Online dating applications use and risky sexual networking: Analyses based on the cases investigations of HIV-infected students in Zhejiang Province, China

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Funding: This work was supported by National Science and Technology Major Project Foundation under the 12th and 13th Five-Year Plan of China (2012ZX10001001, 2017ZX10201101). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

Running title: Online dating applications use and risky sexual networking

Key words: Acquired immunodeficiency syndrome; HIV-infected students; Men who have sex with men

Number of Tables and Figures: 6
Abstract

**Background:** China has 74.9 million high school and college students, in which the number of reported HIV/AIDS cases is increasing rapidly. Most of these cases are attributed to male-to-male sexual contact. But few studies have explored the online dating applications use and risky sexual networking of HIV-reported infected students in Zhejiang province, China.

**Objective:** To explored the online dating applications use and risky sexual networking of HIV-reported infected students.

**Methods:** Using the national surveillance data of HIV-infected students, we conducted a retrospective epidemiology study. The spatial analyses were conducted in ArcGIS 10.2, the statistical analyses were performed in SPSS 18.0.

**Results:** The year from 2011 to 2016 had reported the majority of cases with the number of 628 (87.5%, 628/718) in Zhejiang Province. And the cases showed an overall increasing pattern over time, while the proportion of education with “college or above”, disease status with HIV, source with VCT, and route of homosexual transmission stay stable over time. Significant spatial heterogeneity at the county level had been characterized being located in the main city of Hangzhou. Besides, 124 individuals being collected some detailed information from the staff of the local CDC from 2015–2016 showed that majority of HIV-infected students (83.9%, 104/124) had casual sex; the type of homosexual partners included not only social members, but
also students; online dating applications had been the most common way to seeking and communicating with homosexual partners; the awareness of infected with HIV and the coverage of face-to-face education towards students were not really high.

**Conclusion:** The diagnosed cases of HIV-infected students increased rapidly by years in Zhejiang province, with homosexual being the main mode. The complex transmission and insufficient awareness made it urgently to strength the intervention to prevent HIV transmission among students. Integration of HIV testing promotion and prevention information through online dating applications is needed right now.

**Introduction**

In China, sexual contact is the primary mode of transmission of the human immunodeficiency virus (HIV) currently [1,2,3]. The rates of transmission reached 94.7% in 2016 (67.1% by heterosexual contact and 27.6% by homosexual contact) [4]. Remarkably, the number of HIV infection among young students has increased rapidly [5,6]. The number of new cases increased by five-fold, from 482 in 2008 to 2,552 in 2014, and the proportion of infections by homosexual contact increased from 58.5% to 81.6% in the same period [6]. The HIV/acquired immune deficiency syndrome (AIDS) epidemic among students has been identified as one of the major HIV/AIDS challenges in China [1,5].

The main reasons for this may include inadequate access to comprehensive sex education, lower self-protection awareness, being sexually active [7,8]. Furthermore, students represent as the digital generation. The gay applications such as Jack’d and
social media platforms such as WeChat, QQ, MoMo are providing men with social and sexual networking opportunities and mediums for learning new information. A survey carried out at a high school in Los Angeles, USA showed that bisexual-identifying students reported higher rates of being approached online for sex, being sexually active, and not using condoms at last sex. Thus, gay students were more likely to report online partner seeking and unprotected sex at last sex with an internet-met partner[9]. A study also found over half of their sample spent at least two hours per week looking for a casual sex partner online among young men who have sex with men (MSM) who use the internet[10]. Previous studies among students have mainly focused on the investigation of attitudes and knowledge regarding HIV, sexual behavior, or the comparison of disease prevalence in MSM and those who do not[11-14]. The analysis of online dating applications use and risky sexual networking of HIV-infected students based on cases investigations is clearly limited[5,15,16]. Few studies have tried to assess the risk of infected students, and to describe in detail the epidemiological characteristics of HIV-infected students.

The use of spatial analysis in HIV research has become increasingly common, specifically for the assessment of the geographic distribution of infection, identification of high-risk and space-time clusters. Qin performed a spatial analysis of HIV/AIDS among MSM in China from 2006 to 2015[17]. Zulu described the temporal and spatial distribution of HIV/AIDS prevalence in Malawi from 1994 to 2010[18]. Knowledge of the long-term trends and geographic distribution patterns of HIV infection among students has critical implications for future program planning and
health policies regarding HIV prevention among students in China. These findings will help aid the public health focus and better guide the use of limited resources.

Therefore, we conducted this study to address the paucity of relevant information regarding the epidemiological trends and spatial distribution in Zhejiang Province, China, aiming at illustrating the epidemiological characteristics of HIV-infected students between 2011 and 2016.

Materials and Methods

Data collection

The annual data on HIV-infected students from 2011 to 2016 was obtained from the national reporting sub-database of Zhejiang Province through the National Data Information System for Comprehensive HIV/AIDS Control. HIV-infected students in this study were defined as HIV-positive individuals who were students and reported by the medical institutions in Zhejiang Province at the time of diagnosis. Physicians diagnosed the disease according to national standards [19-21]. Blood samples were initially screened for HIV using enzyme-linked immunosorbent assay, and samples that yielded positive results during screening were confirmed positive by western blot. Only samples that yielded positive results in the confirmatory tests were considered to be HIV seropositive. Data on the sociodemographic characteristics (such as age, gender, occupation, and education), disease status, routes of transmission and risk behavior information were collected by the staff of the local Center for Disease Control and Prevention (CDC) using standardized forms through a face-to-face
interview in a private room. All of the information had been reported to the Chinese Center for Disease Control and Prevention (CCDC) and could be accessed through a web-based system. All personal identifiers were removed from the database for this study to protect the privacy of participants.

In addition, we collected some detailed epidemiological information from the staff of the local CDC during 2015 to 2016 obtained from students who were diagnosed with HIV, including their sexual behavior (heterosexual or homosexual sex with commercial, casual, regular/married partners), the use of online dating applications, the probable self-reported route of transmission, history and willingness for HIV testing, the state of propaganda and intervention.

**Data analyses**

The annual numbers of HIV infection among students divided according to transmission route were plotted to display the trend of the disease. The proportions according to level of education, disease status, and source of infection were calculated and plotted to reveal the variation in the number of cases.

Descriptive analyses were conducted to elucidate sexual risk behaviors and interventions status for the detailed characteristics of HIV-infected students. All descriptive statistical analyses were carried out using SPSS software version 18.0 (IBM Corp., Armonk, NY, USA). The significance level was defined as $P \leq 0.05$.

A map series for the spatial distribution of HIV-infected students for each year were created using the ArcGIS software version 10.2 (ESRI Inc., Redlands, CA, USA) to illustrate the spatiotemporal dynamics from 2011 to 2016 at the county level of
Hangzhou City in Zhejiang Province (displayed across the whole province in 2016). We then carried out the spatiotemporal analysis in two phases for each year. First, a global test (Moran’s I index) was used to assess whether there was spatial autocorrelation in the annual trend of cases during the study period. A negative value of Moran’s I indicates an over-dispersed distribution, while a positive value indicates a clustered distribution, and a value around zero indicates a spatially random distribution. Second, local indicators of spatial association were conducted to explore the spatiotemporal clustering of HIV/AIDS. This was used to identify significant hotspots (High-High), coldspots (Low-Low), and outliers (High-Low and Low-High) by calculating local Moran’s I index between a given location and the average of neighboring values in the surrounding locations. We performed the local test for each year at the county level during the study period. The above tests were both calculated using the ArcGIS 10.2 software.

**Ethical statement**

The collection of data from HIV-infected students was a part of routine surveillance; thus, the data collection was exempt from approval by the institutional review board.

**Results**

**Distribution patterns of HIV infection among students, 2011–2016**

A total of 718 cases of HIV/AIDS had been diagnosed among students in Zhejiang
province, China until 2016. The period from 2011 to 2016 had seen the largest number of cases (628/718, 87.5%), with 41, 53, 69, 136, 170, and 159 cases in the respective years. The proportion of students with HIV/AIDS among the total cases diagnosed annually in Zhejiang increased from 1.7% in 2011 to 3.3% in 2016 over the study period (Cochran-Armitage trend test, \( P<0.01 \)). Among the students diagnosed with HIV/AIDS, 96.5% (606/628) acquired the infection through sexual contact. The proportion of individuals infected through homosexual contact was 77.5% and there was no significant difference among the values obtained in 2011 to 2016 (Cochran-Armitage trend test, \( P>0.05 \), Fig. 1). Besides, the proportion of individuals with college education or higher, disease status “HIV,” and diagnosed by “HIV voluntary counseling & testing (VCT)” also showed no significant change and remained stable over time (Cochran-Armitage trend test, \( P>0.05 \)). The majority of students with HIV/AIDS were single (99.5%) and of Han ethnicity (95.4%).
Figure 1. The temporal trend and the transmission route of HIV-infected students from 2011 to 2016.

Detail information on HIV-infected students collected from the local CDC

In all, 124/329 students (37.7% response rate) accepted to partake in a supplementary inquiry among the cases detected from 2015 to 2016. Compared to the HIV-infected students reported from 2015 to 2016, there was no statistically significant difference in the distribution according to age, gender, marital status, and education (chi-square test, \( P>0.05 \)). Of these, 122 (98.4%) were male, and only 2 (1.6%) were female. The median age was 20.9 years, and ranged from 17 to 31 years. The majority (94.4%) of these cases were young students (15-24 years old), and 111 (89.5%) students had college education or higher. Of the 124 cases, 98 (79.0%) engaged in only homosexual
intercourse, 18 (14.5%) engaged in only heterosexual intercourse, and 8 (6.5%) engaged in both behaviors. Based on self-reported information obtained from the participants, 105 (84.7%) students were infected with HIV from homosexual partners (3 from commercial partners, 91 from casual partners and 11 from regular partners), 19 (15.3%) were infected with HIV through heterosexual partners (4 from commercial partners, 10 from casual partners and 5 from regular partners).

A total of 106 students reported having engaged in homosexual intercourse before being diagnosed with HIV/AIDS. Among these, 3 students engaged in commercial sex (all for making money), 99 students engaged in casual sex, and 40 students engaged in regular sex. Excluding 1 students with missing data, of the casual partners, 36.7% (36/98) were only strangers to the infected student, 17.3% (17/98) were only friends, and 45.9% (45/98) were both strangers and friends. The proportion of individuals who had consistently used condoms with different partners in the preceding year was under 30% (Table 1). Twenty students (17.9%) had other students as partners, 36.8% (39/104) had social members as partners, and 43.4% (46/104) had both types of partners. Excluding 1 students with missing data, there were 80 (81.6%) seeking and communicating with partners by geosocial networking applications targeting MSM such as Blued and Jack’d, 54 (55.1%) by social media messaging platforms such as QQ, WeChat and Momo, 18 (18.4%) by venues prepared for MSM, 25 (25.5%) by telephone, and 7 (7.1%) by other avenues.

Table 1. The information of partners and condom use of HIV-infected students

<table>
<thead>
<tr>
<th>No. of partners and condom use</th>
<th>Students with homosexual sex</th>
<th>Students with heterosexual sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial</td>
<td>Casual</td>
</tr>
<tr>
<td>Commerical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular#</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a: Regular refers to regular sexual partners.*
The age when students diagnosed as HIV positive was mainly 20-24 years old.

There were 19 students with the type of homosexual partners only among students, 39 with social members, and 45 with both of students and social. There were 6 students who had the first homosexual sex under the age of 15 with a student transmitted by commercial route and five students transmitted by casual route. Among HIV-infected students with the homosexual transmission route, 44 students (41.9%) had a homosexual sex before enrolling into school, 19 students (18.3%) participated in parties for homosexuals before diagnosed, 19 students (18.4%) attended courses related to HIV/AIDS organized by school. (Table 2).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Commercial route (n=3)</th>
<th>Casual route (n=99)</th>
<th>Regular route (n=40)</th>
<th>Total (n=15)</th>
<th>(n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median of partners, IQR*</td>
<td>2, -</td>
<td>3, 3</td>
<td>2, 1</td>
<td>3, 2</td>
<td>2, 3</td>
</tr>
</tbody>
</table>

*The numbers of commercial and casual partners were considered during the past one year before diagnosed, and which of regular partner was a cumulative value.

*There is missing data (1 individual) existed among the information of condom use in regular partner.

**Table 2. The characteristics of sexual behavior among HIV-infected students with the homosexual transmission route**

Use a condom or not in the latest sex during the past one year

<table>
<thead>
<tr>
<th>Use</th>
<th>Commercial route (n=3)</th>
<th>Casual route (n=99)</th>
<th>Regular route (n=40)</th>
<th>Total (n=15)</th>
<th>(n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>1(33.3)</td>
<td>42(42.4)</td>
<td>22(56.4)</td>
<td>2(40.0)</td>
<td>8(53.3)</td>
</tr>
<tr>
<td>Not use</td>
<td>2(66.7)</td>
<td>54(54.5)</td>
<td>13(33.3)</td>
<td>3(60.0)</td>
<td>6(40.0)</td>
</tr>
<tr>
<td>Not happened</td>
<td>0(0.0)</td>
<td>3(3.0)</td>
<td>4(10.3)</td>
<td>0(0.0)</td>
<td>1(6.7)</td>
</tr>
<tr>
<td>Age</td>
<td>15-19</td>
<td>20-24</td>
<td>25-</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2(66.7)</td>
<td>23(54.5)</td>
<td>6(54.5)</td>
<td>31(29.5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1(33.3)</td>
<td>64(70.3)</td>
<td>5(45.5)</td>
<td>70(66.7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0(0.0)</td>
<td>4(4.4)</td>
<td>0(0.0)</td>
<td>4(3.8)</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junior high</td>
<td>0(0.0)</td>
<td>2(2.2)</td>
<td>0(0.0)</td>
<td>2(1.9)</td>
<td></td>
</tr>
<tr>
<td>Senior high</td>
<td>2(66.7)</td>
<td>6(6.6)</td>
<td>1(9.1)</td>
<td>9(8.6)</td>
<td></td>
</tr>
<tr>
<td>College or above</td>
<td>1(33.3)</td>
<td>83(91.2)</td>
<td>10(90.9)</td>
<td>94(89.5)</td>
<td></td>
</tr>
<tr>
<td>The registered place of partners</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only in Zhejiang</td>
<td>2(66.7)</td>
<td>64(71.1)</td>
<td>4(36.4)</td>
<td>70(67.3)</td>
<td></td>
</tr>
<tr>
<td>Outside Zhejiang</td>
<td>0(0.0)</td>
<td>10(11.1)</td>
<td>3(27.3)</td>
<td>13(12.5)</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>1(33.3)</td>
<td>16(17.8)</td>
<td>4(36.4)</td>
<td>21(20.2)</td>
<td></td>
</tr>
<tr>
<td>The type of partners</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only students</td>
<td>0(0.0)</td>
<td>15(16.9)</td>
<td>4(36.4)</td>
<td>19(18.4)</td>
<td></td>
</tr>
<tr>
<td>Only social members</td>
<td>1(33.3)</td>
<td>32(36.0)</td>
<td>6(54.5)</td>
<td>39(37.9)</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>2(66.7)</td>
<td>42(47.2)</td>
<td>1(9.1)</td>
<td>45(43.7)</td>
<td></td>
</tr>
<tr>
<td>Age of the first homosexual sex happened</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤15</td>
<td>1(33.3)</td>
<td>5(5.6)</td>
<td>0(0.0)</td>
<td>6(5.8)</td>
<td></td>
</tr>
<tr>
<td>16-18</td>
<td>2(66.7)</td>
<td>31(34.4)</td>
<td>10(90.9)</td>
<td>43(41.3)</td>
<td></td>
</tr>
<tr>
<td>&gt; 18</td>
<td>0(0.0)</td>
<td>54(60.0)</td>
<td>1(9.1)</td>
<td>55(52.9)</td>
<td></td>
</tr>
<tr>
<td>Whether had a homosexual sex before enrolling into school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1(33.3)</td>
<td>37(40.7)</td>
<td>6(54.5)</td>
<td>44(41.9)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2(66.7)</td>
<td>54(59.3)</td>
<td>5(45.5)</td>
<td>61(58.1)</td>
<td></td>
</tr>
<tr>
<td>Whether participated in parties for homosexuals before diagnosed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1(33.3)</td>
<td>18(20.0)</td>
<td>0(0.0)</td>
<td>19(18.3)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2(66.7)</td>
<td>72(80.0)</td>
<td>11(100.0)</td>
<td>85(81.7)</td>
<td></td>
</tr>
<tr>
<td>Whether attended courses related to HIV/AIDS organized by school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1(33.3)</td>
<td>15(16.9)</td>
<td>3(27.3)</td>
<td>19(18.4)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2(66.7)</td>
<td>74(83.1)</td>
<td>8(72.7)</td>
<td>84(81.6)</td>
<td></td>
</tr>
</tbody>
</table>

*There is missing data existed below.

A total of 26 participants (24 male and 2 female) reported that they had engaged in heterosexual intercourse before being diagnosed with HIV/AIDS, among which 5 students engaged in commercial sex (none for making money), 15 students engaged in casual sex, and 8 students engaged in regular sex. The most common venue for
commercial sex was a hotel (4 students), and all the commercial sexual encounters happened in the Zhejiang province. The casual partners were mainly strangers, except for 1 student who had both strangers and friends. The proportion of individuals who had consistently used condom with different partners in the preceding one year was less than 30% (Table 1).

About 39.5% (49/124) reported having tested for HIV before. The most common reason (46/75, 61.3%) for the rest who had not undergone testing for HIV was that “they never thought they might be infected with HIV one day.” Fifty-one students (41.1%) out of 130 had accepted face-to-face education by physicians, propagandists, community workers, partners/colleges, or volunteers. Fifty-four (43.6%) of the 124 students diagnosed with HIV were not familiar with the methods of preventing HIV. Fifty-seven (46.0%) of the 124 students thought they couldn’t be infected with HIV.

**Spatial analyses for HIV infection among students, 2011–2016**

Overall, 72 counties (80.1% of all 89 counties in Zhejiang) reported on HIV infection among students between 2011 and 2016. The number of affected counties had increased from 25 in 2011 to 42 in 2016. The county of Xiacheng, Shangcheng and Xihu in Hangzhou recorded more cases during the study period, with cases being 76, 73, and 65 (Fig. 2), respectively. General spatial autocorrelation showed that it was statistically significant for the number of HIV/AIDS at the county level during the study period except for the year of 2011. Moran’s I values ranged from 0.33 to 0.94 (Table 3), indicating that the cases of HIV/AIDS were not randomly distributed, but clustered. Furthermore, the local indicators of spatial association analysis
identified hotspots (High-High) and outliers of HIV/AIDS in Zhejiang province (Fig. 2). Hotspots were mainly concentrated in the city of Hangzhou and expanded in later years.

![Maps showing annually spatial distribution of HIV-infected students in Hangzhou City, 2011-2016 and the spatial distribution of cases in Zhejiang Province, 2016.]

**Figure 2.** The annually spatial distribution of HIV-infected students in Hangzhou City, 2011-2016 and the spatial distribution of cases in Zhejiang Province, 2016.

**Table 3.** The results of the spatial autocorrelation test on HIV/AIDS among students in Zhejiang Province, 2011–2016.

<table>
<thead>
<tr>
<th>Year</th>
<th>Moran' I</th>
<th>Z score</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0.11</td>
<td>1.70</td>
<td>P&gt;0.05</td>
</tr>
<tr>
<td>2012</td>
<td>0.59</td>
<td>8.92</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>2013</td>
<td>0.33</td>
<td>5.23</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>2014</td>
<td>0.39</td>
<td>6.13</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>2015</td>
<td>0.94</td>
<td>14.09</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>2016</td>
<td>0.73</td>
<td>10.54</td>
<td>P&lt;0.01</td>
</tr>
</tbody>
</table>
Discussion

Our study provides a relatively comprehensive assessment of the epidemiology of HIV among infected students. The proportion of students with HIV/AIDS increased during 2011 to 2016, although the characteristics of education, disease status and source of the infection stayed stable over time. Homosexual intercourse played a more important role among infected students compared with the entire HIV-infected population. The spatial distribution of infected students had expanded and was significantly clustered at the county level. In addition, we described the risky sexual behaviors of some newly diagnosed students in detail and noted that most of the cases had sexual encounters with casual partners.

Why was there an increased trend in the proportion of students with HIV/AIDS?
First of all, the number of young students who accepted HIV antibody testing sponsored by CDC from 2011 to 2016 has been a dramatic increase with 1600, 1600, 9571, 13582, 33306, and 26184, respectively. The active testing from 2011–2012 was mainly focused on two colleges for sentinel surveillance of young students which had expanded to eleven colleges since 2015. We also assigned tasks for CDC in each city to test for young students since 2013. Thus, the measures to promote testing among students and the targeted intervention strategies for students were not previously sufficient. Surveys towards the awareness rate of AIDS-related knowledge also showed large difference among regions ranged from 53.38% to ***95.7%[8,11,22].

Second, homosexual intercourse has been the main mode of transmission among HIV-infected students, as well as other provinces in China [16,23]. Surveys conducted in Liaoning, Beijing and Hefei showed that the HIV prevalence was 1.7%-3.0% among MSM students, which was over fifty times higher than the general Chinese population (0.057%) [24-27]. MSM students had been a vulnerable population for HIV infection. The results of our study showed that there was sexual networking between students, while it was originally thought that it was HIV-positive social members who transmitted the disease to students in school. Furthermore, students who graduated from high school were faced with the psychological transition [28]. Many of them were curious about the gay group and may have tried to have sex with members of this group. A population specific sentinel surveillance during 2010-2015 showed that the HIV antibody positivity rate increased from 5.73% to 7.98% in MSM [29]. However, previous studies in China revealed that condom use in this group was low [30,31], as
reported in our study, and other studies in the USA and Uganda\textsuperscript{[32,33]}, increasing their risk of exposure to HIV-positive partners. And the changes of the concept and behavior towards sex also contributed to the increase\textsuperscript{[34,35]}. A nationwide cross-sectional survey during 2010-2015 revealed that 8.3\% of 312,016 students were sexually active, which was an increase compared with the results before 2010\textsuperscript{[5,28]}.

It was shown that 109/124 (987.9\%) HIV-infected students engaged in casual sex. And the proportion of HIV-positive students being from active source named VCT remained steady ranged from 28.3\% to 35.3\% during the time. Nowadays, mobile smartphone applications with activated global positioning systems enable users to connect with other MSM efficiently at any time and in any place, and they were popular among students for seeking and contacting partners. These applications included not only the geosocial networking applications targeting MSM (Blued, Jack’d, etc.), but also the social media platforms (QQ, WeChat, and Momo) were facilitators of risky sexual behavior among students, as shown in our study. In a previous survey, over 80\% of young MSM indicated that they would be willing to participate in future HIV prevention programs delivered online or via smartphone applications\textsuperscript{[36]}. Darryl Lampkin conducted the implementation and evaluation of Grindr as an outreach and education platform in the Health System of San Mateo County, California, USA. It showed that Grindr outreach by Public Health in a suburban county seemed acceptable to MSM and led to a 14-fold increase in the number of MSM reached for counseling and education compared with a traditional outreach period\textsuperscript{[37]}. So, it is realizable and imperative to develop creative strategies to
address HIV prevention within the young MSM digital generation.

We found that most cases were located in the main city of Hangzhou. As Hangzhou is the capital of the Zhejiang Province, there are many existing universities, which serve as gathering places for students. Furthermore, Hangzhou is a city with a relatively high economic activity level. The MSM here may be more active than in other places. A molecular study among MSM who recently got infected with HIV-1 in Zhejiang Province revealed that the strains bearing the "stamp" of Hangzhou were distributed across the province. It was also pointed out that Hangzhou might play a central regional role in the intra-provincial spread of HIV which contributed to the formation of an interwoven complex network in the MSM population [38].

Furthermore, the frequency of condom use during the preceding one year of our study among individuals with different sexual behaviors was relatively low. The results of an online study revealed that in the preceding 3 months, 78% of HIV-positive gay men reported having engaged in anal sex with men (median number of partners, 3); 61% reported having engaged in condomless anal sex (CAS), and 39% reported having CAS with HIV-negative men or men with unknown status in three states in the U.S. [39]. Results about HIV transmission risk behavior among HIV-positive patients receiving antiretroviral therapy demonstrated that 62% of patients’ recent unprotected sexual acts involved HIV-negative men or those with unknown HIV status in KwaZulu-Natal, South Africa [40]. Therefore, it is necessary to carry out classified management to prevent and control the disease among infected people, and strengthen the intervention regarding sexual behaviors, as well as education about adherence to
medication targeting high-risk individuals.

The National Health and Family Planning Commission of the People’s Republic of China published a notification in 2015 about the establishment of a system of reporting the situation of HIV-infected students to further strengthen the prevention and control of HIV/AIDS in schools. This was aimed at building cooperation between the institutes of public health and the department of education, just as the Health and Family Planning Commission of Zhejiang Province allied with the education department \[41,42\]. It pointed out the importance of termly announcing the reporting situation of HIV-infected students to the departments of education, improving the coverage and objective for the prevention strategies, and strengthening the services of voluntary consultation testing and behavioral interventions. In our study, about one-third of the students tested HIV positive through VCT and most cases were passively detected. There is the need to set up more convenient and available VCT centers to encourage students to test.

Our results should be interpreted with the following limitations in mind. First, all the cases could have been under-reported as the surveillance was passive. Besides, the susceptible denominator for HIV/AIDS among students was unknown. The spatial analyses were calculated towards the absolute amount. Third, the detailed data collected from the local CDC was not complete, and only included some individuals detected from 2015 to 2016.

By the end of 2015, there were an estimated 40.4 million high school students and 34.5 million college school students in China \[43\]. More targeted and effective
intervention should be taken to prevent HIV transmission among these vulnerable students.

Acknowledgements

The authors thank medical staff and health practitioners who have contributed to the reporting and the investigation towards HIV-infected students in Zhejiang Province.
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