

## Preplanned Studies

## Spatial Analysis of HIV/AIDS Cases Among Out-of-School Youth Aged 15–24 Years — China, 2010–2020

Shaorong Wang<sup>1</sup>; Junjie Wang<sup>1</sup>; Peng Xu<sup>1</sup>; Wanting Lyu<sup>1</sup>; Mengjie Han<sup>1, #</sup>

### Summary

#### What is already known about this topic?

There are 4,000 new HIV infections every day worldwide, and 31% of which are in adolescents aged 15–24 years old. However, previous study is not aware of the distribution of out-of-school youth among this age group.

#### What is added by this report?

The crude reporting rate of HIV/AIDS among out-of-school youth aged 15–24 years old increased from 5.25 per 100,000 persons in 2010 to 13.75 per 100,000 persons in 2020 with a weakly aggregated spatial distribution. Local hotspots spread from southwestern China to the central, eastern, and northeastern areas.

#### What are the implications for public health practice?

In the future, HIV/AIDS awareness among out-of-school youth and research on epidemic characteristics should be strengthened.

In 2020, there was a daily increase of 4,000 new human immunodeficiency virus (HIV) infections globally, and 31% of which would be among adolescents aged 15–24 years old (1), defined as the youth by the United Nations (UN) (2). More importantly, a proportion of the youth are sexually active. Due to the lack of school-based HIV education and prevention services, out-of-school youth become more vulnerable to HIV infection than students. This study described the crude reporting rate of out-of-school youth aged 15–24 and illustrated the spatial distribution characteristics using global spatial autocorrelation and hot spot analysis, which was based on case-reporting areas. The objective of this study was to understand the epidemiological situation and spatial distribution of out-of-school youth. The crude reporting rate of human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) among out-of-school youth increased from 5.25 per 100,000 persons in 2010 to 13.75 per 100,000 persons in 2020 with a weakly aggregated spatial distribution. In addition, local hotspots gradually

spread from southwestern China to the central, eastern, and northeastern areas. In-depth studies should continue to be conducted in the future to understand the prevalence characteristics among out-of-school youth, while strengthening HIV prevention interventions and services for out-of-school youth in hotspots.

The crude reporting rate of out-of-school youth HIV/AIDS cases in China (data include the mainland of China only) from 2010 to 2020 was calculated as the ratio of the number of reported cases among out-of-school youths to the total out-of-school youth population, where the total out-of-school youth population was derived as the total population of youth aged 15–24 years old minus the student population in this age group. The total population of youth aged 15–24 was derived from the number of the population of youth aged 15–24 in the sample and the sampling fraction, which were both obtained from the China Statistical Yearbook. The number of enrolled students was obtained from the website of the Ministry of Education of the People's Republic of China and represented the total number of regular senior secondary schools, regular specialized secondary schools, vocational high schools, undergraduates in regular higher educational institutions (HEIs), and those in master's degree programs. The number of reported cases of students by cities in the mainland of China by year was obtained from the HIV/AIDS Comprehensive Response Information Management System (CRIMS).

A total of 128,646 out-of-school youth HIV/AIDS cases aged 15–24 were reported from 2010 to 2020, covering all provincial-level administrative divisions (PLADs) in China. The number of reported HIV/AIDS cases among out-of-school youth in China showed an increasing trend from 8,579 in 2010 to 13,750 in 2015 and decreased to 10,398 in 2020. The proportion of HIV/AIDS cases among out-of-school youth aged 15–24 years declined from 91.53% of all cases in this age group in 2010 to 77.76% in 2020. The Chinese crude reporting rate of out-of-school youth HIV/AIDS cases presented a general upward trend from 5.25 per 100,000 persons in 2010 to 15.04

TABLE 1. Number of reported HIV/AIDS cases and crude reporting rate among out-of-school youth aged 15–24 years in China, 2010–2020.

| Year  | Out-of-school youth aged 15–24 years reported HIV/AIDS cases | Proportion of out-of-school youth HIV/AIDS cases aged 15–24 years to all cases among 15–24 years (%) | Total population of out-of-school youth aged 15–24 years | Crude reporting rate (per 100,000) |
|-------|--|--|--|------------------------------------|
| 2010  | 8,579  | 91.53  | 163,390,413  | 5.25                               |
| 2011  | 9,225  | 89.57  | 157,930,318  | 5.84                               |
| 2012  | 10,043   | 87.87  | 147,002,113  | 6.83                               |
| 2013  | 11,222   | 87.47  | 138,494,425  | 8.10                               |
| 2014  | 12,841   | 83.43  | 125,941,350  | 10.20                              |
| 2015  | 13,750   | 80.95  | 112,201,357  | 12.25                              |
| 2016  | 13,657   | 81.73  | 104,446,501  | 13.08                              |
| 2017  | 13,230   | 81.13  | 95,893,937   | 13.80                              |
| 2018  | 13,333   | 81.11  | 88,623,320   | 15.04                              |
| 2019  | 12,368   | 78.33  | 82,561,534   | 14.98                              |
| 2020  | 10,398   | 77.76  | 75,603,657   | 13.75                              |
| Total | 128,646  | 83.04  | 1,292,088,925  | 9.96                               |

per 100,000 persons in 2018, then dropped to 13.75 per 100,000 persons in 2020 (Table 1).

The cumulative number of newly documented out-of-school youth HIV/AIDS cases nationwide from 2010 to 2020 was analyzed by global spatial autocorrelation. The results showed global Moran's Index (Moran's  $I$ )=0.029,  $Z$ =5.021,  $P$ <0.001, indicating that there was a weakly positive spatial autocorrelation of HIV/AIDS cases among out-of-school youth in China from 2010 to 2020. The annual global autocorrelation analysis shows that Moran's  $I$  decreased from 0.058 in 2010 to 0.018 in 2014 and slightly increased from 0.019 in 2015 to 0.027 in 2020; the Moran's  $I$  in 2020 was still lower than that in 2010, indicating an overall downward trend in spatial aggregation (Table 2).

The study results of local hotspots from 2010 to 2020 using Getis-Ord  $G_i^*$  showed that the number of local hotspots for out-of-school youth HIV/AIDS cases in China, varying between 11 and 15, did not change much from 2010 to 2020. Chongqing, Chengdu, Beijing, Shanghai, Guangzhou, Kunming, and Liangshan Yi Autonomous Prefecture were stable hotspots. From 2010 to 2012, local hotspots for out-of-school youth HIV/AIDS cases were mainly located in the southwest of China, including Chongqing, Chengdu, Liangshan Yi Autonomous Prefecture, Kunming, Honghe Hani Yi Autonomous Prefecture, and Dehong Dai Jingpo Autonomous Prefecture. Between 2013 and 2020, the hotspots area gradually shifted to the central, eastern, and the northeastern regions, and more new hotspot areas began to emerge, mainly in the cities of Hangzhou, Changsha, Wuhan,

TABLE 2. Global autocorrelation analysis of the number of out-of-school youth HIV/AIDS cases in China, 2010–2020.

| Year      | Moran's $I$ | Z Score | P value |
|-----------|-------------|---------|---------|
| 2010–2020 | 0.029       | 5.021   | <0.001  |
| 2010      | 0.058       | 9.811   | <0.001  |
| 2011      | 0.052       | 8.410   | <0.001  |
| 2012      | 0.036       | 5.828   | <0.001  |
| 2013      | 0.026       | 4.294   | <0.001  |
| 2014      | 0.018       | 3.188   | 0.001   |
| 2015      | 0.019       | 3.273   | 0.001   |
| 2016      | 0.019       | 3.335   | <0.001  |
| 2017      | 0.020       | 3.403   | <0.001  |
| 2018      | 0.016       | 3.004   | 0.003   |
| 2019      | 0.021       | 3.577   | <0.001  |
| 2020      | 0.027       | 4.503   | <0.001  |

Note: If Moran's  $I \neq 0$  and  $Z \geq 1.96$  or  $Z \leq -1.96$ , the distribution of cases is indicated as spatially correlated. If Moran's  $I$  was close to 0 and  $Z$  values ranged between  $-1.96$  and  $1.96$ , the cases were randomly distributed and there was no correlation.

Xi'an, Zhengzhou, Shenyang, and Harbin. However, there were no cold spot cities in the country from 2010 to 2020, indicating that there have been no low agglomerative areas in China in recent years.

## DISCUSSION

Young students aged 15–24 years old are a key group for HIV prevention in China, but the results of this study showed that out-of-school youth still accounted for more than 3/4 of young people aged 15–24 years old living with HIV/AIDS. Thus, out-of-

school youth should be a high priority group for prevention and control strategies. The results of this study demonstrated that the number of out-of-school youth HIV/AIDS cases had decreased since 2015. The increasing number of out-of-school youth HIV/AIDS cases may be attributable to the expanded testing strategy implemented in China, an actual increase in the number of cases or some other factors. The subsequent decline may be related to factors such as the gradual improvement of HIV prevention strategies and services in China and an increased awareness of health protection among out-of-school youth. The proportion of infected out-of-school youths among all HIV-infected persons aged 15–24 years presented decline in general. However, the crude reporting rate of HIV/AIDS cases among out-of-school youth was rising approximately 2.5 times from 5.25 per 100,000 persons in 2010 to 13.75 per 100,000 persons in 2020. Non-significant decreases in crude reporting rates were likely attributable to insignificant decreases in the number of cases in the numerator as well as a decrease of out-of-school youths in the denominator. In addition to that, this may be related to the expansion of HIV testing and the introduction of HIV prevention services in China. Specific factors will need to be explored in future studies.

The spatial autocorrelation results showed that the general spatial clustering was low, and the spatial clustering of each year decreased despite fluctuations. This might be due to a combination of factors, for instance, the development of more accessible transportation and a more mobile out-of-school youth population, which may lead to narrowing of the gap between high and low clustering areas. This suggests that HIV testing and intervention of mobile populations should be strengthened in the future.

This study found few changes in the number of hotspot districts. However, the number of hotspot cities in the southwest area gradually dropped over time, and those in the central and eastern area grew annually. Hotspot cities in the northeastern region, including Shenyang and Harbin were found in this study. However, hotspots were generated by various factors, such as the level of local economic development (3), the improvement of the level of testing, an increase in testing (4), and the rise of the number of cases, which requires in-depth work and further investigations in the future.

A previous study has shown that the proportion of HIV/AIDS cases among young students aged 15–24 years to all HIV/AIDS cases among young people 15–24 years has increased and the proportion of relative out-of-school youth has decreased between

2008 and 2016 (5), which is roughly the same trend as the change demonstrated in this study. A study among all infected cases aged 15–24 years showed that the proportions of reported cases increased in eastern and central China and decreased in the southwest (6). This is the same trend as the hotspots shown in this study.

This study was subject to some limitations. First, data on HIV/AIDS cases analyzed in this study were derived from CRIMS, where the number of reported cases was correlated with local HIV testing strategies and prevention service capacity. These factors need to be considered when CRIMS is being used. Additionally, demographic information reported in CRIMS for HIV/AIDS cases were reported by the infected individuals themselves, such as occupation, and may be subject to some information bias.

The number of cases among out-of-school youth aged 15–24 years between 2010 and 2020 showed an increase and then a decrease, and the spatial clustering was low, with local hotspots gradually spreading from southwestern China to the central, eastern, and northeastern areas. Future studies focusing on out-of-school youth should seek a deeper understanding of the epidemiological characteristics and the transmission patterns of HIV among this population, as well as strengthening HIV prevention interventions and services for out-of-school youth in hotspots.

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# Corresponding author: Mengjie Han, [mjhan@chinaaids.cn](mailto:mjhan@chinaaids.cn).

<sup>1</sup> National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China.

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