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HIV Incidence in Asia: A Review of Available Data and Assessment of the Epidemic

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Abstract

Rates of new HIV infections in Asia are poorly characterized, likely resulting in knowledge gaps about infection trends and the most important areas to target for interventions. We conducted a systematic review of peer-reviewed English language publications and conference abstracts on HIV incidence in thirteen countries – Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Taiwan, Thailand, and Vietnam. We obtained data on HIV incidence rate, incidence estimation method, population, and risk factors for incident infection. Our search yielded 338 unique incidence estimates from 70 published articles and 41 conference abstracts for eight countries. A total of 138 (41%) were obtained from prospective cohort studies and 106 (31%) were from antibody-based tests for recent infection. High HIV incidence rates were observed among commercial sex workers (0.4-27.8 per 100 person-years), people who inject drugs (0.0-43.6 per 100 person-years) and men who have sex with men (0.7-15.0 per 100 person-years). Risk factors for incident HIV infection include brothel-based sex work and cervicitis among commercial sex workers; young age, frequent injection use and sharing needles or syringes among people who inject drugs; multiple male sexual partners, receptive anal intercourse and syphilis infection among men who have sex with men. In the countries with available data, incidence rates were highest in key populations and varied widely by incidence estimation method. Established surveillance systems that routinely monitor trends in HIV incidence are needed to inform prevention planning, prioritize resources, measure impact, and improve the HIV response in Asia. **(AIDS Rev. 2013;15:67-76)**

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Key words

HIV. HIV incidence. HIV surveillance. Asia. Systematic review.

Introduction

To achieve the vision of an AIDS-free generation, with no new HIV infections and no AIDS-related deaths, effective HIV prevention efforts are needed globally. More than three decades since the start of the epidemic, HIV/AIDS continues to pose a challenge to public health. Although the greatest burden of disease is in sub-Saharan Africa, Asia ranks second highest in the number of people living with HIV (estimated at 4.8 million[1]), and the HIV epidemic in the region has largely been concentrated in key populations at higher risk of HIV exposure, including commercial sex workers (CSW), people who inject drugs (referred to as injection drug users, IDU), and men who have sex with men (MSM). Of the estimated 370,000 new cases of HIV in the region in the past year, the majority of infections were among these key populations[1]. A number of countries have adopted strategies to reduce the spread of HIV,

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including implementation of nationwide surveillance systems, establishment of effective prevention strategies among key populations, increasing access to HIV testing and linkage to comprehensive services, and providing care and treatment for people living with HIV. The importance of targeted prevention strategies is exemplified by Thailand's implementation of a national campaign promoting 100% condom use in all commercial sex establishments, which has contributed to the decreased rate of transmission of HIV and other sexually transmitted infections (STI) among commercial sex workers[2].

Although there are ample data on HIV prevalence in Asia, the rates of new HIV infections are poorly characterized in the region. Prospective cohort studies, where HIV-uninfected individuals are followed over a period of time until they seroconvert, is the gold standard measure of HIV disease incidence and provides reliable estimates of HIV incidence rates. Additional methods for estimating HIV incidence that are often applied in resource-limited settings include the use of prevalence trends among specific groups as a proxy for incidence trends in the general population[3,4], mathematical modeling using HIV surveillance data and assumptions around mortality[5], and laboratory detection of biomarkers of recent HIV infection in cross-sectional studies. Antibody-based laboratory assays, such as the less sensitive enzyme immunoassay (LS-EIA) and the BED-Capture Enzyme Immunoassay (BED-CEIA), have been used to estimate HIV incidence based on immunologic biomarkers of recent infection[6-8]. However, the accuracy of these incidence assays has been questioned in the literature as assay-derived incidence rates may overestimate actual incidence rates due to misclassification of some long-term infections as recent infections[9,10]. Recent development of laboratory assays with relatively low misclassification rates and ability to estimate incidence among HIV-positive persons on antiretroviral therapy may increase their application in HIV incidence estimation.

Given the length of time between infection with HIV and the onset of symptoms, many HIV cases are not diagnosed until late in the course of the disease, making the detection of recent HIV infections in resource-constrained settings a challenge[11]. Accurate incidence estimates in Asia are essential for monitoring the HIV/AIDS epidemic, identifying high-risk populations, informing HIV prevention efforts, evaluating HIV prevention programs, and guiding strategic planning for program managers[12].

HIV incidence rates in Asia: key populations at higher risk of exposure

A systematic review of studies on HIV incidence in Asia focused on 13 countries: Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Taiwan, Thailand and Vietnam (Fig. 1) over the past 30 years was performed (Fig. 2; see Supplementary data). Seventy publications and 41 conference abstracts on HIV incidence were retained, with most of the available data coming from Thailand (53 studies)[10,69-118,121,122], China (26 studies)[21-46] and India (17 studies)[47-63] (Fig. 3). No data were available for Bangladesh, Laos, Malaysia, Myanmar, and Singapore. The 111 included studies provided 338 unique HIV incidence estimates over the past 30 years. Of these, 138 (41%) estimates were obtained from prospective cohort studies, 106 (31%) from LS-EIA or BED-CEIA, 41 (12%) from cross-sectional studies not otherwise specified, 31 (9%) from retrospective cohort studies, and the rest from other estimation methods including mathematical modeling.

The number of studies on HIV incidence has increased over the past 30 years (Fig. 4), and prospective cohort studies are still the predominant method of determining HIV incidence. In the past decade, however, the use of antibody-based laboratory assays, LS-EIA and BED-CEIA, for detecting recent HIV infection saw a two-fold increase from eight to 16 studies.

Figure 5 displays HIV incidence among different groups. Among CSW, the highest HIV incidence rate was 27.8 per 100 person-years, based on a prospective cohort study from 1993-1995 in Pune, India[59]. The lowest incidence rate was 0.4 per 100 person-years in the Yunnan province of China in 2006 using BED-CEIA[23]. The most recent incidence rate available was 0.67 per 100 person-years in Vietnam in 2011, based on a cross-sectional study[124]. Of note, CSW refers to female sex workers except in a few studies that included data on male sex workers[70, 98], both male and female sex workers[52], and one study that did not specify the gender of the sex workers[88].

Among IDU, the highest reported HIV incidence rate was from a prospective cohort study in Northern Thailand from 2000-2003, with a rate of 43.6 per 100 person-years[99]. The lowest incidence rate was 0.0 per 100 person-years in Ning Ming province, China in 2008[40] and Ha Giang, Vietnam in 2011[40], both using BED-CEIA. The most recent incidence rate was 0.0 per 100 person-years in Ha Giang, Vietnam in 2011 using BED-CEIA[40].

For MSM, HIV incidence ranged from 0.7 per 100 person-years in Thailand in 2005 based on modeling[88] to 15.0 per 100 person-years in Taiwan in 2007 using

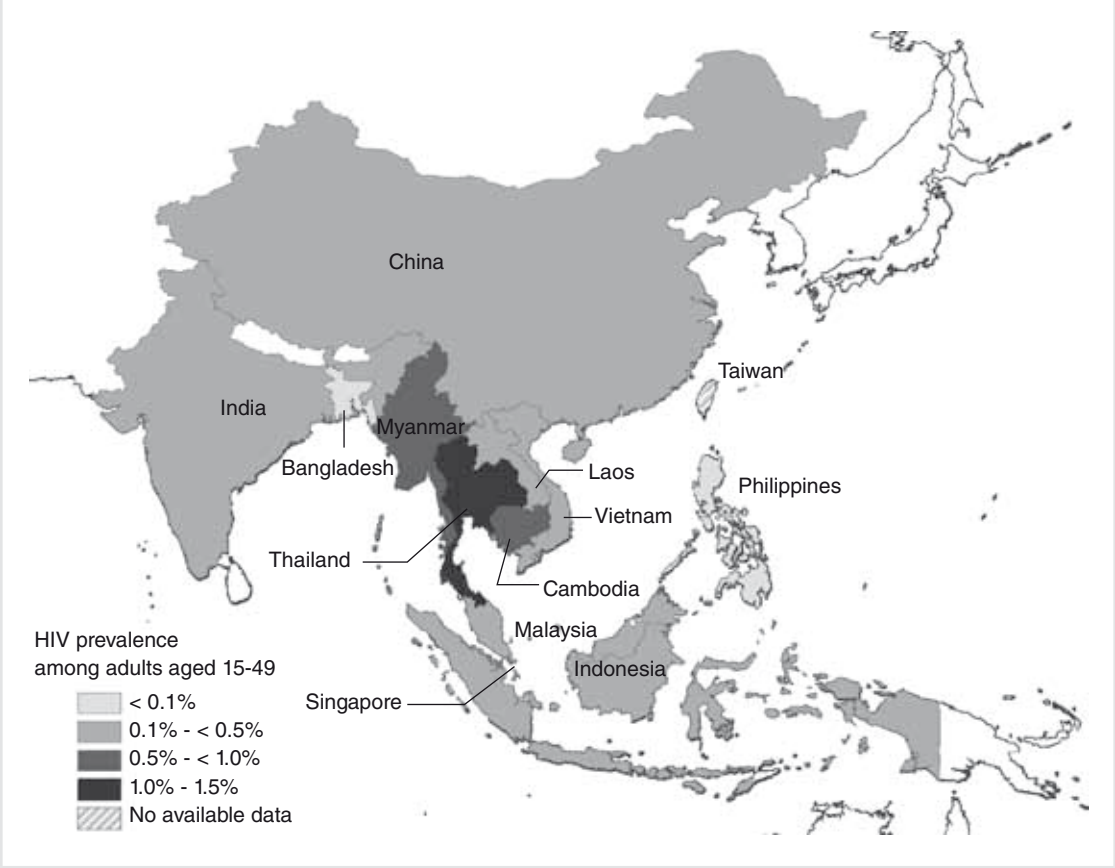

Figure 1. *Map of Asia showing HIV prevalence in focus countries (UNAIDS, 2011).*

BED-CEIA[67]. The most recent incidence rate available was 5.9 per 100 person-years from a prospective cohort study in Bangkok, Thailand in 2012[121].

Among STI clinic attendees, HIV incidence ranged from 0.2 per 100 person-years from a prospective cohort study in Thailand in 1999-2001[96] to 19.9 per 100 person-years in Pune, India in 1993-1994 using HIV-1 RNA testing of pooled sera[53]. The most recent incidence rate was 0.84 per 100 person-years in Guangxi Province, China in 2009 using BED-CEIA[39].

HIV incidence among bridge populations was lowest among clients of CSW in Thailand in 2005 at 0.05 per 100 person-years based on modeled estimates[88] and highest among fishermen in Cambodia in 2000 at 4.35 per 100 person-years using BED-CEIA[15]. The most recent incidence rates available were from Thailand in 2005: 0.7 per 100 person-years among partners of IDU[88], 0.4 per 100 person-years among female partners of MSM[88], and 0.05 per 100 person-years among clients of CSW[88], all based on modeling.

In the general population, the lowest incidence rate reported was 0.0 per 100 person-years from a prospective cohort study among adults aged 20-35 years in Northern Thailand from 1998-1999[97] and a cohort of women followed prospectively in Vietnam in 2009[123]. The highest incidence rate reported was 7.2 per 100 person-years among HIV-serodiscordant couples in Dehong Prefecture, China in 2007 based on BED-CEIA[21], and the most recent incidence rate available was 0.009 per 100 person-years from a prospective follow-up of repeat blood donors in China in 2010[44].

Risk factors for incident HIV infection in Asia

Few studies reported risk factors for incident HIV infection. The CSW who engage in brothel-based sex work, female sex workers who have ever had cervicitis, and those with a history of injection drug use had a higher risk of incident HIV infection. Among IDU, factors

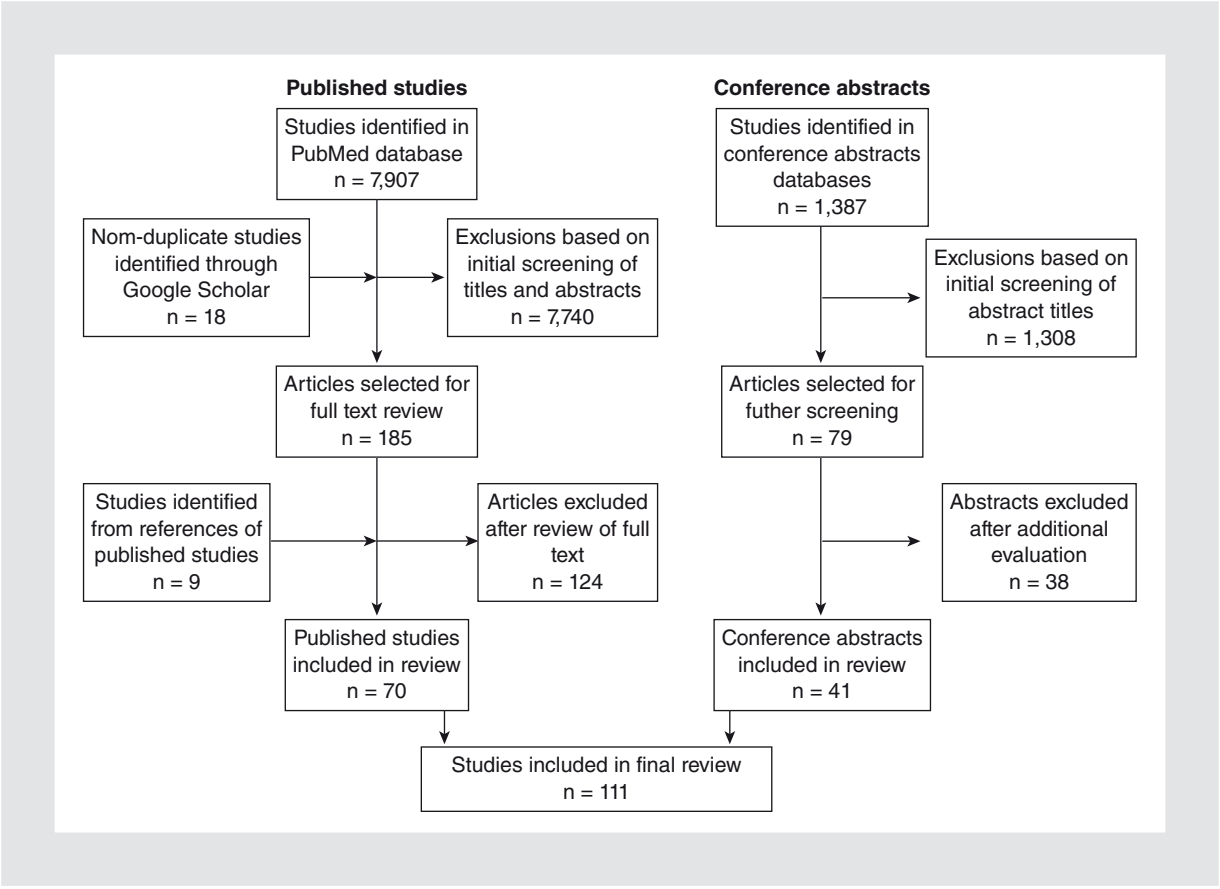

Figure 2. *Flowchart of studies included in review of HIV incidence in Asia.*

associated with an increased risk for new HIV infections were young age (< 25 years), frequent injection use, and sharing of needles or syringes. Factors associated with incident HIV infection among MSM include having multiple male sexual partners, engaging in receptive anal sexual intercourse, and a history of current or prior syphilis infection. The STI clinic attendees with a current or previous genital ulceration, a history of cervicitis or urethritis, or a CSW partner were at increased risk for HIV infection. In the general population, the most common risk factors for incident HIV infection include engaging in sex with a CSW, having multiple sexual partners, not using condoms consistently during sex, and having a recent genital ulceration.

HIV epidemic in Asia: future perspectives

Data on HIV incidence are necessary to fully characterize the HIV epidemic, identify hidden or masked epidemics, inform prevention efforts, guide funding allocation for programs, and evaluate HIV prevention interventions. The available data provide useful estimates of HIV incidence in key populations; however, this review indicates that studies on HIV incidence are not routinely conducted or published across many countries in Asia. Most of the available incidence estimates were concentrated in specific locations, resulting in an inability to estimate HIV incidence for many geographic areas or for specific populations. Almost 50% of the studies reviewed were from Thailand, 23% of the studies were from China, and India accounted for 15% of the studies in this review.

There was variability in the rates of HIV incidence among different populations, even within the same geographic location. However, there were insufficient incidence data available to estimate recent trends in specific populations, a critical data gap to monitor the HIV epidemic and strategically plan targeted interventions. Overall, high rates of incident HIV infections were observed among known at-risk populations including CSW, IDU, and MSM, although surveillance among these often hidden populations can be difficult. The STI clinic attendees also had higher estimates in comparison to the general population. There were limited

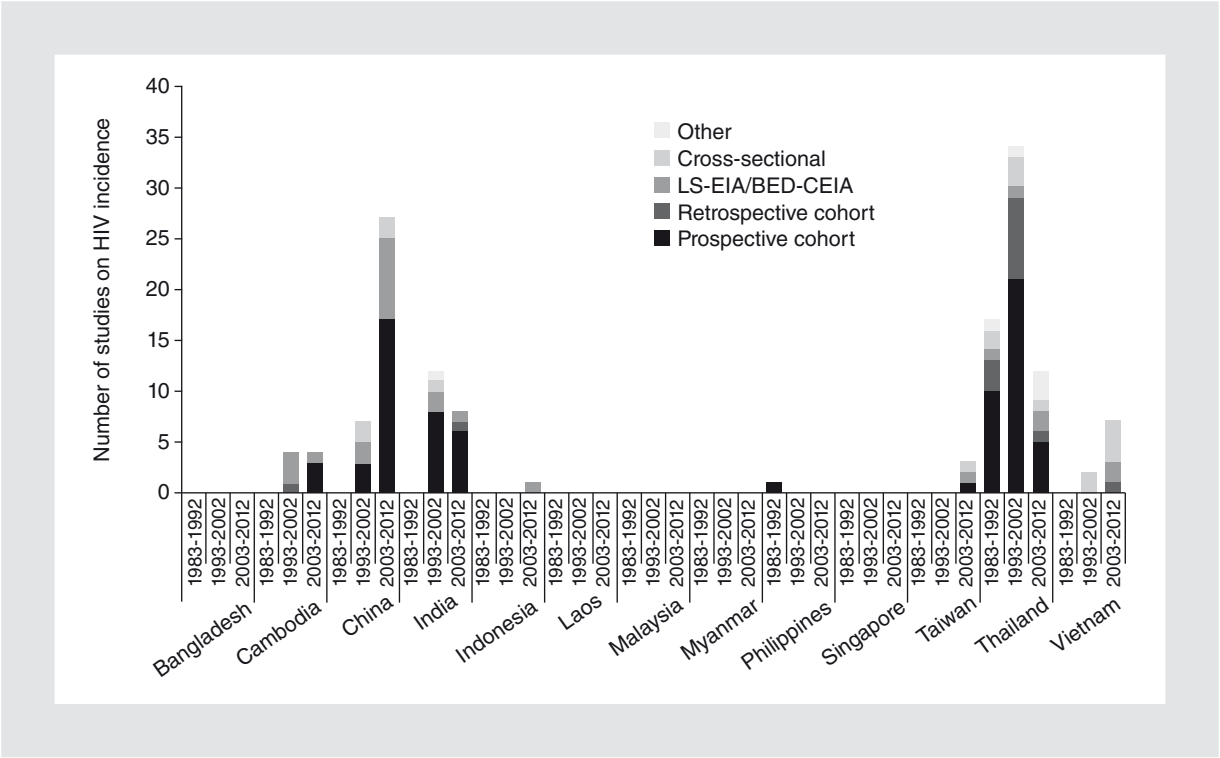

Figure 3. *Studies on HIV incidence in focus countries by incidence estimation method.*

data among bridge populations, a potential source of HIV transmission between high-risk groups and the general population. This indicates the need for established systems to monitor trends in this group, who have the potential to shift an epidemic from concentrated to generalized[119]. Routine data on the rates of new HIV infection among high-risk groups and the general population are needed, particularly data that are derived from direct measures of incidence.

Based on qualitative observations of HIV incidence estimates in Asia, patterns of declining HIV incidence were observed in all groups except among MSM, and also among the general population, particularly in China. However, a firm conclusion about these trends cannot be made without appropriate statistical analysis. These findings are consistent with recent reports of increasing HIV incidence among MSM in Asia[120,125], and a molecular epidemiology study showing a rise in HIV infections among general populations in China[126]. Additional incidence data are needed to clarify overall trends and characterize the current epidemic.

A few studies reported on risk factors for incident HIV infection, including the presence of a cervical infection among CSW, being of a young age (< 25 years), engaging in frequent injection use and sharing of needles or syringes among IDU, and having multiple male sexual partners, engaging in receptive anal sexual intercourse and having a history of current or prior syphilis infection among MSM. Most of these findings are consistent with known risk factors for HIV acquisition.

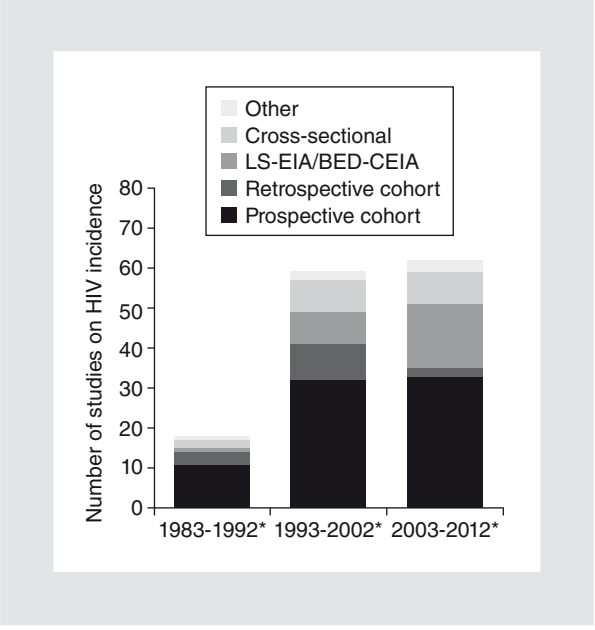

Figure 4. *Studies on HIV incidence in Asia by incidence estimation method. *Includes studies that overlap multiple time periods.*

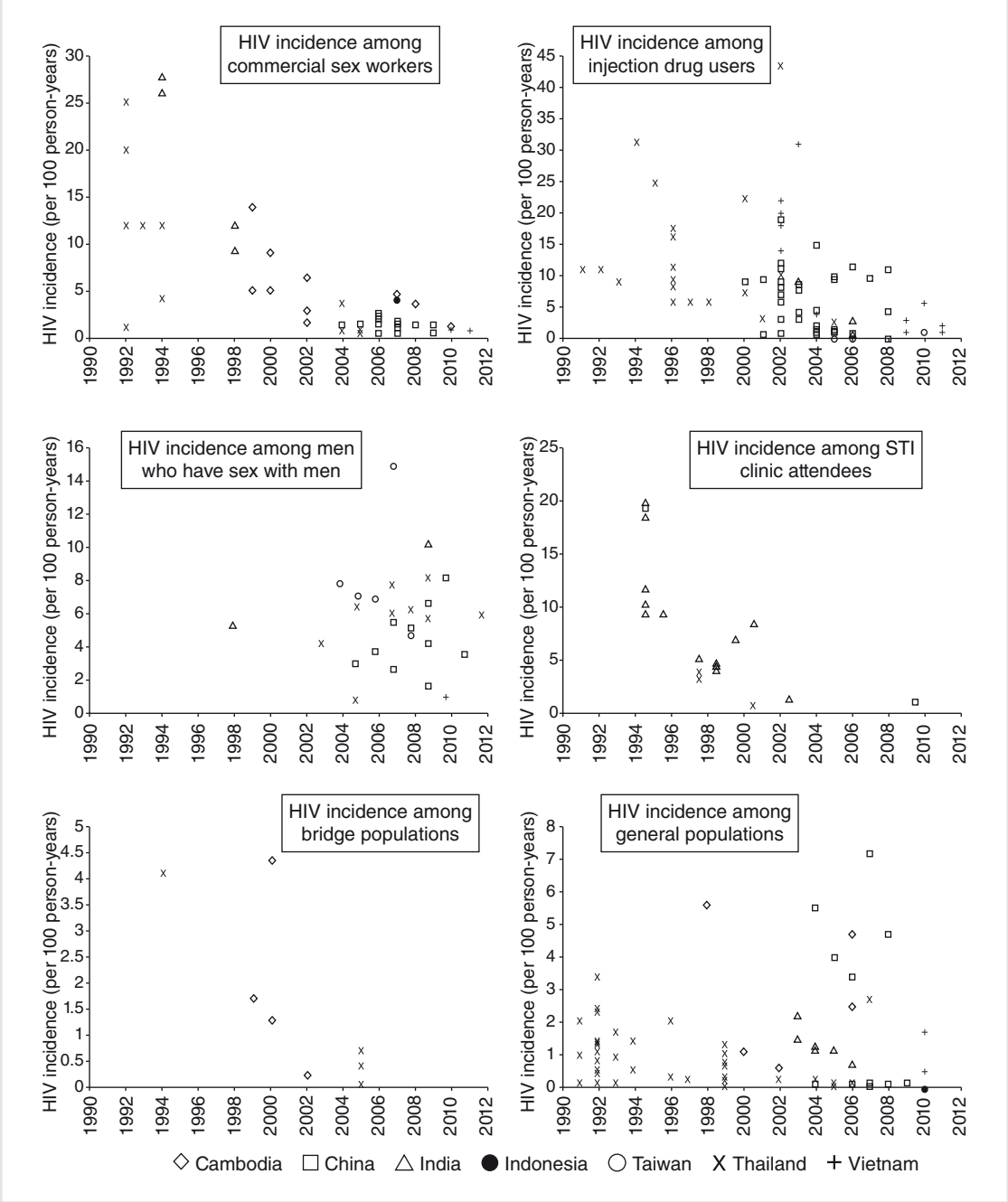

Figure 5. *HIV incidence rates in Asia by groups of risk and general population. STI: sexually transmitted infection.*

These identified risk factors for incident infections can be targeted by program managers, which should lead to more effective use of limited resources in preventing new HIV infections. Brothel-based sex work was reported to increase the risk of new HIV infections among CSW in Thailand[79]; however, the Thai government's implementation of the "100% condom program", which enforces mandatory condom use in commercial sex establishments, has been credited with contributing to the decline in HIV prevalence in the country[2].

There are a number of potential limitations in this review. The studies included in our review were restricted

to conference abstracts and English-language peer-reviewed publications, resulting in exclusion of valuable unpublished data from government and partner reports as well as non-English language publications. Another key limitation is the interpretation of data on HIV incidence by population over time. Given that each data point may not represent the same population over time but likely varies by factors that may impact incidence (e.g. age, gender, geographic location), we cannot make any conclusions on statistical trends, but are limited to qualitative assessments on the general tendency of the estimates. In addition, because incidence is a relatively rare event, incidence surveys require relatively large sample sizes for reliable estimates of incidence, which can be difficult to obtain in the resource-limited settings of many countries included in this review. Thus, while not specifically examined, it is likely that some of these studies were underpowered, limiting the utility of the incidence estimates that were generated. It is also important to note the limitations for estimating incidence by the various methodologies employed. In cohort studies, incidence estimates are subject to biases regarding selection of participants, individuals that continue follow-up, and the effect of interventions that may be carried out in the cohort. Mathematical models of incidence rely on assumptions about mortality and uptake of antiretroviral therapy, and also require quality data on HIV prevalence and population size estimates, which may not be consistently available or reliable. Consequently, minor variations inputted into the models can result in large variations in the incidence estimates.

There has been a rise in the use of enzyme immunoassays to detect recent HIV infection and estimate HIV incidence. For the LS-EIA and BED-CEIA, the proportion of known long-term HIV infections in a population that incorrectly classify as recent infections on the laboratory assay, the assay false-recent rate, is a critical parameter required to estimate HIV incidence[127]. Because the assay false-recent rate may vary by population, it is recommended that a false-recent rate measured with adequate precision be determined for each setting in which the assay is applied in order to generate unbiased estimates of HIV incidence[127]. Another critical parameter required to estimate incidence is the duration of recency (i.e. the mean time it takes for a specimen from an HIV-infected person to produce a non-recent test on the assay), which may also vary by population[128] and could result in an overestimate of true HIV incidence if the duration of recency applied was too low and an underestimate if the value was too high. While the validity of incidence estimates derived from incidence assays has been questioned[129-132], the antibody-based laboratory assays are less expensive and are appealing because they can provide quick, up-to-date information on where and among whom the infection is spreading, and have the potential to increase incidence testing with their widespread application[133].

In spite of the limitations of this review, the collation of data shows the pattern of new HIV infections in Asia over time, highlights the high incidence among key populations, and suggests that MSM continue to experience increasing rates of new HIV infections. This review of HIV incidence in Asia indicates that routine HIV incidence testing should be focused on key populations at higher risk of HIV exposure in order to provide a sensitive measure of the trends in new HIV infections, population risk behaviors and the impact of HIV prevention programs.

Conclusion

Asia accounts for the largest population of people living with HIV outside of sub-Saharan Africa, and the epidemic in the region continues to be concentrated in high-risk groups, as reflected in the high rates of HIV incidence among key populations, including CSW, IDU, and MSM. In the past 30 years, HIV incidence estimation in Asia has occurred in specific geographic areas in a few countries, without a clear strategy or routinely collected estimates.

The limited data available carries implications for HIV prevention on the continent and could potentially hinder an effective response to the epidemic globally. Monitoring recent HIV infections is critical for understanding the epidemic trajectory in the region and prioritizing resources in each country. Established surveillance systems that routinely monitor new infections using validated methods to estimate incidence are urgently needed, and these systems ideally should also have the ability to collect data on risk factors for recent infection. Identifying where and among whom new infections are occurring, as well as how these factors change over time, can help guide our response to the HIV epidemic in Asia and maximize the use of increasingly scarce resources.

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Supplementary data

Supplementary data is available at AIDS Reviews journal online (http://www.aidsreviews.com).

This data is provided by the author and published online to benefit the reader.

The contents of all supplementary data are the sole responsibility of the authors.

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Author contributions

E. Kainne Dokubo conducted the literature search, data abstraction, data interpretation and drafted the manuscript. Andrea Kim contributed to the study concept, literature search, data interpretation, and editing the manuscript. Linh-Vi Le was involved in the literature search, data abstraction, and data interpretation. Patrick Nadol was involved in the literature search, data abstraction, data interpretation and editing the manuscript. Dimitri Prybylski and Mitchell Wolfe developed the study concept and were involved in data interpretation and editing the manuscript. All authors approved the final content of the manuscript.

Competing interests

All authors declare no competing interests.

References

1. Joint United Nations Programme on HIV/AIDS. Global Report: UNAIDS Report on the Global AIDS Epidemic. Geneva, Switzerland: UNAIDS; 2012. Last accessed March 20, 2013. Available from: http://www.unaids.org/globalreport/global_report.htm.
2. Park L, Siraprapasiri T, Peerapatanapokin W, Manne J, Niccolai L, Kunanusont C. HIV transmission rates in Thailand: Evidence of HIV prevention and transmission decline. J Acquir Immune Defic Syndr. 2010;54:430-6.
3. Hallett T, Zaba B, Todd J, et al; ALPHA Network. Estimating incidence from prevalence in generalised HIV epidemics: methods and validation. PLoS Med. 2008;5:e80.
4. Ghys P, Kufa E, George M. Measuring trends in prevalence and incidence of HIV infection in countries with generalised epidemics. Sex Transm Infect. 2006;82(Suppl 1):i52-6.
5. Posner S, Myers L, Hassig S, Rice J, Kissinger P, Farley T. Estimating HIV incidence and detection rates from surveillance data. Epidemiology. 2004;15:164-72.
6. Hargrove J, Humphrey J, Mutasa K, et al. Improved HIV-1 incidence estimates using the BED capture enzyme immunoassay. AIDS. 2008;22:511-18.
7. McDougal J, Pilcher C, Parekh B, et al. Surveillance for HIV-1 incidence using tests for recent infection in resource-constrained countries. AIDS. 2005;19(Suppl 2):S25-30.
8. Parekh B, Kennedy M, Dobbs T, et al. Quantitative detection of increasing HIV type 1 antibodies after seroconversion: a simple assay for detecting recent HIV infection and estimating incidence. AIDS Res Hum Retroviruses. 2002;18:295-307.
9. Dobbs T, Kennedy S, Pau C, McDougal J, Parekh B. Performance characteristics of the immunoglobulin G-capture BED-enzyme immunoassay, an assay to detect recent human immunodeficiency virus type 1 seroconversion. J Clin Microbiol. 2004;42:2623-8.
10. Hu D, Vanichseni S, Mock P, et al. HIV type 1 incidence estimates by detection of recent infection from a cross-sectional sampling of injection drug users in Bangkok: use of the IgG capture BED enzyme immunoassay. AIDS Res Hum Retroviruses. 2003;19:727-30.
11. Diaz T, De Cock K, Brown T, Ghys P, Boerma J. New strategies for HIV surveillance in resource-constrained settings: an overview. AIDS. 2005;19(Suppl 2):S1-8.
12. Mahy M, Warner-Smith M, Stanecki K, Ghys P. Measuring the impact of the global response to the AIDS epidemic: challenges and future directions. J Acquir Immune Defic Syndr. 2009;52(Suppl 2):S152-9.
13. Saphonn V, Parekh B, Dobbs T, et al. Trends of HIV-1 seroincidence among HIV-1 sentinel surveillance groups in Cambodia, 1999-2002. J Acquir Immune Defic Syndr. 2005;39:587-92.
14. Kruy S, Glaziou P, Flye Sainte Marie F, Buisson Y. Incidence of HIV infection in consultants reviewed after a first negative test in an anonymous and free screening center at the Institut Pasteur of Cambodia, 1996-1999. Bull Soc Pathol Exot. 2001;94:415-17.
15. Truong H, Samnang P, Page-Shafer K, Louie B, McFarland W, Grant R. Concordance of STARHS and BED assays for identifying recent HIV infections in Cambodian fishermen. XV International AIDS Conference, Bangkok, 2004. [Abstract C10754].
16. Saphonn V, Mean C, Ly P, Sopheab H, Kaldor J, Detels R. Current estimate of HIV incidence in potential participants of HIV prevention trial in Cambodia. XV International AIDS Conference, Bangkok, 2004. [Abstract MoPeC3502].
17. SaphonnV, Shafer K, Kaldor J, et al. Risk factors and HIV incidence among voluntary counselling and testing site clients in Phnom Penh, Cambodia: 2006. 4th IAS Conference on HIV Pathogenesis, Treatment and Prevention, Sydney, 2007. [Abstract WEPDC02].
18. Page-Shafer K, Saphonn V, Phal K, et al. High incidence of HIV infection among young women in the sex and entertainment industry in Phnom Penh, Cambodia. XVII International AIDS Conference, Mexico City, 2008. [Abstract MOPE0288].
19. Couture M, Sansothy N, Sapphon V, et al. Young women engaged in sex work in Phnom Penh, Cambodia, have high incidence of HIV and sexually transmitted infections, and amphetamine-type stimulant use: new challenges to HIV prevention and risk. Sex Transm Dis. 2011;38:33-9.
20. Page K, Stein E, Sansothy N, Evans J, Couture M, Sichan K. High HIV and risk in Cambodian entertainment and sex workers: results from two prospective cohorts. XIX International AIDS Conference, Washington DC, 2012. [Abstract MOPE240].
21. Duan S, Shen S, Bulterys M, et al. Estimation of HIV-1 incidence among five focal populations in Dehong, Yunnan: a hard hit area along a major drug trafficking route. BMC Public Health. 2010;10:180.
22. Jiang Y, Wang M, Ni M, et al. HIV-1 incidence estimates using IgG-capture BED-enzyme immunoassay from surveillance sites of injection drug users in three cities of China. AIDS. 2007;21(Suppl 8):S47-51.
23. Xu J, Wang H, Jiang Y, et al. Application of the BED capture enzyme immunoassay for HIV incidence estimation among female sex workers in Kaiyuan City, China, 2006-2007. Int J Infect Dis. 2010;14:e608-12.
24. Lai S, Liu W, Chen J, et al. Changes in HIV-1 incidence in heroin users in Guangxi Province, China. J Acquir Immune Defic Syndr. 2001;26:365-70.
25. Li S, Zhang X, Li X, et al. Detection of recent HIV-1 infections among men who have sex with men in Beijing during 2005-2006. Chin Med J (Engl). 2008;121:1105-8.
26. Li D, Jia Y, Ruan Y, et al. Correlates of incident infections for HIV, syphilis, and hepatitis B virus in a cohort of men who have sex with men in Beijing. AIDS Patient Care STDS. 2010;24:595-602.
27. Ruan Y, Qin G, Liu S, et al. HIV incidence and factors contributed to retention in a 12-month follow-up study of injection drug users in Sichuan Province, China. J Acquir Immune Defic Syndr. 2005;39:459-63.
28. Ruan Y, Qin G, Yin L, et al. Incidence of HIV, hepatitis C and hepatitis B viruses among injection drug users in southwestern China: a 3-year follow-up study. AIDS. 2007;21:S39-46.
29. Ruan Y, Jia Y, Zhang X, et al. Incidence of HIV-1, syphilis, hepatitis B, and hepatitis C virus infections and predictors associated with retention in a 12-month follow-up study among men who have sex with men in Beijing, China. J Acquir Immune Defic Syndr. 2009;52:604-10.
30. Xiao Y, Jiang Y, Feng J, et al. Seroincidence of recent human immunodeficiency virus type 1 infections in China. Clin Vaccine Immunol. 2007;14:1384-6.
31. Wei L, Chen J, Rodolph M, et al. HIV Incidence, retention, and changes of high-risk behaviors among rural injection drug users in Guangxi, China. Substance Abuse. 2006;27:53-61.
32. Xu J, Zhang M, Brown K, et al. Syphilis and HIV seroconversion among a 12-month prospective cohort of men who have sex with men in Shenyang, China. Sex Transm Dis. 2010;37:432-9.
33. Yang H, Hao C, Huan X, et al. HIV incidence and associated factors in a cohort of men who have sex with men in Nanjing, China. Sex Transm Dis. 2010;37:208-13.

34. Zhang Y, Shan H, Trizzino J, et al. HIV incidence, retention rate, and baseline predictors of HIV incidence and retention in a prospective cohort study of injection drug users in Xinjiang, China. Int J Infect Dis. 2007;11:318-23.
35. Des Jarlais D, Kling R, Hammett T, et al. Reducing HIV infection among new injecting drug users in the China-Vietnam Cross Border Project. AIDS. 2007;21(Suppl 8):S109-14.
36. Yin L, Qin G, Ruan Y, et al. HIV incidence, retention rate, and changes of high-risk behaviors in a 6-month follow-up study of female sex workers in Sichuan Province, China. XVI International AIDS Conference, Toronto, 2006. [Abstract CDC0241].
37. Wang N, Xu J, Lu L, et al. Application of BED-CEIA and prospective cohort study for HIV incidence estimation among FSWs in Yunnan, China. 4th IAS Conference on HIV Pathogenesis, Treatment and Prevention, Sydney, 2007. [Abstract CDC047].
38. Hao C, Qin G, Qian H, et al. HIV incidence among injection drug users in Southwestern China: a 4-year follow-up cohort study. XVII International AIDS Conference, Mexico City, 2008. [Abstract CDC0149].
39. Li F, Shen S, Zhu J, et al. The finding of HIV-1 incidence surveillance in Guangxi, China, 2009. XVIII International AIDS Conference, Vienna, 2010. [Abstract THPE0299].
40. Hammett T, Des Jarlais D, Kling R, et al. Controlling HIV epidemics among injection drug users: eight years of Cross-Border HIV prevention interventions in Vietnam and China. PLoS One. 2012;7:e43141
41. Xu J, An M, Han X, et al. Prospective cohort study of HIV incidence and molecular characteristics of HIV among men who have sex with men (MSM) in Yunnan Province, China. BMC Infect Dis. 2013;13:3.
42. Peng Z, Yang H, Norris J, et al. HIV incidence and predictors associated with retention in a cohort of men who have sex with men in Yangzhou, Jiangsu Province, China. PLoS One. 2012;7:e52731.
43. Li D, Li S, Liu Y, et al. HIV incidence among men who have sex with men in Beijing: a prospective cohort study. BMJ Open. 2012;2:e001829.
44. Wang J, Liu J, Yao F, et al. Prevalence, incidence, and residual risks for transfusion-transmitted human immunodeficiency virus Types 1 and 2 infection among Chinese blood donors. Transfusion. 2012. [Epub ahead of print].
45. Wang H, Reilly K, Brown K, et al. HIV incidence and associated risk factors among female sex workers in a high HIV-prevalence area of China. Sex Transm Dis. 2012;39:835-41.
46. Hao C, Yan H, Yang H, et al. The incidence of syphilis, HIV and HCV and associated factors in a cohort of men who have sex with men in Nanjing, China. Sex Transm Infect. 2011;87:199-201.
47. Brookmeyer R, Quinn T, Shepherd M, Mehendale S, Rodrigues J, Bollinger R. The AIDS epidemic in India: a new method for estimating current human immunodeficiency virus (HIV) incidence rates. Am J Epidemiol. 1995;142:709-13.
48. Mehendale S, Ghate M, Kishore Kumar B, et al. Low HIV-1 incidence among married serodiscordant couples in Pune, India. J Acquir Immune Defic Syndr. 2006;41:371-3.
49. Mehendale S, Gupte N, Paranjape R, et al. Declining HIV incidence among patients attending sexually transmitted infection clinics in Pune, India. J Acquir Immune Defic Syndr. 2007;45:564-9.
50. Gupta P, Kingsley L, Sheppard H, et al. High incidence and prevalence of HIV-1 infection in high risk population in Calcutta, India. Int J STD AIDS. 2003;14:463-8.
51. Gupte N, Sastry J, Brookmeyer R, Phadke M, Bhosale R, Bollinger R. Declining HIV infection rates among recently married primigravid women in Pune, India. J Acquir Immune Defic Syndr. 2007;45:570-3.
52. Mehendale S, Rodrigues J, Brookmeyer R, et al. Incidence and predictors of human immunodeficiency virus type 1 seroconversion in patients attending sexually transmitted disease clinics in India. J Infect Dis. 1995;172:1486-91.
53. Quinn T, Brookmeyer R, Kline R, et al. Feasibility of pooling sera for HIV-1 viral RNA to diagnose acute primary HIV-1 infection and estimate HIV incidence. AIDS. 2000;14:2751-7.
54. Shepherd M, Gangakhedkar R, Sahay S, et al. Incident HIV infection among men attending STD clinics in Pune, India: pathways to disparity and interventions to enhance equity. J Health Popul Nutr. 2003;21:251-63.
55. Bollinger R, Shepherd M, Ghate M, et al. Declining HIV-1 incidence rates among high-risk persons in Pune, India: 1993-2002. XV International AIDS Conference, Bangkok, 2004. [Abstract MoPpC2016].
56. Meenakshi M, Sameer K, Christina L, Hemangi J, Maninder S. Estimation of HIV-1 incidence using serological testing algorithm for recent HIV seroconversion among men attending STI clinics in Mumbai, India. 10th CROI, Boston, 2003. [Abstract 906a].
57. Mehendale S, Kishore Kumar B, Ghate M, et al. Low HIV incidence in HIV sero-discordant couples in Pune, India. XV International AIDS Conference, Bangkok, 2004. [Abstract MoPeC3462].
58. Gupte N, Sastry J, Brookmeyer R, et al. BJ Medical College-Johns Hopkins University MTCT Study Group. Declining HIV infection rates among recently married, pregnant women in Pune, India. XVI International AIDS Conference, Toronto, 2006. [Abstract MOPE0538].
59. Bollinger R, Mehendale S, Gangakhedkar R, et al. National Cooperative Vaccine Development Groups for AIDS. HIV transmission in India: HIVNET update. 8th Conference on Advances in AIDS Vaccine Development, Bethesda, 1996. [Poster 101].
60. Shepherd M, Mehendale S, Paranjape R, et al. Stable HIV incidence over an 8-year period among male patients attending STD clinics in Pune India. XIV International AIDS Conference, Barcelona, 2002. [Abstract TuPeC4899].
61. Solomon S, Celentano D, Srikrishnan A, et al. Low HIV incidence and declining risk behaviors in a cohort of injection drug users in Chennai, India. 15th CROI, Boston, 2008. [Abstract 553].
62. Solomon S, Celentano D, Srikrishnan A, et al. Low incidences of human immunodeficiency virus and hepatitis C virus infection and declining risk behaviors in a cohort of injection drug users in Chennai, India. Am J Epidemiol. 2010;172:1259-67.
63. Das A, Narayanan P, Morineau G, Setia M, Rao G, Gangakhedkar R. High incidence of HIV and herpes simplex virus type-2 in an urban cohort of men who have sex with men in India. XIX International AIDS Conference, Washington DC, 2012. [Abstract MOPE271].
64. Morineau G, Magnani R, Nurhayati A, Bollen L, Mustikawati D. Is the bed capture enzyme immunoassay useful for surveillance in concentrated epidemics? The case of female sex workers in Indonesia. Southeast Asian J Trop Med Public Health. 2011;42:634-42.
65. Hayes C, Manaloto C, Basaca-Sevilla V, et al. Epidemiology of HIV infection among prostitutes in the Philippines. J Acquir Immune Defic Syndr. 1990;3:913-20.
66. Yen Y, Rodwell T, Yen M, et al. HIV infection risk among injection drug users in a methadone maintenance treatment program, Taipei, Taiwan 2007-2010. Am J Drug Alcohol Abuse. 2012;38:544-50.
67. Ko N, Lee H, Hung C, et al. Trends of HIV and sexually transmitted infections, estimated HIV incidence, and risky sexual behaviors among gay bathhouse attendees in Taiwan: 2004-2008. AIDS Behavior. 2011;15:292-7.
68. Yang C, Yang S, Shen M, Kuo H. The changing epidemiology of prevalent diagnosed HIV infections in Taiwan, 1984-2005. Int J Drug Policy. 2008;19:317-23.
69. Ananworanich J, Phanuphak N, de Souza M, et al. Incidence and characterization of acute HIV-1 infection in a high-risk Thai population. J Acquir Immune Defic Syndr. 2008;49:151-5.
70. Beyrer C, Brookmeyer R, Natpratan C, et al. Measuring HIV-1 incidence in northern Thailand: prospective cohort results and estimates based on early diagnostic tests. J Acquir Immune Defic Syndr Hum Retrovirol. 1996;12:495-9.
71. Celentano D, Nelson K, Lyles C, et al. Decreasing incidence of HIV and sexually transmitted diseases in young Thai men: evidence for success of the HIV/AIDS control and prevention program. AIDS. 1998;12:F29-36.
72. Carr J, Sirisopana N, Torugsa K, et al. Incidence of HIV-1 infection among young men in Thailand. J Acquir Immune Defic Syndr. 1994;7:1270-5.
73. Celentano D, Nelson K, Suprasert S, et al. Risk factors for HIV-1 seroconversion among young men in northern Thailand. JAMA. 1996;275:122-7.
74. Celentano D, Hodge M, Razak M, et al. HIV-1 incidence among opiate users in northern Thailand. Am J Epidemiol. 1999;149:558-64.
75. Choopanya K, Des Jarlais D, Vanichseni S, et al. Incarceration and risk for HIV infection among injection drug users in Bangkok. J Acquir Immune Defic Syndr. 2002;29:86-94.
76. Jittiwutikarn J, Sawanpanyalert P, Rangsiveroj N, Satitvipawee P. HIV incidence rates among drug users in northern Thailand, 1993-7. Epidemiol Infect. 2000;125:153-8.
77. Kawichai S, Beyrer C, Khamboonruang C, et al. HIV incidence and risk behaviours after voluntary HIV counselling and testing (VCT) among adults aged 19-35 years living in peri-urban communities around Chiang Mai city in northern Thailand, 1999. AIDS Care. 2004;16:21-35.
78. Kawichai S, Celentano D, Vongchak T, et al. HIV voluntary counseling and testing and HIV incidence in male injecting drug users in northern Thailand: evidence of an urgent need for HIV prevention. J Acquir Immune Defic Syndr. 2006;41:186-93.
79. Kilmarx P, Limpakarnjanarat K, Mastro T, et al. HIV-1 seroconversion in a prospective study of female sex workers in northern Thailand: continued high incidence among brothel-based women. AIDS. 1998;12:1889-98.
80. Kitayaporn D, Kaewkungwal J, Bejrachandra S, Rungroung E, Chandanayingyong D, Mastro T. Estimated rate of HIV-1-infectious but seronegative blood donations in Bangkok, Thailand. AIDS. 1996;10:1157-62.
81. Kitayaporn D, Uneklabh C, Weniger B, et al. HIV-1 incidence determined retrospectively among drug users in Bangkok, Thailand. AIDS. 1994; 8:1443-50.
82. Martin M, Vanichseni S, Suntharasamai P, et al; Bangkok Vaccine Evaluation Group. Drug use and the risk of HIV infection amongst injection drug users participating in an HIV vaccine trial in Bangkok, 1999-2003. Int J Drug Policy. 2010;21:296-301.
83. Natpratan C, Nantakwang D, Beyrer C, et al. Feasibility of northern Thai factory workers as participants in HIV vaccine trials. Southeast Asian J Trop Med Public Health. 1996;27:457-62.
84. Nelson K, Suriyanon V, Taylor E, et al. The incidence of HIV-1 infections in village populations of northern Thailand. AIDS. 1994;8:951-5.
85. Nopkesorn T, Mock P, Mastro T, et al. HIV-1 subtype E incidence and sexually transmitted diseases in a cohort of military conscripts in northern Thailand. J Acquir Immune Defic Syndr Hum Retrovirol. 1998; 18:372-9.

86. Hu D, Subbarao S, Vanichseni S, et al. Frequency of HIV-1 dual subtype infections, including intersubtype superinfections, among injection drug users in Bangkok, Thailand. AIDS. 2005;19:303-8.
87. Hu D, Subbarao S, Vanichseni S, et al. Higher viral loads and other risk factors associated with HIV-1 seroconversion during a period of high incidence among injection drug users in Bangkok. J Acquir Immune Defic Syndr. 2002;30:240-7.
88. Gouws E, White P, Stover J, Brown T. Short term estimates of adult HIV incidence by mode of transmission: Kenya and Thailand as examples. Sex Transm Infect. 2006;82(Suppl 3):51-5.
89. Sawanpanyalert P, Ungchusak K, Thanprasertsuk S, Akarasewi P. HIV-1 seroconversion rates among female commercial sex workers, Chiang Mai, Thailand: a multi cross-sectional study. AIDS. 1994;8:825-9.
90. Sawanpanyalert P, Supawitkul S, Yanai H, Saksoong P, Piyaworawong S. Trend of HIV incidence rates among drug users in an HIV epicenter in northern Thailand (1989-1997). J Epidemiol. 1999;9:114-20.
91. Sutcliffe C, Aramrattana A, Sherman S, et al. Incidence of HIV and sexually transmitted infections and risk factors for acquisition among young methamphetamine users in northern Thailand. Sex Transm Dis. 2009;36:284-9.
92. van Griensven F, Varangrat A, Wimonsate W, et al. Trends in HIV prevalence, estimated HIV incidence, and risk behavior among men who have sex with men in Bangkok, Thailand, 2003-2007. J Acquir Immune Defic Syndr. 2010;53:234-9.
93. Vanichseni S, Kitayaporn D, Mastro T, et al. Continued high HIV-1 incidence in a vaccine trial preparatory cohort of injection drug users in Bangkok, Thailand. AIDS. 2001;15:397-405.
94. Verachai V, Phutiprawan T, Sawanpanyalert P. HIV infection among substance abusers in Thanyarak Institute On Drug Abuse, Thailand, 1987-2002. J Med Assoc Thai. 2005;88:76-9.
95. Xu F, Kilmarx P, Supawitkul S, et al. Incidence of HIV-1 infection and effects of clinic-based counseling on HIV preventive behaviors among married women in northern Thailand. J Acquir Immune Defic Syndr. 2002;29:284-8.
96. Salata R, Cornelisse P, Chipato T, et al. Prevalence and incidence of HIV and sexually transmitted infections (STI) among young women in Thailand, Uganda and Zimbabwe participating in the hormonal contraception and risk of HIV acquisition cohort. XIV International AIDS Conference, Barcelona, 2002. [Abstract ThPeC7413].
97. Khamboonruang C, Natpratan P, Borwornsin S, et al. Sustained low HIV-1 incidence among cohorts of young northern Thai adults: Confirmation of Thailand's success in HIV prevention. XIII International AIDS Conference, Durban, 2000. [Abstract ThOrC671].
98. Beyrer C, Kunawararak P, Natpratan C, et al. The role of same-sex behavior in the HIV epidemic among northern Thai men. XII International AIDS Conference, Geneva, 1998. [Abstract 13136].
99. Beyrer C, Tovanabutra S, Vongchak T, et al. Incident HIV-1 infections among a cohort of northern Thai drug users, 2000-2003: implications for HIV vaccine trials and preventive interventions. 11th CROI, San Francisco, 2004. [Abstract 858].
100. Limpakarnjanarat K, Mastro T, Saisorn S, et al. Incidence of HIV-1 subtype E in a cohort of female prostitutes in northern Thailand. X International AIDS Conference, Yokohama, 1994. [Abstract PC0365].
101. Suriyanon V, Razak M, Rungruengthanakit K, et al. The incidence of HIV and hepatitis C, and their association among drug users in Northern Thailand. XIV International AIDS Conference, Barcelona, 2002. [Abstract ThPeC7507].
102. Rangsin R, Piyaraj P, Sirisanthana T, Sirisopana N, Short O, Nelson K. HIV incidence among young Thai men 10-12 years after discharge from the Royal Thai army. XVI International AIDS Conference, Toronto, 2006. [Abstract CDC0383].
103. Rangsin R, Chiu J, Sirisopana N, et al. HIV incidence among young Thai men 4-6 years after discharge from Royal Thai Army. XIII International AIDS Conference, Durban, 2000. [Abstract MoPpC1032].
104. Beyrer C, Khamboonruang C, Natpratan C, et al. Community cohorts for HIV-1 vaccine trials in northern Thailand; the Thai HIVNET/WRAIR collaboration. XII International AIDS Conference, Geneva, 1998. [Abstract 33212].
105. Choopanya K, Tappero J, Pitisuttithum P, et al. Preliminary results of a phase III HIV vaccine efficacy trial among injecting drug users in Thailand. XV International AIDS Conference, Bangkok, 2004. [Abstract ThOrA1427].
106. Celentano D, Razak M, Short O, et al. Incidence of HIV and risk behavior change in a drug user cohort in northern Thailand. XIII International AIDS Conference, Durban, 2000. [Abstract MoPpC1107].
107. Kawichai S, Nelson K, Khamboonruang C, et al. Risk behaviors and HIV incidence in villagers aged 20-35 who previously tested negative in northern, Thailand. XIII International AIDS Conference, Durban, 2000. [Abstract ThPeD5788].
108. Khamboonruang C, Beyrer C, Natpratan C, Eiumtrakul S, Celentano D, Nelson K. HIV incidence in adults in northern Thailand. XI International AIDS Conference, Vancouver, 1996. [Abstract We.C.220].
109. Bond K, Na Chiang M, Vaddhanaphuti C, Eiumtrakul S, Nelson K, Celentano D. Behavioral intervention for Thai Army conscripts may reduce HIV incidence. X International AIDS Conference, Yokohama, 1994. [Abstract 032D].
110. Celentano D, Razak M, Jittiwutikarn J, et al. HIV incidence and behavior change in a prospective cohort study of drug users in northern Thailand. XIV International AIDS Conference, Barcelona, 2002. [Abstract ThOrC1395].
111. Supawitkul S, Saksoong P, Sawanpanyalert P, Piyaworawong S, Yanai H. Trend of HIV incidence among drug users in an HIV epicenter in northern Thailand, 1989-1997. XII International AIDS Conference, Geneva, 1998. [Abstract 583/23198].
112. Plipat T, Teeraratkul A, Chalermchan W, et al. National HIV incidence surveillance using BED capture immunoassay among pregnant women and female sex workers, Thailand. XVI International AIDS Conference, Toronto, 2006. [Abstract CDC0356].
113. Celentano D, Jittiwutikarn J, Razak M, et al. HIV incidence among drug users in northern Thailand is limited to injectors. XV International AIDS Conference, Bangkok, 2004. [Abstract WePeC5982].
114. van Griensven F, Wimonsate W, McNicholl J, et al. Continuing high HIV incidence in a cohort of men who have sex with men: Bangkok, Thailand. 16th CROI, Montreal, 2009. [Abstract 1037b].
115. Sinthuwattaniwibool C, Wasinrapee P, Chaowanachan T, et al. Application of the BED-CEIA to a cohort of military conscripts in Northern Thailand to estimate HIV-1 incidence: a validation study. 12th CROI, Boston 2005. [Abstract 731].
116. Wimonsate W, Chaikummao S, Tongtoyai J, et al. Trends in HIV and T. pallidum (TP) prevalence and incidence among men who have sex with men (MSM) attending the Silom Community Clinic (SCC), Bangkok, Thailand, 2005-2009. XVIII International AIDS Conference, Vienna, 2010. [Abstract CDC0368].
117. Kana K, Tabprasit S, Chaitaveep P, Tienamporn P, Chuenchitra T. HIV-1 incidence estimates among Royal Thai Army conscripts: use of the IgG-capture BED-enzyme immunoassay. XVII International AIDS Conference, Mexico City, 2008. [Abstract CDC0142].
118. van Griensven F, Thienkrua W, McNicholl J, et al. Three years of follow-up in the Bangkok MSM cohort study: evidence of an explosive epidemic of HIV infection. : XVIII International AIDS Conference, Vienna, 2010. [Abstract TUAC0301].
119. Shah N, Shiraishi R, Subhachaturas W, et al. Bridging populations-sexual risk behaviors and HIV prevalence in clients and partners of female sex workers, Bangkok, Thailand 2007. J Urban Health. 2011;88:533-44.
120. van Griensven F, de Lind van Wijngaarden J. A review of the epidemiology of HIV infection and prevention responses among MSM in Asia. AIDS. 2010;24(Suppl 3):S30-40.
121. van Griensven F, Thienkrua W, McNicholl J, et al. Evidence of an explosive epidemic of HIV infection in a cohort of men who have sex with men in Bangkok, Thailand. AIDS. 2012. [Epub ahead of print].
122. Chariyalertsak S, Kosachunhanan N, Saokhieo P, et al. HIV incidence, risk factors, and motivation for biomedical intervention among gay, bisexual men, and transgender persons in Northern Thailand. PLoS One. 2011;6:e24295.
123. Sexton C, Costenbader E, Vinh D, et al. Correlation of prospective and cross-sectional measures of HIV type 1 incidence in a higher-risk cohort in Ho Chi Minh City, Vietnam. AIDS Res Hum Retroviruses. 2012; 28:866-73.
124. Thanh D, Tuan N, Thang P, et al. Estimating HIV incidence using behavioral proxies among key populations in seven sentinel provinces in Viet Nam in 2010 and 2011. XIX International AIDS Conference, Washington DC, 2012. [Abstract TUPE208].
125. Zhang M, Chu Z, Wang H, Xu J, Lu C, Shang H. A rapidly increasing incidence of HIV and syphilis among men who have sex with men in a major city of China. AIDS Res Hum Retroviruses. 2011;27:1139-40.
126. Yao X, Wang H, Yan P, et al. Rising epidemic of HIV-1 infections among general populations in Fujian, China. J Acquir Immune Defic Syndr. 2012;60:328-35.
127. UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance. When and how to use assays for recent infection to estimate HIV incidence at a population level. Geneva, Switzerland: UNAIDS/WHO; 2011. Last accessed 23 March 2013. Available from: http://whqlibdoc.who.int/publications/2011/9789241501675_eng.pdf.
128. Parekh B, Hanson D, Hargrove J, et al. Determination of mean recency period for estimation of HIV type 1 Incidence with the BED-capture EIA in persons infected with diverse subtypes. AIDS Res Hum Retroviruses. 2011;27:265-73.
129. Brookmeyer R. Should biomarker estimates of HIV incidence be adjusted? AIDS. 2009;23:485-91.
130. Guy R, Gold J, Calleja J, et al; WHO Working Group on HIV Incidence Assays. Accuracy of serological assays for detection of recent infection with HIV and estimation of population incidence: a systematic review. Lancet Infect Dis. 2009;9:747-59.
131. Kim A, McDougal J, Hargrove J, et al. Evaluating the BED capture enzyme immunoassay to estimate HIV incidence among adults in three countries in sub-Saharan Africa. AIDS Res Hum Retroviruses. 2010;26: 1051-61.
132. Sakarovitch C, Rouet F, Murphy G, et al. Do tests devised to detect recent HIV-1 infection provide reliable estimates of incidence in Africa? J Acquir Immune Defic Syndr. 2007;45:115-22.
133. Incidence Assay Critical Path Working Group. More and Better Information to Tackle HIV Epidemics: Towards Improved HIV Incidence Assays. PLoS Med. 2011;8:e1001045.