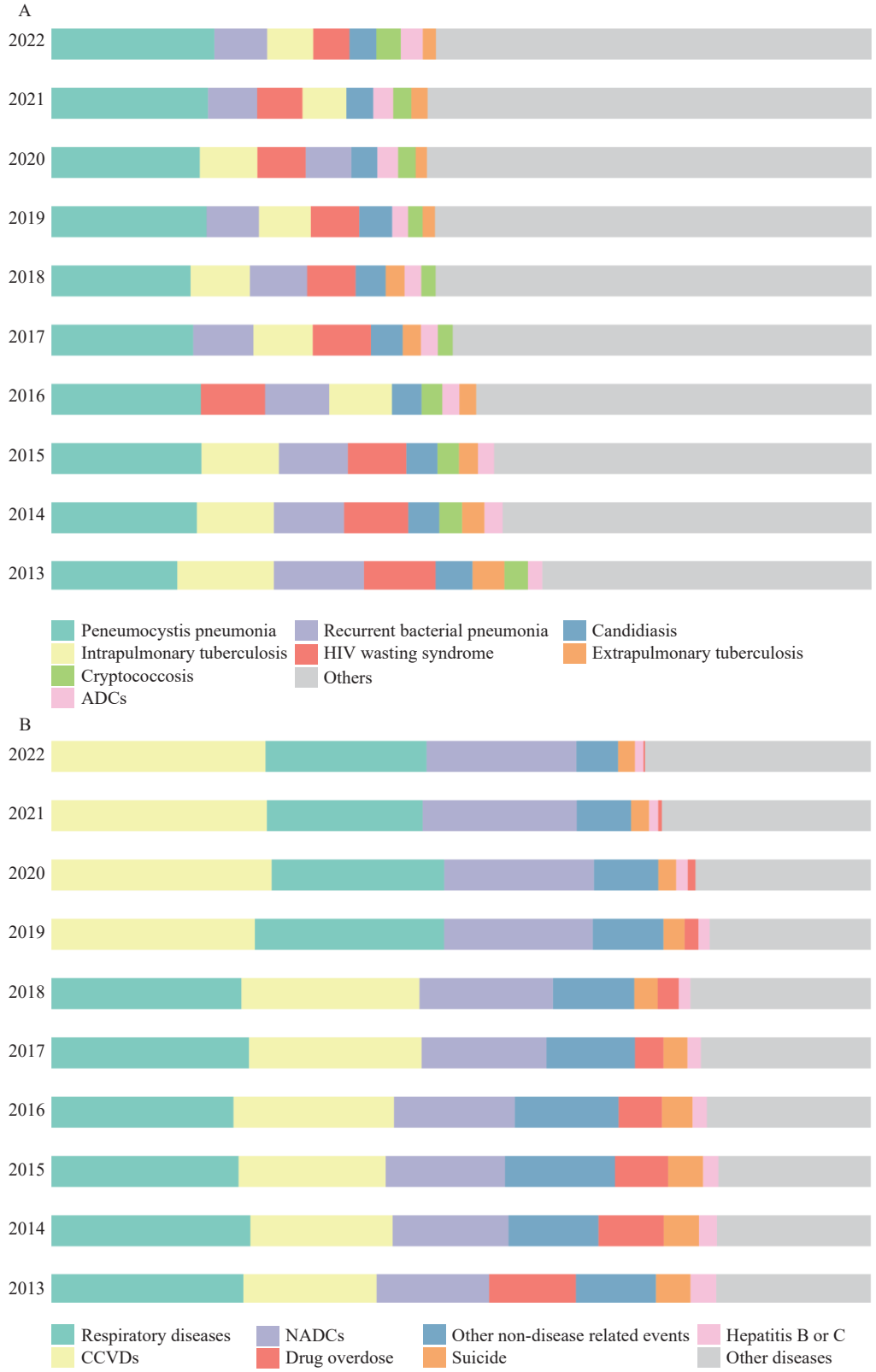

FIGURE 2. Detailed cause composition of reported AIDS related and non-AIDS related deaths in China, 2013–2022. (A) AIDS related deaths; (B) non-AIDS related deaths.
Abbreviation: AIDS=acquired immunodeficiency syndrome; HIV=human immunodeficiency virus; ADCs=AIDS-defining cancers; NADCs=non-AIDS-defining cancers; CCVDs=cardiovascular and cerebrovascular diseases.

categorization of fatalities and the ascertainment of specific causes of death are contingent upon the reliability of the reporting individuals, despite them having undergone standardized training. This subjectivity may result in an undetermined number of HIV-positive individuals with causes of death that cannot be classified, potentially leading to an underrepresentation of the proportion of deaths related to AIDS or other causes. Second, as a real-world observational study that relies on routine reporting systems, there is a risk that mortality rates may be underestimated due to delays in death reporting. Moreover, temporal comparisons may be compromised due to the utilization of historical data from various time periods, thus potentially yielding inconsistent mortality outcomes. Furthermore, survivorship bias must be considered, as only those HIV-infected patients who survive can access ART, which may confound interpretations of mortality rates among those receiving treatment.

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Vital Surveillances

Comparative Analysis of Epidemiological Features of HIV/AIDS Cases Aged Over and Under 50 Years Old — China, 2010–2022

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ABSTRACT

Introduction: Recent data indicate a year-on-year increase in the proportion of human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) cases reported among individuals aged ≥50 in China. This study compares the epidemiological characteristics of HIV/AIDS cases in populations above and below 50 years of age. By doing so, it seeks to scrutinize the current epidemiological landscape of HIV within these distinct age cohorts and suggest tailored interventions for each group.

Methods: We utilized data from the Chinese HIV/AIDS Comprehensive Response Information Management System for our comparative analysis. Joinpoint regression analysis was employed to assess the trends in standardized detection rates.

Results: In China, the number of newly reported HIV/AIDS cases in the 15–49 age group increased from 51,436 in 2010 to 55,397 in 2022, while it increased from 11,751 in 2010 to 51,856 in 2022 in the group aged ≥50 years. Recent years have seen a greater proportion and detection rate of HIV/AIDS cases among the ≥50 age demographic compared to the 15–49 age group. In 2022, significant statistical differences were observed between males and females in both age cohorts with respect to education, marital status, occupation, mode of transmission, location of diagnosis, and region.

Conclusions: The observed trend of a rising proportion of HIV/AIDS cases in individuals aged 50 years and older necessitates heightened attention. It is imperative that we develop and implement interventions specifically designed to prevent and control the transmission of HIV within this demographic.

As the global population ages, there is a concurrent persistence of high-risk behaviors among individuals aged 50 and older, leading to an escalating incidence of human immunodeficiency virus (HIV) infections within this demographic (*1*). Data from China indicates a consistent rise in the proportion of people aged 50 and above living with HIV/acquired immune deficiency syndrome (AIDS) (PLWHA) (*2*). Research suggests that the reported infection rates for HIV/AIDS vary with age, with a notably higher incidence recorded among the elderly, defined as persons aged 50 years and older (*3*). Extensive literature indicates that HIV transmission has extended beyond high-risk populations to infect the general population, particularly the elderly. Yet, the majority of prior studies have primarily concentrated on high-risk behaviors in the 15–49 age cohort, with little comparative analysis on the epidemiological characteristics of HIV/AIDS cases among individuals aged 15–49 years and those aged 50 and above. This study seeks to address this gap by investigating the epidemiological trends and demographic attributes of HIV/AIDS cases in China, stratified by age groups over and under 50 years, reported between 2010 and 2022. The objective is to elucidate the current epidemiological landscape of HIV among these populations and to propose age-specific interventions tailored to each group.

METHODS

Data from the Chinese HIV/AIDS Comprehensive Response Information Management System (CRIMS) were utilized to assess the epidemiological profile of newly diagnosed HIV infections in individuals aged 15–49 years and ≥50 years. Medical facilities and the regional Centers for Disease Control (CDCs) use the CRIMS to report cases. The permission to access data in the CRIMS database was obtained from the National Center for AIDS/STD Control and Prevention, China CDC. All newly reported PLWHA in the CRIMS between 2010 and 2022 were included in our study. The detection rate was calculated as the number of newly identified cases within a given year

divided by the respective population size for that age bracket.

For the statistical analysis, Chi-square tests were employed to examine differences by using SPSS software (version 24.0, IBM Inc., Armonk, NY, USA). To assess trends in standardized incidence rates, we conducted Joinpoint regression analysis with the Joinpoint Regression Program (version 4.9.0.0, March 2021; Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute), devised by Kim et al. (*4*). Additionally, the annual percent change (APC) was determined through Joinpoint regression analysis. The years were designated as the independent variable (x_i), and the number of HIV/AIDS cases was considered the dependent variable (y_i). Gender and age were classified as categorical variables. The grid search method (GSM) was applied to detect turning points and model parameters. Furthermore, the modified Bayesian information criterion (MBIC) was employed to ascertain the optimal model. The model with the smallest MBIC value was selected as the optimal one for analyzing the time trend of new detection rates and calculating the APC. A significance threshold (α) was set at 0.05, with a *P*-value of less than 0.05 indicating statistical significance.

RESULTS

In China, the number of newly reported HIV/AIDS cases in the 15–49 age group increased from 51,436 in 2010 to 55,397 in 2022, while it increased from 11,751 in 2010 to 51,856 in 2022 in the group aged ≥50 years. In the male group, the percentage of individuals aged 50 and older with HIV/AIDS saw a significant increase from 19.57% in 2010 to 44.39% in 2022 (χ^2=30,268.80, *P*<0.01). Similarly, among females, the percentage of HIV/AIDS in those aged 50 and above rose markedly from 16.26% in 2010 to 62.78% in 2022 (χ^2=12,529.83, *P*<0.01). Among new diagnoses in China, males aged between 15 and 49 accounted for 79.24% of cases, resulting in a gender ratio of 3.82∶1. Among the demographic aged 50 and older, 73.34% of cases were male, with a reduced gender ratio of 2.75∶1 (Figure 1).

The trend in detection rates of HIV/AIDS case from 2010 to 2022 was rising, with a little decline after 2019. For males, the detection rate of HIV/AIDS cases in the ≥50 age group exceeded that of the 15–49 age group around 2017. Conversely, in females, the detection rates remained relatively stable across both age groups, although the detection rate for those aged 50 and over was greater than that for the 15–49 cohort beginning around 2014 (Figure 2). A comparative analysis of the annual new detection rates for HIV/AIDS cases across different gender and age groups revealed an upward trend for males aged 50 and above, with rates climbing from 0.5 per 10,000 in 2010 to 2.2 per 10,000 in 2019, before the trend reversed and fell to 1.5 per 10,000 by 2022. Joinpoint regression analysis indicated an APC of 18.3% [95% confidence interval (*CI*): 16.1%, 20.6%] from 2010 to 2018 and an APC of −8.0% (95% *CI*: −11.2%, −4.6%) from 2018 to 2022. In females aged 50 and over, detection rates rose from 0.2 per 10,000 in 2010 to 0.8 per 10,000 in 2019, then similarly reversed,

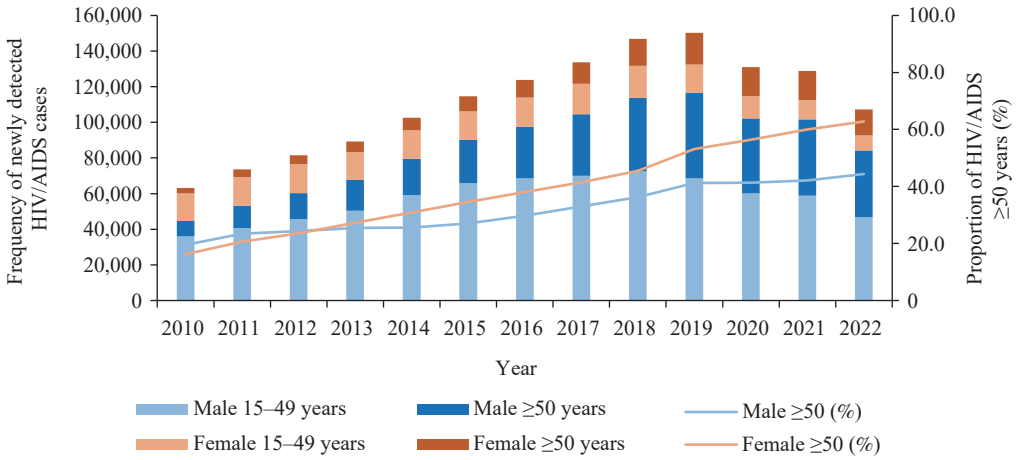

FIGURE 1. Frequency of HIV/AIDS cases in individuals aged 15–49 and ≥50 years, and proportion of HIV/AIDS cases in individuals aged ≥50 years between male and female in China, 2010–2022.
Abbreviation: HIV=human immunodeficiency virus; AIDS=acquired immunodeficiency syndrome.

decreasing to 0.6 per 10,000 in 2022. Joinpoint regression analysis for this group showed an APC of 19.2% (95% *CI*: 17.2%, 21.4%) from 2010 to 2018 and an APC of -6.7% (95% *CI*: -9.6%, -3.7%) from 2018 to 2022 (Table 1).

In 2022, significant disparities were observed among different age cohorts, distinguished by gender. Our analysis revealed that men and women across these groups presented statistically significant dissimilarities in terms of educational background, marital status, occupation, transmission route, site of diagnosis, and region (P<0.01). Furthermore, when comparing age groups, distinct patterns in transmission routes emerged (χ^2=72,936.81, P<0.01).

In the 15–49 age category, heterosexual transmission was predominant, accounting for 55.62% (30,813/55,397) of cases. This trend was even more pronounced in those aged 50 and above, with heterosexual transmission representing 90.16% (46,754/51,856) of instances. Notably, among men aged 15–49, homosexual transmission constituted a significant proportion at 50.13% (23,463/46,802). In contrast, the rate for homosexual transmission was markedly lower in men aged 50 and above, at 11.04% (4,125/37,358).

In terms of female cases, however, non-mainstream non-commercial heterosexual contact (NMNCHC) (12,595/22,448, 56.11%) was identified as the primary

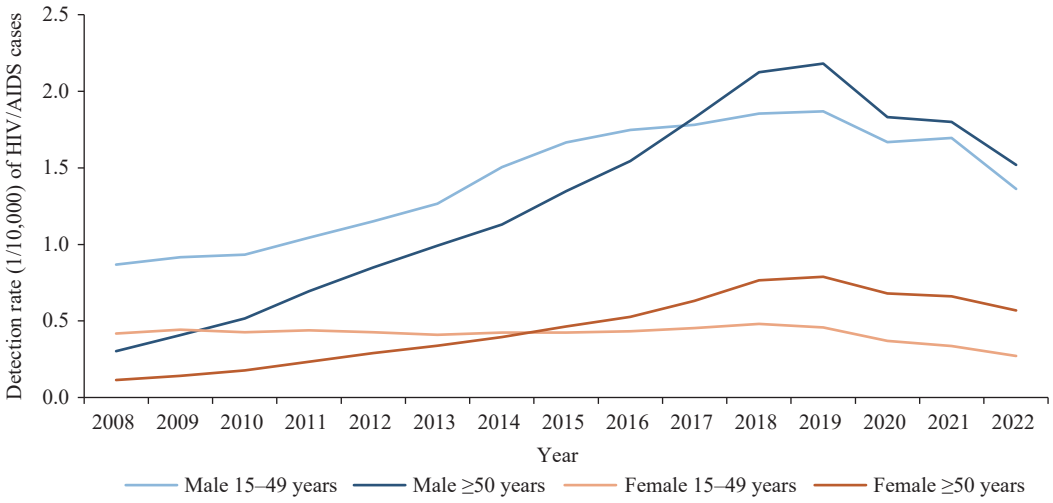

FIGURE 2. The trending change in the detection rate of HIV/AIDS cases in individuals aged 15–49 and ≥50 years old in China, 2010–2022.
Abbreviation: HIV=human immunodeficiency virus; AIDS=acquired immunodeficiency syndrome.

TABLE 1. Annual percent change in detection rate of HIV/AIDS in individuals aged 15–49 and ≥50 years old in China, 2010–2022.

Age, years	AAPC, % (95% *CI*)	*t*	*P*	Year	APC, % (95% *CI*)	*t*	*P*
Male							
15–49	3.8 (0.8, 6.8)	2.5	0.013	2010–2015	12.8 (8.1, 17.6)	7.3	0.001
				2015–2019	3.2 (−4.4, 11.4)	1.0	0.343
				2019–2022	−8.9 (−16.6, −0.5)	−2.7	0.041
≥50	8.8 (7.2, 10.4)	11.2	<0.001	2010–2018	18.3 (16.1, 20.6)	20.5	<0.001
				2018–2022	−8.0 (−11.2, −4.6)	−5.4	0.001
Female							
15–49	−3.5 (−5.3, −1.7)	−3.7	<0.001	2010–2019	1 (−0.1, 2.2)	2.0	0.079
				2019–2022	−15.8 (−22.3, −8.7)	−4.9	0.001
≥50	9.9 (8.4, 11.4)	13.8	<0.001	2010–2018	19.2 (17.2, 21.4)	23.1	<0.001
				2018–2022	−6.7 (−9.6, −3.7)	−5.1	0.001

Abbreviation: HIV=human immunodeficiency virus; AIDS=acquired immunodeficiency syndrome; AAPC=average annual percent change; APC=annual percent change; *CI*=confidence interval.

TABLE 2. Characteristics of newly reported HIV/AIDS cases aged 15–49 and ≥50 years in China, 2022 (*n*, %).

Characteristics	Male			Female		
	15–49 years (*n*=46,802)	≥50 years (*n*=37,358)	χ^2	15–49 years (*n*=8,595)	≥50 years (*n*=14,498)	χ^2
Ethnicity						
Han	39,965 (85.39)	33,655 (90.09)	422.2*	5,553 (64.61)	12,133 (83.69)	1,102.1*
Others	6,837 (14.61)	3,703 (9.91)		3,042 (35.39)	2,365 (16.31)	
Marital status						
Single	12,484 (26.67)	21,476 (57.49)		4,876 (56.73)	8,887 (61.30)	
Married or living with partner	27,959 (59.74)	3,208 (8.59)	23,465.9*	1,384 (16.10)	109 (0.75)	2,178.1*
Divorced or widowed	6,141 (13.12)	12,522 (33.52)		2,296 (26.71)	5,452 (37.61)	
Unknown	218 (0.47)	152 (0.42)		39 (0.45)	50 (0.34)	
Occupation						
Farming	12,856 (27.47)	24,475 (65.51)		4,273 (49.71)	9,720 (67.04)	
Housekeeping service or unemployment	11,666 (24.93)	5,142 (13.76)	12,284.7*	2,322 (27.02)	2,969 (20.48)	749.1*
Others	22,280 (47.60)	7,741 (20.72)		2,000 (23.27)	1,809 (12.48)	
Education						
Primary school or illiterate	6,988 (14.93)	21,734 (58.18)		3,687 (42.90)	10,407 (71.78)	
Junior high school	13,625 (29.11)	11,111 (29.74)	23,289.4*	3,164 (36.81)	3,275 (22.59)	2,259.1*
High school	9,619 (20.55)	3,199 (8.56)		1,069 (12.44)	654 (4.51)	
College and above	16,570 (35.40)	1,314 (3.52)		675 (7.85)	162 (1.12)	
Transmission route						
Heterosexual	22,448 (47.96)	32,516 (87.04)		8,365 (97.32)	1,4238 (98.21)	
Homosexual	23,463 (50.13)	4,125 (11.04)	14,632.7*	-	-	36.86*
Injecting drugs	287 (0.61)	86 (0.23)		47 (0.55)	21 (0.14)	
Others	604 (1.29)	631 (1.69)		183 (2.13)	239 (1.65)	
Site of diagnosis						
Hospital	26,048 (55.66)	26,997 (72.27)		5,279 (61.42)	9,484 (65.42)	
High-risk population screening	15,999 (34.18)	6,447 (17.26)	3,143.3*	2,341 (27.24)	3,656 (25.22)	42.8*
Others	4,755 (10.16)	3,914 (10.48)		975 (11.35)	1,358 (9.36)	
Regions						
North China	4,275 (9.13)	1,322 (3.54)		220 (2.56)	268 (1.85)	
Northeast	2,727 (5.83)	818 (2.19)		154 (1.79)	213 (1.47)	
East China	10,424 (22.27)	5,813 (15.56)	4,245.1*	1,048 (12.19)	1,799 (12.41)	476.4*
South Central	13,793 (29.47)	11,676 (31.25)		2,132 (24.81)	4,527 (31.22)	
Southwest	12,424 (26.55)	16,304 (43.64)		4,188 (48.73)	7,187 (49.57)	
Northwest	3,159 (6.75)	1,425 (3.81)		853 (9.92)	504 (3.48)	
CD4+T cells (cells/μL)						
0–199	11,890 (25.40)	13,171 (35.26)		2,041 (23.75)	4,351 (30.01)	
200–349	12,510 (26.73)	10,029 (26.85)		2,388 (27.78)	4,376 (30.18)	
350–500	8,965 (19.16)	4,832 (12.93)	2,295.7*	1,642 (19.10)	2,302 (15.88)	215.4*
501–	7,142 (15.26)	2,942 (7.88)		1,375 (16.00)	1,631 (11.25)	
Undetected	6,295 (13.45)	6,384 (17.09)		1,149 (13.37)	1,838 (12.68)	

Abbreviation: HIV=human immunodeficiency virus; AIDS=acquired immunodeficiency syndrome.
* $P<0.01$.

transmission route for both age brackets, at 70.65% and 64.33%, respectively, as detailed in Table 2.

CONCLUSIONS

Our study revealed that the detection rates of HIV/AIDS among individuals aged 50 and older have surpassed those in the 15–49 age group in recent years in China. This aligns with research indicating that the proportion of PLWHA who are aged 50 years or older has been on an annual rise (*5*). Factors contributing to this trend include high-risk sexual behaviors and a deficit in HIV-related knowledge and awareness among this demographic (*6*). Consequently, the rising trend underscores the need for heightened attention and targeted interventions for the population aged 50 years and above.

The observed prevalence of newly identified HIV infections across two distinct age demographics exhibited an increasing trend prior to the year 2019, followed by a notable decline commencing in 2020. This pattern not only captures the ongoing dynamics of the epidemic but is also influenced by the enactment of comprehensive prevention and control tactics aimed at broadening diagnostic evaluations (*7*). These measures have contributed to the identification of a higher number of HIV-positive individuals. Moreover, the downward trend could be indicative of advancements in prevention and control efforts (*3*), as well as the consequences of intensified COVID-19 mitigation policies during the same timeframe. These policies, which curtailed movement and social gatherings, may have indirectly led to a reduction in high-risk behaviors (*8*).

In China, there are distinct variations in the transmission routes and regional distribution of HIV cases. Men aged between 15 and 49 years are at an elevated risk of contracting HIV through homosexual contact, whereas the primary transmission route for elderly men is CHC. Additionally, there is a rising trend in HIV/AIDS cases among women aged 50 years or older, which can be partly attributed to the fact that post-sterilization, older women may not feel the need to engage in contraceptive practices (*9*).

Moreover, the data reveals a significant proportion of HIV/AIDS cases with critically low CD4+ cell counts (below 200 cells/μL), indicating a substantial number of undiagnosed cases. This underscores the urgent need for intensifying efforts to identify and diagnose individuals living with HIV/AIDS.

This study has some limitations. The data from CRIMS were used in this study to conduct a macro-level analysis. However, we were unable to investigate the behavioral characteristics of PLWHA in-depth due to monitoring data limits.

In conclusion, there are differences in demographic characteristics and transmission routes between PLWHA aged over and under 50 years old. The proportion of HIV/AIDS cases among people aged ≥50 years showed an increasing trend. Further research is also required to identify the factors that contribute to the HIV epidemic in various age groups. We should focus on the elderly population and establish specific prevention and control measures for them.

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Recollection

Preventing HIV Epidemic in China: Policy Evolution and Coordination Mechanisms in the Past Four Decades

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INTRODUCTION

China has achieved commendable success in stabilizing human immunodeficiency virus (HIV) prevalence at a relatively low level of transmission (*1*). Nevertheless, the total number of people living with HIV in China rose to approximately 1.05 million, with cumulative reported acquired immune deficiency syndrome (AIDS)-related fatalities reaching 351,000 by the end of 2020 (*2*). Since the initial infiltration of HIV into China in 1982 (*3*), the nation has enacted over 471 national policies through 2021 to combat the epidemic. Initially, the outbreak was perceived primarily as a healthcare issue rather than the complex societal challenge that it manifested into. The Ministry of Health (MOH, now known as National Health Commission) was initially tasked with HIV prevention, issuing the nation's first HIV/AIDS-related policy in 1984, which aimed to ban HIV-infected products and individuals from entry. Regrettably, this approach proved inadequate as significant HIV outbreaks unfolded. At this juncture, the State Council Research Office recognized the HIV epidemic as a grave societal and public health issue, posing a threat to the "Survival of the Chinese Nation" (*4*). Engagement at a higher governmental level became imperative to coordinate an effective response across diverse administrative agencies.

In 1995, the State Council issued *"the Notice on Strengthening the Prevention and Control of AIDS* (NSPCA)*"*, creating the first policy specifically dedicated to orchestrating a cohesive HIV response among government agencies. The following year, the State Council advanced this effort by approving the establishment of the Issues Concerning the Coordination Conference System for the Prevention and Control of AIDS and Sexually Transmitted Diseases (STDs). This system introduced a formal coordination mechanism that encompassed various agencies (*5*). By 2004, in an effort to further enhance the leadership and collaboration in the fight against HIV/AIDS, the State Council formally established the State Council AIDS Working Committee (SCAWC).

China's evolving approach to HIV/AIDS policy has been the subject of extensive scholarly attention, encompassing reviews of institutional changes (*6*), specific policy shifts (*7*), and the history of the HIV epidemic within the country (*8*). Studies to date have discerned a correlation between the epidemiology of HIV/AIDS and policy responses. Despite previous efforts, most analyses have focused on a limited selection of key policies, with the exception of Yan et al.'s comprehensive examination of national-level HIV/AIDS policies, which cataloged 217 policies implemented from 1984 to 2005 (*9*). However, even this thorough study did not investigate the relationship between policy development and the various governmental bodies responsible for them. Moreover, in the two decades since that study, there has been substantial progress.

To date, insufficient attention has been devoted to the examination of HIV/AIDS policies. Research indicates that the delivery of healthcare policies necessitates considerable collaboration; a deficiency in coordination frameworks may constitute a significant barrier to the provision of integrated services (*10–11*). The establishment of a policy coordination mechanism is essential for the effective prevention of HIV/AIDS transmission. How this coordination mechanism is structured and the nature of its formation are questions that remain unanswered. This article seeks to enrich the theoretical discourse on the evolution of China's HIV/AIDS policy by scrutinizing the interconnection between policy development and coordination mechanisms.

METHODS

Data Source

Our data acquisition encompassed a wide array of materials linked to HIV/AIDS spanning from 1982 to

2021. This collection comprises national policy documents, detailed accounts of significant outbreaks, and expressive commentary from esteemed entities such as high-level government dignitaries, delegates of the National People's Congress (NPC), and members of the Chinese People's Political Consultative Conference (CPPCC). Additionally, we included insights from public health authorities, HIV/AIDS activists, and other influential individuals who have made significant contributions to combating HIV/AIDS. The data collection process for this study involved sourcing material from a variety of reputable online platforms and scientific journal publications (*12–15*)*. By the conclusion of the data collection in February 2022, a comprehensive set of 471 relevant documents issued by China's central government from 1982 to 2021 had been amassed.

Study Design

Drawing upon the contents of the text and consultations with experts, we examined the trajectory of policy evolution across three dimensions: the substance of the policies, the stakeholders involved, and the governmental levels at which the policies were enacted. To quantify this analysis, we devised a set of indicators organized into three categories: policy focus areas; government agencies responsible for issuing policies; and the scope of government agendas.

Identification and Categorization of Policy Focus Areas: We endeavor to refine the methodology for classifying policies according to their salient content. Upon reviewing the content, we categorized 471 pertinent policies and events into 16 distinct classifications, as delineated in Table 1.

Policies promulgated by either individual or multiple governmental bodies: Certain policies have emanated from a solitary agency, whereas others have been collaboratively issued by multiple responsible entities. The count of agencies engaged acts as a barometer for gauging the level of priority attributed to HIV/AIDS policy measures.

Governmental response stratification: the evolution of China's HIV/AIDS policy coordination mechanism has led to its classification into distinct phases: the initial Department-Agenda Period (DAP) (1982–1994), followed by the comprehensive National (State-Council)-Agenda Period (NAP) (1995–2021). The NAP bifurcates further into two stages: the earlier

TABLE 1. HIV/AIDS policy development indicators.

Policy indicators	Variables
Policy focus areas	1) Treatment 2) Public education 3) Surveillance and monitoring 4) Social engagement and participation 5) Governmental departments coordination 6) Oversight and evaluation of policy implementation 7) Assistance to people affected by HIV/AIDS 8) Strategic plans 9) International collaborations 10) Specific interventions to transmission routes 11) Scientific studies and researches 12) Comprehensive policies 13) Initiations & reforms of government program management mechanism and personnel training 14) Academic conferences 15) Press releases 16) Other areas
Government agencies which have issued policies	1) State Council and/or Central Party Committee (CPC) 2) Ministry of Health (MOH) 3) Other Ministries (Ministries or Agencies other than the MOH collaborated to issue policies together, without an apparent lead) 4) MOH-Led with Other Ministries (MOH led and other Ministries participated) 5) Other Ministry Led (Another Ministry/Agency led with participation from multiple ministries/agencies, MOH may also participate)
Level of government agendas	1) DAP (1982–1994) 2) NAP (1995–2021) a) a period of Jointly Conferences (1995–2003) b) a period of SCAWC established (institutionalized) (2004–2021)

* Data Sourse: Chinese Center for Disease Control and Prevention, https://www.chinacdc.cn; Ministry of Education, http://www.moe.gov.cn; National General Administration of Customs, http://www.customs.gov.cn; National Health Commission, http://www.nhc.gov.cn/; People's Congress, http://www.npc.gov.cn; State Council, https://www.gov.cn.

Joint Conference Period (1995–2003), designated as NAP I, and the subsequent SCAWC Period (2004–2021), hereafter referred to as NAP II.

Data Analysis

We conducted an analysis to illustrate the evolution of HIV/AIDS policies from 1984 to 2021, presenting the changes in the form of a line chart. Additionally, a cross-tabulation analysis was performed to examine the relationship between policy indicators and the policy coordination mechanism.

RESULTS

HIV/AIDS Policy Evolution Trends

Figure 1 shows changes in the number of HIV/AIDS policies from 1984 to 2021. The annual number of policies varied significantly, with a peak in 2004 at 36 policies. Notably, a consistently high number of policies were issued from 2005 to 2007. In 1995, another peak occurred with 29 policies. Before 1995, policy issuance was low, averaging 5.2 policies per year. The fewest policies were issued in 1984 and 1994. The periods between 1996–2003 and 2008–2021 saw relatively large and stable outputs of policies following the peak years. Since 2000, approximately 10 policies were issued annually (except in 2013), though the yearly maximum did not exceed 20 policies.

Policy Focus Areas by Issuing Agencies

Table 2 presents the responsible government agencies and policy focus areas. China has promulgated a total of 471 HIV/AIDS-related policies, of which 85 (18.0%) pertain to public education.

In examining the distribution of policies promulgated by specific agencies since 1984, it is evident that the State Council issued 104 policies, the MOH issued 223, while other ministries issued 61. There were also collaborative efforts, with the MOH leading and supported by other ministries in issuing 50 policies, and other ministries leading in the issuance of 33 policies. Regarding the types of policies issued, public education was a predominant focus for the State Council, collaborative efforts led by the MOH, and initiatives led by other ministries, with respective emphasis of 21.2%, 24.0%, and 36.4%. The State Council concentrated more on coordinating government departments and implementing strategic plans, with each area receiving 14.4% of its policy efforts. The MOH, tasked with drafting health-related policies, emphasized specific interventions targeted at transmission routes (20.6%), as well as endorsing comprehensive policies, surveillance, and monitoring (each at 8.5%). Other ministries and ministry-led initiatives placed a significant emphasis on scientific studies and research with these categories receiving 24.6% and 15.2% of the policies, respectively. For the MOH-led collaborations with support from other ministries, the focus after public education was on specific interventions to address transmission routes, which accounted for 22.0% of the policies.

Level of Government Agenda by Period

Table 3 presents the distribution of policies issued by agencies as well as by periods over the past four decades, demonstrating a significant shift in the perception of HIV/AIDS from an issue of MOH-level importance to one of national importance.

The approach to policy coordination underwent

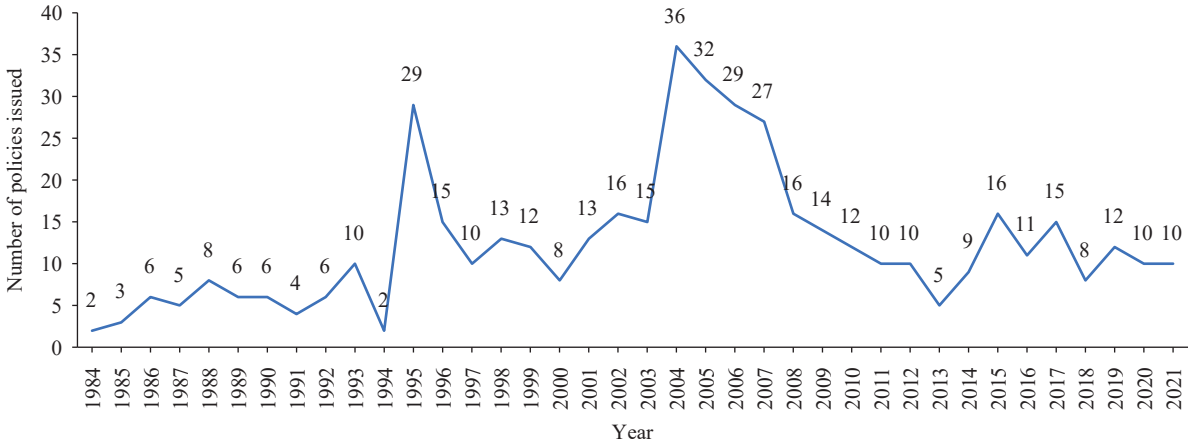

FIGURE 1. Number of policies issued from 1984 to 2021.

TABLE 2. Policy focus areas by issuing agencies.

Policy focus areas	*n* (%)	Issuing agencies				
		State Council (*n*=104), %	MOH (*n*=223), %	Other ministries* (*n*=61), %	MOH-led with other ministries (*n*=50), %	Other ministry led† (*n*=33), %
Treatment	28 (5.9)	1.0	8.5	6.6	2.0	9.1
Public education	85 (18.0)	21.2	11.2	23.0	24.0	36.4
Surveillance and monitoring	26 (5.5)	1.9	8.5	1.6	8.0	0.0
Social engagement and participation	6 (1.3)	0.0	0.9	0.0	6.0	3.0
Governmental departments coordination	25 (5.3)	14.4	3.6	3.3	0.0	0.0
Oversight and evaluation of policy implementation	23 (4.9)	7.7	5.4	1.6	4.0	0.0
Assistance to people affected by HIV/AIDS	8 (1.7)	0.0	0.4	6.6	2.0	6.1
Strategic plans	25 (5.3)	14.4	2.7	3.3	4.0	0.0
International collaborations	25 (5.3)	4.8	8.1	0.0	2.0	3.0
Specific interventions to transmission routes	66 (14.0)	1.9	20.6	8.2	22.0	6.1
Scientific studies and researches	35 (7.4)	1.0	4.0	24.6	10.0	15.2
Comprehensive policies	37 (7.9)	7.7	8.5	9.8	4.0	3.0
Initiations & reforms of government program management mechanism and personnel training	21 (4.5)	5.8	4.9	3.3	2.0	3.0
Academic conferences	9 (1.9)	0.0	2.7	0.0	2.0	6.1
Press releases	6 (1.3)	1.0	2.2	0.0	2.0	0.0
Other areas	46 (9.8)	17.3	7.6	8.2	6.0	9.1

Abbreviation: MOH=ministry of health; HIV=human immunodeficiency virus; AIDS=acquired immune deficiency syndrome.
* Other Ministries: ministries (other than the MOH) collaborated to issue policies together, without an apparent lead.
† Other Ministry Led: a ministry other than the MOH led the policy development, however, the MOH may still be part of the policy development.

significant evolution over the years. Initially, from 1982 to 1994, there was an absence of any formal coordination mechanism. This shifted in the period from 1995 to 2003, during which a coordination mechanism existed, albeit without the support of a formally established committee. Subsequent to this phase, a formal committee was established.

During the DAP era, governmental entities functioned autonomously, frequently with conflicting objectives, employing rigid regulatory instruments without harmonized collaboration or the institutional adaptability to adjust to evolving circumstances over time. Conversely, in the NAP phase, the approach to HIV/AIDS policy extended beyond the confines of the healthcare sector and treatment in isolation. The State Council shifted its emphasis to broader public education initiatives, the coordination of government departments, strategic planning, and additional sectors.

Government Agencies Involved by Period

During the DAP, the MOH was responsible for formulating and promulgating over half of the policies, accounting for 56.9%.

In the analysis of the NAP (1995–2021), there is a discernible trend in the reallocation of policy-making authority. The MOH, whether acting independently or in collaboration with other ministries, experienced a reduction in its share of policy initiatives — from 56.9% to 46% for MOH-led policies, and from 19.0% to 9.4% for those involving a partnership with other ministries. In contrast, the role of the State Council in policy enactment has more than doubled, increasing from 10.3% to 23.7%.

During the NAP I (1995–2003), there was a discernible shift in the pattern of policy-making among governmental entities. The State Council saw its contribution to policy issuance rise from 10.3% to 13.7%. Nevertheless, the MOH retained a significant influence throughout this era, originating 61.8% of the policies and spearheading an additional 9.2% of policy development efforts. Consequently, the MOH was responsible for the oversight of a substantial 71% of policies implemented during this timeframe.

During the NAP II (2004–2021), there was a noticeable rise in the volume of policy-making activity

TABLE 3. HIV/AIDS policy development by government policy agenda periods.

Items	Whole period (1982–2021)	Level of government agendas			
		DAP (1982–1994) MOH agenda	NAP (1995–2021)		
			NAP (1995–2021)	NAP I (1995–2003)	NAP II (2004–2021)
Total policies issued (*n*)	471	58	413	131	282
Average policies per year (*n*)	11.8	4.5	15.3	14.6	15.7
Government agencies issued policies (%)					
State Council	22.1	10.3	23.7	13.7	28.4
Ministry of Health	47.3	56.9	46.0	61.8	38.7
Other ministry	13.0	10.3	13.3	13.0	13.5
Health led with other ministries	10.6	19.0	9.4	9.2	9.6
Other ministry led	7.0	3.4	7.5	2.3	9.9
Policy focus areas (%)					
Treatment	5.9	1.7	6.5	6.9	6.4
Public education	18.0	12.1	18.9	13.7	21.3
Surveillance and monitoring	5.5	15.5	4.1	6.1	3.2
Social engagement and participation	1.3	3.4	1.0	0.0	1.4
Governmental departments coordination	5.3	1.7	5.8	9.9	3.9
Oversight and evaluation of policy implementation	4.9	1.7	5.3	3.1	6.4
Assistance to people affected by HIV/AIDS	1.7	0.0	1.9	0.0	2.8
Strategic plans	5.3	3.4	5.6	5.3	5.7
International collaborations	5.3	3.4	5.6	9.9	3.5
Specific interventions to transmission routes	14.0	24.1	12.6	19.8	9.2
Scientific studies and researches	7.4	3.4	8.0	2.3	10.6
Comprehensive policies	7.6	10.3	7.3	6.1	7.8
Initiations & reforms of government program management mechanism and personnel training	4.5	12.1	3.4	3.8	3.2
Academic conferences	1.9	0.0	2.2	4.6	1.1
Press releases	1.5	3.4	1.2	2.3	0.7
Other areas	9.8	3.4	10.7	6.1	12.8

Abbreviation: HIV=human immunodeficiency virus; AIDS=acquired immune deficiency syndrome; DPA=department-agenda period; MOH=ministry of health; NAP=national-agenda period; NAP I=Joint Conference Period; NAP II=State Council AIDS Working Committee Period.

by the State Council, evidenced by an increase from 13.7% of proposals during the NAP I to 28.4% in the NAP II. Concurrently, the proportion of policy proposals from the MOH experienced a marked decline, falling from 61.8% to 38.7% from NAP I to NAP II. However, there was a marginal uptick in policies spearheaded by the MOH, rising slightly from 9.2% to 9.6%.

Evolution of Policy Focus Areas by Period

Transitioning from the DAP to the NAP, there has been a discernible shift in policy emphasis from targeted interventions and pathways of transmission, along with surveillance and monitoring (decreasing from 24.1% to 12.6%, and from 15.5% to 4.1%, respectively), to an enhanced focus on public education (increasing from 12.1% to 18.9%) and treatment strategies (rising from 1.7% to 6.5%). There was a notable decline in the proportion of policies dedicated to the initiation and reform of government program management mechanisms and staff training, from 12.1% to 3.4%. Significantly, increased attention has been given to scientific researches (increasing from 3.4% to 8.0%) and the coordination between government departments (rising from 1.7% to 5.8%).

Additionally, previous deficiencies in areas such as academic conferences and support for individuals impacted by HIV/AIDS have been incrementally addressed over time (increasing from 0.0% to 2.2% and from 1.9% respectively).

During distinct periods, policy emphasis and decision-making priorities shifted markedly. Within the duration of DAP, policies emphasis was placed on targeted interventions to impede transmission routes and other strategies. Conversely, throughout the NAP I, while maintaining a focus on targeted transmission interventions (19.8%) and public education (13.7%), there was an observable uptick in attention to the coordination of governmental departments (9.9%) and bolstering international collaborations (9.9%). Notably, the prevalence of treatment-related policies expanded during this phase, escalating from 1.7% to 6.9%. The subsequent phase, the NAP II, was characterized by a heightened prioritization of public education, representing 21.3% of the policy output. This shift suggests that the SCAWC has begun to effectively fulfill a coordinating role in the formulation of policies.

DISCUSSION

This study conducted a systematic and comprehensive analysis of China's HIV/AIDS policies over the past four decades, examining the policy shifts and the underlying rationale for these transitions. The investigation delineated two distinct eras in the coordination of China's HIV/AIDS policies: the DAP and the NAP. This temporal division contrasts with the triphasic categorization — consisting of the entry/introduction phase from 1985 to 1988, the spreading phase from 1989 to 1994, and the expansion phase from 1995 to the present — proposed by previous studies, which were predicated on the number of HIV/AIDS infections (*16–19*). Consistent with prior studies, our findings indicate a significant transformation in HIV/AIDS policy formulation commencing in 1995 (*18*,*20*).

Our investigation revealed that 2004 marked the apex of policy issuance related to HIV/AIDS over the past four decades, with a sustained increase in policy introductions observed from 2005 to 2007. This surge can be attributed to several factors: the 2003 severe acute respiratory syndrome (SARS) outbreak, a significant shift in the political landscape due to the establishment of a new government, and heightened awareness regarding the HIV/AIDS epidemic (*6*,*18*,*21–22*). Advocacy efforts further contributed to a paradigm shift, transforming the discourse from a disease-centric to a human-centric narrative concerning HIV/AIDS (*23*). While HIV/AIDS assistance and support policies have been in existence since 2003, there remains substantial scope for policy enhancement. There is a pressing need for more nuanced support measures, social services, and programs that align with the actual needs of those impacted by HIV/AIDS.

Transitioning from the DAP to the NAP, there was a notable shift in the perceptions of HIV/AIDS. A more effective policy coordination framework emerged. This evolution progressed from an informal coordination structure exemplified by the Joint Conference in the DAP period, to an institutionalized form of coordination seen with the establishment of the SCAWC during the NAP era. This structured coordination mechanism allowed for government agencies to fulfill their designated roles more effectively.

The initiation of the NAP was precipitated by a marked increase in the incidence of HIV/AIDS in 1995. At that time, reports of the disease had emerged from every province, autonomous region, and municipality under direct central governance (*18*,*22*). The swift and extensive propagation of the HIV/AIDS epidemic prompted the government to acknowledge that tackling HIV/AIDS transcended healthcare and necessitated interventions at the societal and political levels. Consequently, the government established a coordination conference to streamline efforts. This aligns with our research findings, which identify 1995 as another pivotal year in the development of HIV/AIDS policy. Notably, the first policy document on HIV/AIDS prevention and control from the State Council, the NSPCA drafted by the Ministry of Health, was ratified and promulgated. The NSPCA laid the foundational policy infrastructure, addressing and reconciling previously conflicting stances among various departments — such as divergent perspectives on condom usage between health and public security agencies — in the nascent stages of AIDS prevention. This policy acted as a catalyst, fostering interdepartmental coordination and paving the way for enhanced HIV/AIDS prevention and treatment strategies.

Since 1982, there has been a significant transition from a casual and sporadic coordination — characterized by mere annual AIDS/STDs prevention and control coordination meetings — to the

establishment of a formalized coordination entity. This evolution reflects an increased recognition of the critical role coordination plays. There have been notable structural changes as well; the coordination model evolved from the Coordination Conference System for the Prevention and Control of AIDS and STDs founded in 1996 to the creation of the SCAWC in 2004. Furthermore, AIDS working committees have been instituted at the local government level. Each tier of government now boasts comprehensive mechanisms for the prevention, treatment, and care of HIV/AIDS and has effectively rallied robust support across society and various sectors for the HIV/AIDS response (*24*).

CONCLUSIONS

This paper chronicles the evolution of HIV/AIDS policy development and coordination across four decades, with particular emphasis on the transformative years of 1995 and 2004. These years marked significant shifts in the organizational framework, as evidenced by the transition between the DAP and the NAP, and the subsequent progression from the NAP I to the NAP II, concurrent with an unprecedented surge in policy enactments. The restructuring during these periods laid a robust groundwork for a cooperative approach to HIV/AIDS prevention and control, enabling the MOH and various sectors to effectively collaborate. A notable elevation in HIV/AIDS awareness and comprehension emerged between 2003 and 2004, catalyzing a pivotal redirection of policy focus towards the support of individuals impacted by HIV/AIDS. Nevertheless, despite these advancements, current HIV/AIDS care and support mechanisms continue to exhibit significant deficiencies. To address these shortcomings, the development of more inclusive policies is imperative. These policies should be co-designed with the HIV/AIDS community, targeting the enhancement of employment prospects, eradication of stigma, and provision of mental health services. Furthermore, additional research is warranted to ascertain the optimal strategies for the formulation and execution of HIV/AIDS-related policies.

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