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Spatial clusters of AIDS in Indonesia

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KEYWORDS
AIDS;
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Cluster analysis

Abstract
Objective: This study seeks to determine whether distinctive clusters of case rates, number of new cases, treatment types, and other socio-demographic characteristics exist among provinces in Indonesia. Hierarchical Agglomerative and k-means clustering techniques are used to empirically derive the patterns of AIDS among Indonesian provinces by forming clusters of provinces with similar characteristics.
Methods: Cluster analysis is used to segment the Indonesian provinces in terms of how their rates of medical care and number of new cases of AIDS vary with respect to the socio-economic characteristics and sustainable health system of the province. Data from the 2011 *Statistik Indonesia* (2014–2015) and the 2006 Governance and Decentralization Survey were used.
Results: Cluster analysis yielded three distinct clusters: the high incidence rates and moderately high case rates cluster, the low case and incidence rates cluster, and the high case and incidence rates cluster.
Conclusion: Addressing the socioeconomic, demographic, and health inequalities that exist among the provinces should be a priority. Preventive interventions should consider provincial poverty and illiteracy rates, the population and its density, the type of self-treatment sought, the unmet need for healthcare services, the density of medical professionals, as well as the number of opportunistic infections.

Introduction

During the early 1980s, Asia countries seemed to have little cause for concern with regards to the Acquired Immune Deficiency Syndrome (AIDS) [1]. Prior to 1988, the reported AIDS cases were mainly concentrated among hemophiliacs and men who had sex with other men and tests conducted among these individuals suggest that the infection levels of the human immunodeficiency virus (HIV) rarely exceeded one percent of any group [11,13]. The early political and social responses to the disease often focused on marginalized populations like homosexuals and IV drug users [8]. Even during the early 21st century, AIDS-related deaths in Southeast Asia (23 per 1000 persons) is only nearly 50 percent of that of the World average [17].

During the mid-1980s, HIV cases in Indonesia were concentrated among sex workers, homosexual men, and transvestites [26]. The prevalence of HIV in Indonesia throughout

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most of the 1990s was low with minimal increases in the rate of infection [7]. In a trajectory that mirrors Thailand and India, Indonesia experienced a surge in the number of HIV infection and AIDS cases. This increase could largely be attributed to unprotected/unsafe sex and injection drug use [26].

The growing number of HIV and AIDS cases was addressed in numerous ways. Following the identification of an HIV positive foreign tourist in Bali in 1987, the Indonesian government initiated a systematic sentinel surveillance of sex workers in Jakarta and Surabaya the following year [7]. A year later, the Indonesia's Ministry of Health established the National AIDS Committee which was comprised of multi-sectorial and non-governmental organization (NGO) representatives. The Indonesian government has shown increased commitment to HIV and AIDS prevention and reduction, particularly following the Asian Economic Crisis. With financial assistance from the United State (USAID), Australia (AusAID), United Kingdom (DFID), and Germany (KfW), the Setani Commitment was implemented to target provinces with the highest rates of HIV and AIDS (e.g. DKI Jakarta, Riau, Bali, East Java, West Java, and Papua) [20,26]. To date, AIDS prevention efforts focused primarily on encouraging condom use, harm reduction, antiretroviral (ARV) treatment, and promoting other types of AIDS education under the Information, Education, and Communication initiative (IEC) [26]. These efforts mainly targeted sex workers and their clients or partners, homosexual men, and injection drug users (IDUs) as well as people living with HIV (PLHIV) and their partners [26]. Between 2007 and 2010, more than 200 Voluntary Counseling and Testing (VCT) centers were established in 118 cities and districts across the country [20]. These counseling, testing and outreach services are provided by the government, the private sector, and NGOs [26].

Unfortunately, the number of PLHIVs needing treatment far exceeded the number of individuals who actually receive treatment [20,27]. In addition, treatment for opportunistic infections and the provision of second line ARV were not part of these initiatives [20,27]. The progress of prevention, intervention, and care is also hampered by social stigma as people who are most at risk refrain from getting tested [26].

Review of relevant literature

In Indonesia, HIV and AIDS related studies focus mainly on program evaluation [7,26] and the genetic characterization of the HIV virus [22]. In other countries, studies tend to focus on health and socioeconomic inequality among HIV positive or infected individuals. Much of the work conducted in many European countries and in China and Argentina examining the risk factors and outcomes of HIV and AIDS have been conducted at the individual or patient-level [3,4,15,18,19,21,23,28]. To my knowledge, only five studies conducted in Canada, the United States, and Switzerland take regional characteristics into account [5,12,14,16,23]. Three of these studies focus on neighborhood-level socioeconomic characteristics [12,14,16] while the other two focus on neighborhood residential patterns and HIV prevalence [5,23]. Studies in North America find a positive association between neighborhood-level poverty and the risk of death in HIV-infected patients after taking age, clinical, and treatment variables into account [14,16]. Similarly, evidence in Switzerland suggests that mortality among HIV-positive individuals varies according to the socio-economic position (SEP) of neighborhoods [12].

To fill this research gap, this study seeks determine whether distinctive clusters of case rates, number of new cases, treatment types, and other socio-demographic characteristics exist among provinces in Indonesia. Hierarchical Agglomerative and k-means clustering techniques are used to empirically derive the patterns of AIDS among Indonesian provinces by forming clusters of provinces with similar characteristics. Maps created through ArcGIS software are also used in conjunction with the cluster analysis to visualize the data. Taking multiple provincial contexts into account can add value to the existing literature examining AIDS and HIV infection because little is known about how the rates of medical care and the number of new cases of AIDS varies with respect to the socio-economic characteristics and sustainable health system of the province in most developing countries, Indonesia included. Given the delineation of its provinces into distinct clusters, health policy-makers and practitioners can design and customize their delivery approaches for different segments of the population to reduce health burdens associated with HIV and AIDS.

Methods

Data

Data on case rates, number of new cases, population, population density, inequality, poverty, illiteracy, self-treatment, as well as the number of opportunistic infections (i.e. tuberculosis and pneumonia) were obtained from the *Statistik Indonesia*, an institution that collects data that describe the conditions of Indonesia across multiple indicators. A description of the dataset can be found at the institution's public domain. Data on unmet need for tuberculosis treatment services, the credentials of *Puskesmas* heads, and the density of medical professionals were obtained from a World Bank report [24] that used information from the 2006 Governance and Decentralization Survey.

Measures

The *case rates* refer to the number of AIDS cases per 100,000 persons. The *incidence rates* refer to the number of new AIDS cases in 2011. Both population and population density are continuous variables. The degree of *inequality* is measured by the 2013 Gini ratio of the province. *Poverty* is measured by the percentage of poor people in 2011. *Illiteracy rates* are represented by the percentages of illiterate individuals who are 10 and older in 2011. Measures for *self-treatment* are the percentages of individuals who used modern and traditional self-treatment in 2011. *Unmet need for health services* is represented as the proportion of inpatient and outpatient tuberculosis services that are unavailable at the *Puskesmas* level in 2006. The *credentials of Puskesmas heads* is measured as the proportion of head *Puskesmas* with higher education. The *density of medical professionals* is represented as the ratio of doctors/midwives per 100,000 people. Because tuberculosis and pneumonia occur commonly among individuals with AIDS and

Fig. 1 Spatial clusters of AIDS in Indonesia, *Statistik Indonesia*.

those who are HIV-infected, [2,9] the *number of opportunistic infections* is measured as the number of tuberculosis and pneumonia cases.

Analytic strategy

Both Hierarchical Agglomerative and k-means clustering techniques were used to segment Indonesian provinces based on case rates, number of new cases, population, population density, inequality, poverty, illiteracy, self-treatment, the number of opportunistic infections, unmet need for tuberculosis treatment services, the credentials of *Puskesmas* heads, and the density of medical professionals. Hierarchical Agglomerative Clustering was used first to generate centroids of the hierarchical clusters. The centroids of these clusters were then used as initial seeds for the k-means clustering. Analysis is conducted using Statistical Analysis System (SAS) software version 9.4.

Results

Cluster analysis yielded three distinct clusters based on the above-mentioned characteristics (see Fig. 1 and Appendix 1). Provinces in all three clusters have moderate levels of inequality (Gini ratios ranging between 0.38 and 0.39). The first group of provinces constitutes the *high incidence rates and moderately high case rates* cluster. There are 10 provinces in this cluster. Poverty rates are relatively lower for the provinces located in this cluster. The number of new cases (incidence rates) are relatively higher for provinces located in this cluster, partly because a few of these provinces have relatively high populations and population densities (e.g. Jakarta and Eastern and Central Java). The unmet need for outpatient tuberculosis for both outpatient and inpatient treatment services are lower than the other two clusters. On average, provinces located in this cluster have relatively higher ratios of doctors while the reverse is true for the ratios of midwives.

The second group of provinces constitutes the *low case and incidence rates* cluster. There are 17 provinces in this cluster. Provinces located in this cluster have the lowest case and incidence rates. The unmet need for outpatient tuberculosis treatment services is substantially lower than the other two clusters while the reverse is true for inpatient tuberculosis treatment services (See Fig. 2). Fig. 2 also illustrates that the percentages of modern self-treatment usage for provinces located in this cluster are somewhat higher than the provinces located in Cluster 3 but the reverse is true for the usage of traditional self-treatment usage for provinces located in this cluster are somewhat lower than provinces located in Cluster 3. On average, provinces located in this cluster have the lowest ratios of doctors.

The third group of provinces constitutes the *high case and incidence rates* cluster. There are six provinces in this cluster. On average, compared to the other two clusters, the population density for this cluster is relatively lower and poverty and illiteracy rates are somewhat higher for the provinces located in this cluster. A somewhat lower percentage of the population in the provinces located in this cluster used modern self-treatment for AIDS while the reverse is true for the usage of traditional self-treatment for AIDS (see Fig. 2). The ratios of doctors are somewhat higher for provinces located in this cluster than provinces located in the second cluster. However, the ratios of midwives are substantially higher for provinces located in this cluster when compared to the other two clusters. On average, provinces located in this cluster have relatively higher unmet need for outpatient tuberculosis treatment than provinces located in the other two clusters.

Conclusion

Even though Indonesia signed the Millennium Development Goals and UNAGSS Declaration of Commitments, coordinating a national response to stop new HIV infections and to reverse the AIDS epidemic has not been a top priority of the Indonesian government [26]. Understanding the patterns and dynamics of sexual lifestyle remain a challenge for the HIV prevention programs in Indonesia [10].

The sustainability of efforts is questioned because the Indonesian government relies heavily on foreign aid and the contributions from these donors are volatile and unpredictable [26]. Predictions by epidemiologists suggest that, in the 2015, the number of HIV infection cases is expected to increase to 1 million while AIDS-related deaths are expected to reach 350,000 if the Indonesian government does not scale up its response in the near future [20]. Results from the cluster analysis suggest that priority should be given to provinces characterized by *high incidence rates and moderately high case rates* (Cluster 1) and *high case rates high incidence rates* (Cluster 3). As reported in Table 1, provinces located in Cluster 3 are characterized by high case rates for AIDS and provinces located in Cluster 1 are characterized by high incidence rates for AIDS. The numbers of tuberculosis and pneumonia cases are also relatively higher for provinces located in Cluster 1. Population densities are also higher for

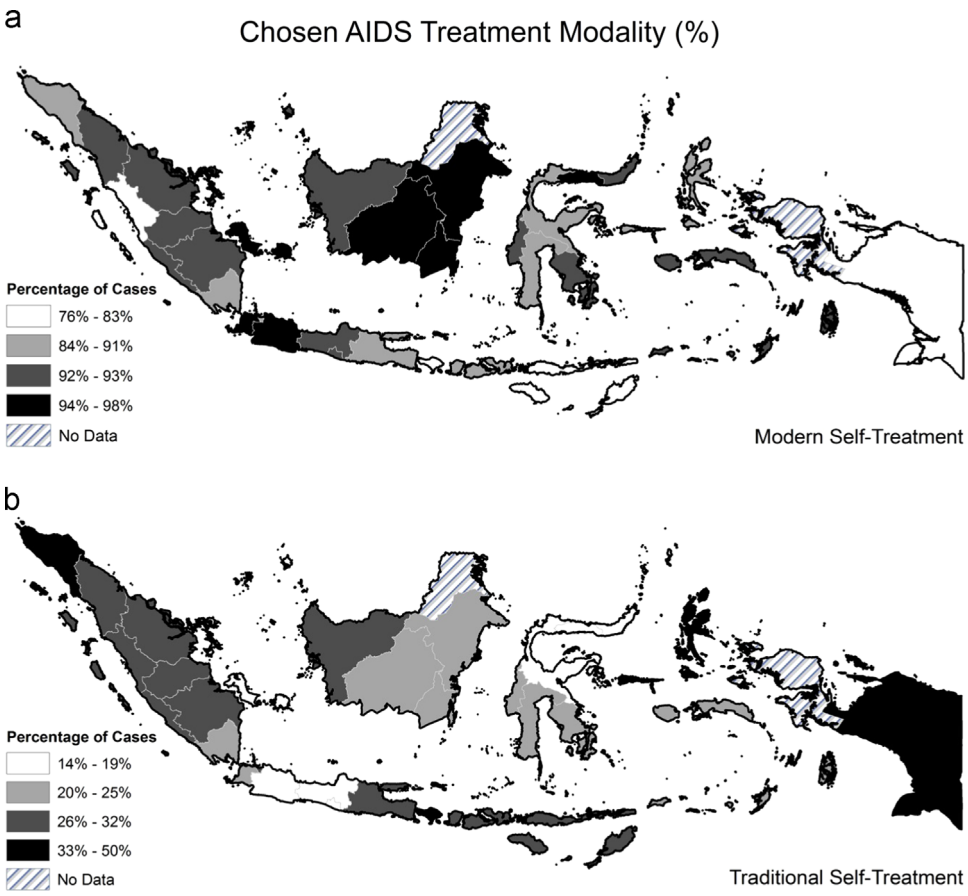

Fig. 2 Provincial data (2013) on the percentage of population who had self-treatment, *Statistik Indonesia.*.

Table 1 Descriptive statistics by cluster.

Measures	Cluster 1	Cluster 2	Cluster 3
	(N = 10)	(N = 17)	(N = 6)
2011 Case rate	17.81 (11.66)	4.27 (4.16)	48.60 (68.60)
2011 Incidence (Number of new cases)	256.90 (348.66)	29.24 (51.03)	182.67 (246.76)
Population (2010 Census)	10,606,687.30 (13,150,483.30)	6,683,621.53 (9,974,244.33)	2,950,147.33 (1,716,953.41)
Population density (2010 Census)	1,631 (3,940.53)	205.47 (325.18)	139.50 (238.48)
2013 Gini ratio	0.39 (0.04)	0.38 (0.03)	0.38 (0.05)
Percentage of poor people in 2011	9.33 (4.07)	11.97 (4.92)	18.12 (10.43)
Percentage of males aged 10 and older who were illiterate in 2011	3.48 (2.61)	3.29 (2.36)	8.54 (9.90)
Percentage of females aged 10 and older who were illiterate in 2011	7.77 (5.34)	6.64 (4.09)	14.48 (13.17)
Percentage of population who had modern self-treatment in 2011	91.77 (1.51)	92.23 (3.35)	83.59 (5.33)
Percentage of population who had traditional self-treatment in 2011	23.09 (6.00)	23.96 (4.55)	38.33 (8.51)
Proportion of services where outpatient tuberculosis is unavailable in 2006	1.11 (2.26)	5.64 (5.12)	13.60 (6.27)
Proportion of services where inpatient tuberculosis is unavailable in 2006	82.44 (11.96)	87.00 (9.56)	84.20 (11.76)
Proportion of head *Puskesmas* with higher education	94.00 (5.83)	76.00 (10.26)	75.80 (24.31)
2006 ratio of doctors (per 100,000 persons)	24.62 (11.01)	16.63 (4.46)	21.74 (11.80)
2006 ratio of midwives (per 100,000 persons)	32.76 (11.70)	50.33 (18.62)	75.80 (26.39)
Number of tuberculosis cases in 2011	13,919.60 (15,630.11)	9,095.24 (14,531.23)	3,791.17 (2,184.11)
Number of pneumonia cases in 2011	16,025.70 (23,593.21)	18,159.94 (39,521.61)	1,842.83 (2,201.93)

Note: Standard deviations in parentheses.

provinces located in Cluster 1. Thus the AIDS epidemic may spread more quickly among people who live in provinces located in Cluster 1.

Despite great efforts to monitor and control the spread of the epidemic, data from *Statistik Indonesia* suggests that case and incidence rates are relatively higher in some of Indonesian provinces (e.g. Bali, Jakarta, Central Java, East Java, Papua, and West Papua). Promotion of HIV testing should be renewed to target these provinces while paying particular attention to individuals whose attitudes and beliefs towards HIV/AIDS might prevent them from getting tested. Another public health priority is to develop new healthcare delivery strategies for the hardest to reach segments of the population. Efforts to reach and educate men having sex with men (MSM), injection drug users (IDUs), and people living with HIV (PLHIV), and their partners about HIV transmission patterns and interventions to reduce their risk for infection should be continued.

This study has also shown the socioeconomic, demographic, and health inequalities exist among the provinces. Some of the provinces experiencing higher case and incidence rates are also characterized by higher rates of poverty, illiteracy and traditional self-treatment, as well as a higher proportion of unavailability in outpatient and inpatient tuberculosis services. The Gini indices are relatively higher in Jakarta, Papua, and West Papua compared to the other Indonesian provinces. Poverty and illiteracy rates are also relatively higher in Papua and West Papua when compared to the other Indonesian provinces. With respect to treatment, the prevalences of modern self-treatment are relatively lower in Papua and Bali compared to the other Indonesian provinces while the reverse is true for traditional self-treatment (see Fig. 2). The number of tuberculosis cases is also relatively higher in Papua compared to the other Indonesian provinces. This suggests that efforts to expand the availability, affordability, and quality of care should be continued in provinces characterized by high levels of inequality and high rates of poverty and illiteracy such as Jakarta, Java, Papua and Bali. Since the cost of ART is highest during the initial stages of the treatment, [25] there is a pressing need for sound policies that reduce the cost of treatment and consultation in these provinces. Therefore, instead of focusing on scaling up its AIDS budget [26] alone, preventive interventions should also consider provincial poverty and illiteracy rates, the population and its density, the type of self-treatment sought, the unmet need for healthcare services, the density of medical professionals, as well as the number of opportunistic infections. Given that much of Indonesia's healthcare is delivered through an extensive primary care system which relies heavily on midwives and nurses, equipping these health practitioners with the necessary clinical skills to prevent, diagnose, and treat AIDS and HIV-related infections and diseases will be imperative to reduce the health burdens associated with the epidemic in Indonesia.

Individualized treatment through shared decision making would be a viable option where the patient works closely with the health provider to come up with a treatment plan based on his or her preferences and needs. This type of treatment should be continued or implemented in provinces characterized by a high unmet need for health services and a low density of medical professionals. Papua and Bali have higher levels of unmet need for outpatient tuberculosis treatment. This suggests that uneven distribution of health workers and a heavy concentration of health workers remains a problem in these provinces despite great efforts to mobilize health human resources more equitably [6]. Incentive schemes to recruit health workers and contracted staff to serve in very remote areas should be continued.

Population density and urbanization can also affect the spread of the epidemic and disease. Provinces with a higher population and population density have somewhat higher occurrence of new AIDS cases in 2011 than low population, low density provinces (e.g. Banten, Jakarta, North Sumatra, Central Java, East Java, and West Java). The number of tuberculosis and pneumonia cases is also relatively higher in these provinces. Part of the reason for this finding hinges on the possibility of increased contact rate of infected and susceptible individuals living in some of these provinces. Living in close proximity to one another in unhealthy living conditions and poor sanitation can hasten the spread of the disease and weakens the attempts to control the disease. One of the primary methods of reducing the spread of these diseases and the health burdens associated with AIDS and HIV in these provinces is to improve access to quality and affordable healthcare and treatment by integrating the HIV prevention program into the existing healthcare system. Efforts to recruit health workers and contracted staff to serve in these provinces should also be continued.

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Competing interests

Author certify that there is no conflict of interest regarding this manuscript. Author also declare that he has no connection, financial or otherwise, that might introduce in any aspect of his work. The author has not signed any agreement from any sponsoring agencies that funds the author from submitting the manuscript to a journal for publication.

Ethical approval

Not required.

Author's contribution

The sole author, Hui Lion, is solely responsible for data analysis, GIS mapping, and the writing of the manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.hlpt.2017.01.005.

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