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Original Research Article

A Study on Spatial Distribution of HIV/AIDS Using Histogram and Geographic Information System

Thi-Hong Dao[1], Thi-Bich-Thuy Luong[2]

[1,2]Faculty of Nursing, East Asia University of Technology, Hanoi, Vietnam

Corresponding author: Thi-Hong Dao

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ABSTRACT

Background: The high prevalence of human immunodeficiency virus (HIV) infections has become a devastating publi6c health problem. In response, many governments have taken measures to reduce the transmission of HIV and the number of deaths from HIV/acquired immunodeficiency syndrome (AIDS). This study aims to investigate spatial distribution of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 with the help of a histogram and Geographic Information System (GIS).
Materials and Methods: Datasets of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 were first collected from website of the Vietnam Ministry of Health. Histogram was then used to study distribution of HIV/AIDS cases and deaths from AIDS. It will go on to analyze the spatial distribution of HIV/AIDS cases and deaths from AIDS. Finally, the results will be discussed and concluded.
Results: It was found that a high number of HIV/AIDS cases was mainly concentrated in the provinces of the north central region, Da Nang and some provinces in the south of Vietnam. High number of deaths due to AIDS was mainly concentrated in the provinces/cities of the northeast and north central regions of Vietnam. Meanwhile, low and very low numbers of deaths due to AIDS were mainly found in the south central and south-central regions of Vietnam.
Conclusion: Histogram and GIS-based mapping technique can be useful tools for mapping spatial distribution of HIV/AIDS cases and deaths from AIDS. Findings in this study can also provide an insight into the spread patterns of HIV/AIDS.

Keywords: Spatial distribution, HIV/AIDS, Infectious diseases, Deaths, Histogram, Geographic Information System.

INTRODUCTION

Human immunodeficiency virus (HIV) affects the immune system and causes a disease called acquired immunodeficiency syndrome (AIDS) (1). The number of HIV infections is rising annually (2). It is becoming a major public health concern in many countries worldwide. According to the Joint United Nations Program on HIV/AIDS (UNAIDS), in 2022, 39 million (33.1 million - 45.7 million) people globally were living with HIV. Moreover, 1.3 million (1 million - 1.7 million) people became newly infected with HIV in 2022. A total of 630 000 (480,000 - 880,000) people died from AIDS-related illnesses in 2022. In addition, 85.6 million (64.8 million - 113.0 million) people have become infected with HIV and 40.4 million people have died from AIDS-related illnesses since the start of the epidemic (3). Certain illness incidences lead to serious public health issues as well as a number of obstacles related to culture, social status, and general well-being, all of which have an adverse effect on the mental health of communicators (4). A study conducted by experts at Penn State College of Medicine indicated that around 38 million people worldwide suffer from HIV and AIDS, and that these individuals are more likely to commit suicide than general population members (5). HIV/AIDS is a disease that affects the human immune system, which results in a number of socioeconomic and cultural issues in countries, raises healthcare costs, and leaves people with severe mental illnesses (6). Numerous research studies have revealed that the majority of HIV/AIDS patients experience elevated levels of melancholy, stress, anxiety, and frustration, especially during their hospital stays as a result of their illness (7). People with certain mental illnesses have tough lives and may experience social rejection (8,9). In addition, there has been a nearly 15 % increase in mental disorders and substance use during the last decade (10).

GIS has become a crucial part of many epidemiology and public health programs (11–13). Maps have long been used by epidemiologists to examine correlations between location (14), environment (15), and disease (16). GIS has been applied to health situation analysis, policy and planning analysis, identification of high-risk health groups, planning and scheduling of activities, monitoring and assessment of interventions, surveillance and monitoring of vector-borne diseases, water-borne diseases, environmental health, and generation and analysis of research hypotheses. Researchers were able to identify places in need of resources, pinpoint high prevalence areas and populations at risk, and allocate resources using the use of GIS. Good geographic information science and good epidemiology science go hand in hand. In India, a large number of government organizations and development agencies are investigating health GIS (17). However, the need of having a health GIS in India is increased by the vastness of our nation, the diversity of our lifestyles, our climatic zones, and our environmental conditions. Three primary groups of studies exist on the spatial distribution of diseases: disease mapping, disease clustering, and ecological analysis (18). In order to analyze spatial relationships within the affected area, GIS-based disease mapping depends on identifying a number of factors, the most crucial of which are locations of disease occurrence, patterns of disease spread, environmental risk factors that lead to disease spread, and socio-economic data (19). In addition, GIS-based mapping has been successfully employ in studies in HIV/AIDS in many countries such as Africa (20), Nigeria (21), Zambia (22), and Iran (23).

Vietnam is one of the countries in Southeast Asia with the highest number of HIV cases. This study aims to investigate spatial distribution of HIV/AIDS in Vietnam in 2017 with the help of histogram and Geographic Information System. Datasets of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 were first collected. Histogram was then used to study distribution of HIV/AIDS cases and deaths from AIDS. It will go on to analyze the spatial distribution of HIV/AIDS cases and deaths from AIDS. Finally, the results will be discussed and concluded.

MATERIALS & METHODS

Materials

The HIV epidemic in Vietnam is still categorized as being in its "concentrated stage" due to the country's current HIV prevalence rate of less than 1%, which is greater among high-risk populations including female sex workers and injectable drug users (24). Although there are over 230,000 HIV-positive individuals in Vietnam, the country saw a dramatic drop in the number of new cases from an estimated 16,000 in 2010 to 5700 in 2018 (25). Vietnam is implementing programs to raise public awareness of HIV in addition to adopting interventions that are largely targeted at high-risk groups in order to combat the HIV epidemic. (26). In addition to government efforts, international organizations have also contributed significantly to the fight against the HIV epidemic in Vietnam. However, after 2010, when Vietnam progressed from a low-income country to a lower middle-income country, international resources for HIV prevention in Vietnam decreased substantially (27). In this study, datasets of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 collected from website of the Vietnam Ministry of Health (VMH) were used to investigate spatial distribution of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 using a histogram and Geographic Information System.

Methods

Histograms

Histograms visually summarize the distribution of a continuous numeric variable by measuring the frequency at which certain values appear in the dataset. The x-axis in a histogram is a number line that has been split into number ranges, or bins. For each bin, a bar is drawn where the width of the bar represents the range of the bin, and the height of the bar represents the number of data points that fall into that range. Understanding the distribution of the data is an important step in the data exploration process. Data from Figure 1 demonstrate the different types of histogram distributions, including normal distribution, skewed distribution, uniform distribution, bimodal distribution, and multimodal distribution.

It can be seen from Figure 1 that the shape of a histogram provides essential insights into the nature of the data distribution. This shape could be symmetrical, skewed right, skewed left, unimodal (having one peak), bimodal (having two peaks), or multimodal (having multiple peaks). In a symmetrical histogram, the left and right sides are mirror images of each other. This type of distribution suggests that the data points are evenly distributed around the mean. One common type of symmetrical distribution is a normal (bell-shaped) distribution. In a skewed histogram, the data points tend to lean more to one side. If the histogram leans towards the left, it is positively skewed, indicating that the data has a longer tail on the right. Conversely, if it leans towards the right, it is negatively skewed, meaning there's a longer tail on the left.

Unimodal, bimodal, and multimodal histograms are the main types. Unimodal histograms have a single prominent peak, which represents the most frequent observation. Bimodal histograms, on the other hand, have two distinct peaks, indicating two frequent observations, and multimodal histograms display multiple peaks.

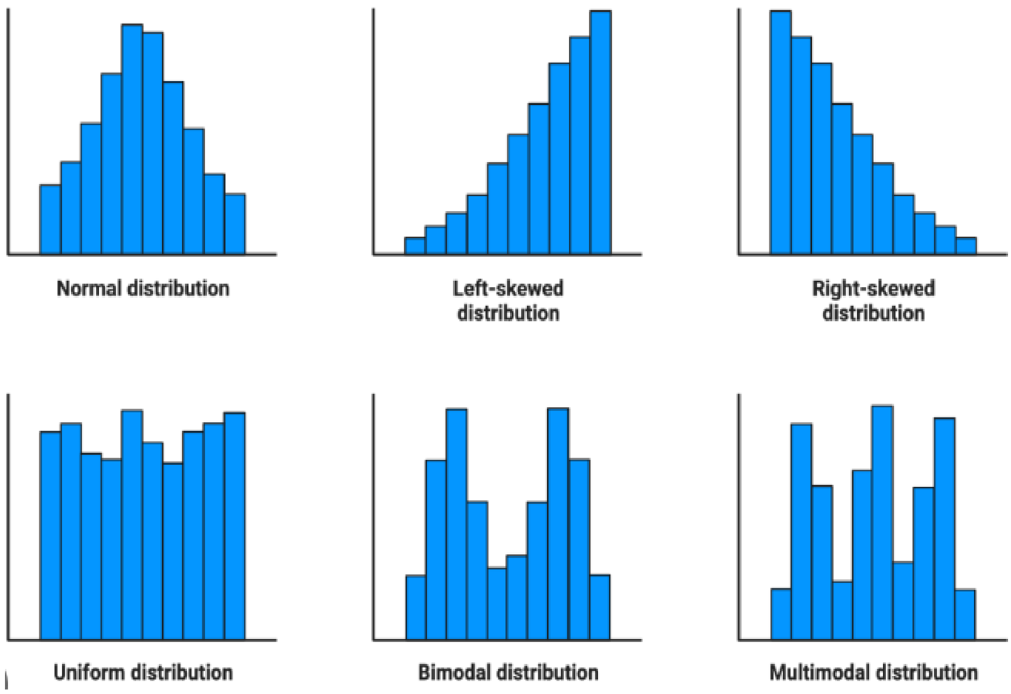

Figure 1. Different types of histograms.

GIS-based mapping

A Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. The key word to this technology is geography - this means that some portion of the data is spatial. In other words, data that is in some way referenced to locations on the earth. Map projection is an important problem in a GIS. A map projection refers to any of the numerous techniques employed in cartography to depict the three-dimensional surface of the Earth or other spherical objects on a two-dimensional plane. While these map projection methods often involve mathematical calculations, some also rely on graphical approaches. A map projection is the means by which the coordinate system and data is displayed on a flat surface, such as a piece of paper or a digital screen. Mathematical calculations are used to convert the coordinate system used on the curved surface of earth to one for a flat surface. Since there is no perfect way to transpose a curved surface to a flat surface without some distortion, various map projections exist that provide different properties. Some preserve area, while others preserve local angles. Some preserve specific distances or directions. The extent, location, and property to preserve must inform the choice of map projection for theprojected coordinate system. There are approximately 6,000 coordinate systems in the ArcGIS platform, so it is likely to match the data. It is possible to create a custom projected coordinate system from more than 100 map projections to display the data. ArcGIS Pro reprojects data on the fly so any data can be added to a map adopts the coordinate system definition of the first layer added. As long as the first layer added has its coordinate system correctly defined, all other data with correct coordinate system information reprojects on the fly to the coordinate system of the map. This approach facilitates exploring and mapping data, but it should not be used for analysis or editing, because it can lead to inaccuracies from misaligned data among layers. Data is also slower to draw when it is projected on the fly. If it intends to perform analysis or edit the data, first project it into a consistent coordinate system shared by all layers. This creates a new version of data.

A projected coordinate system based on a map projection such as transverse Mercator, Albers equal area, or Robinson, all of which (along with numerous other map projection models) provide various mechanisms to project maps of the earth's spherical surface onto a two-dimensional Cartesian coordinate plane. Projected coordinate systems are sometimes referred to as map projections. Mercator created his projection in space. The forward equations for the Space-oblique Mercator projection for the sphere are as follows:

$\frac{x}{\mathrm{R}} = \int_0^{\lambda'} \frac{H - S^2}{\sqrt{1+S^2}} d\lambda' - \frac{S}{\sqrt{1+S^2}} \ln\tan\left(\frac{\pi}{4} + \frac{\varphi'}{2}\right)$	(1)
$\frac{y}{\mathrm{R}} = (H+1) \int_0^{\lambda'} \frac{S}{\sqrt{1+S^2}} d\lambda' + \frac{1}{\sqrt{1+S^2}} \ln\tan\left(\frac{\pi}{4} + \frac{\varphi'}{2}\right)$	(2)
$S = \frac{P_2}{P_1} \sin(i) \cos(\lambda')$	(3)
$H = 1 - \frac{P_2}{P_1} \sin(i)$	(4)

where: φ is geodetic (or geographic) latitude, λ is geodetic (or geographic) longitude, P_2 is the time required for revolution of satellite, P_1 is the length of Earth rotation, i is the angle of Earth rotation, is the radius of Earth, x and y are rectangular map coordinates.

It has been reported that one of powerful tools in GIS is mapping technique, especially infectious disease mapping. Disease mapping is the process of visualizing the distribution and variation of disease cases or rates in a geographic area. GIS can reveal spatial patterns, clusters, trends, and anomalies that may indicate underlying causes or effects of the disease. Some of the common methods for disease mapping are dot maps, choropleth maps, kernel density maps, and spatial scan statistics. Dot maps show the location of each case or event, while choropleth maps show the aggregated rate or count of cases per unit area. Kernel density maps show the smoothed intensity of cases over a continuous surface, while spatial scan statistics identify clusters of cases that are statistically significant.

RESULTS AND DISCUSSIONS

Spatial distribution of HIV/AIDS cases

The data in the histogram in Figure 2 shows the distribution of the number of HIV/AIDS cases in Vietnam in 2017. The histogram shows that columns in red and orange represent the provinces/cities having the high and very high number of HIV/AIDS infections, meanwhile, the yellow and blue columns represent provinces/cities having medium and low numbers of HIV/AIDS infections, respectively. Two provinces having extremely high numbers of HIV/AIDS cases were Ho Chi Minh and Hanoi with the corresponding number of cases of 47,303 and 20,724 cases, respectively. Then followed by Son La (8,164 cases), Hai Phong (7,331), Thai Nguyen (6,265), An Giang (6,121 cases) and Dong Nai (6,067 cases). In Vietnam, the province having the lowest number of HIV/AIDS cases in 2017 was Quang Tri (204 cases), followed by Quang Binh (206 cases), Phu Yen (245 cases), Ninh Thuan (276 cases), and Kon Tum (330 cases) and Binh Dinh (362 cases), respectively.

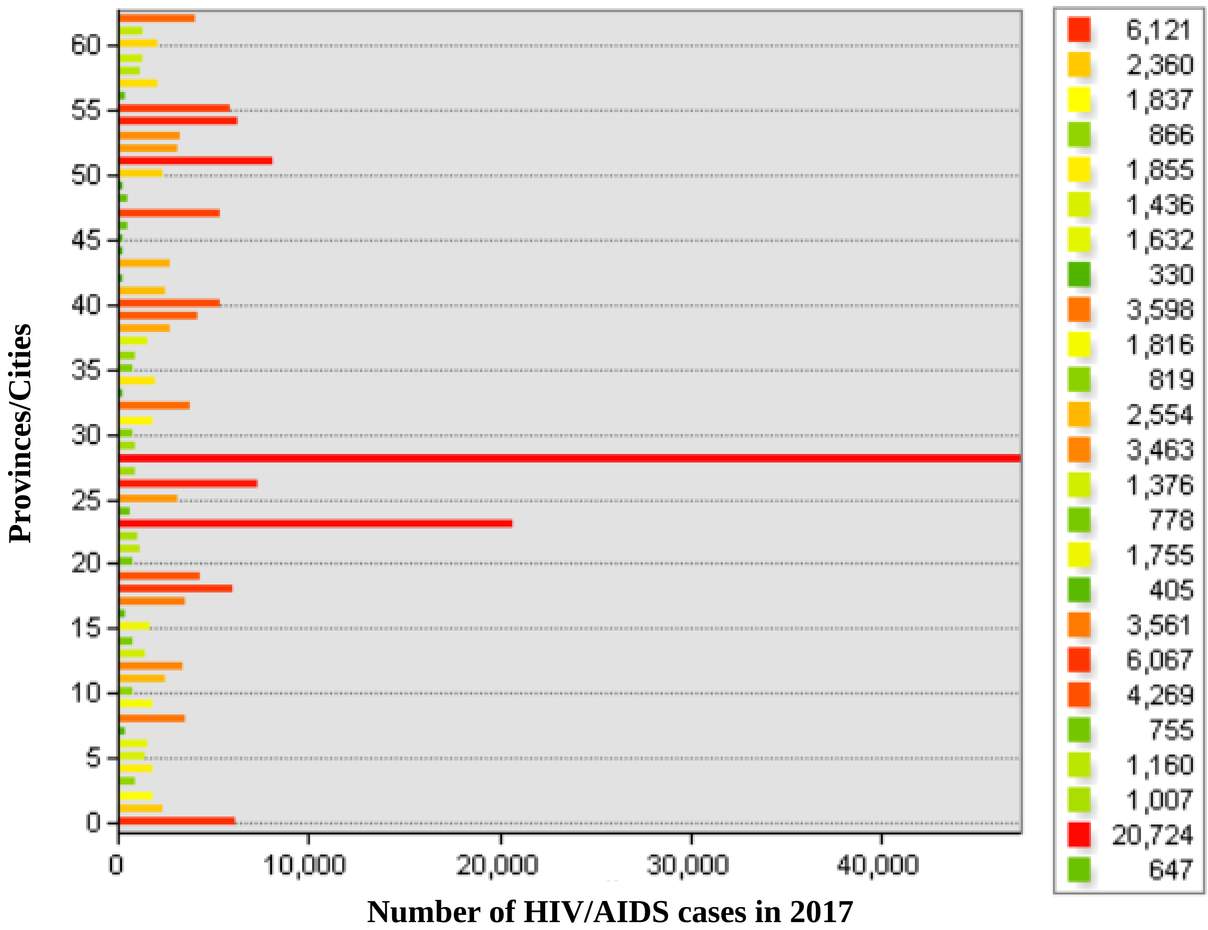

Figure 2. A histogram of HIV/AIDS cases in 2017.

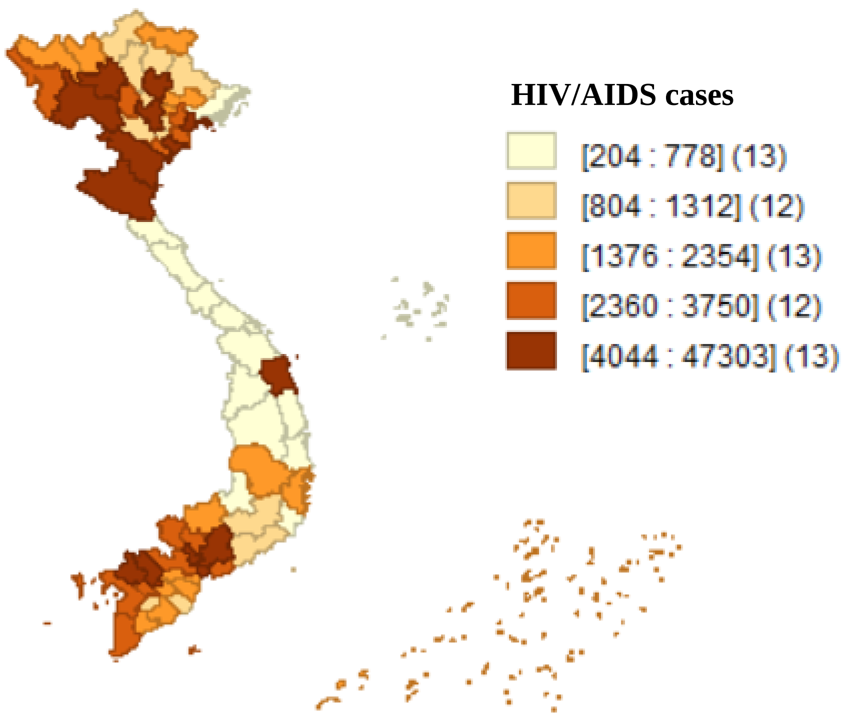

Figure 3. Spatial distribution of HIV/AIDS cases in 2017.

The spatial distribution of the number of HIV/AIDS cases in 2017 was shown in the map in Figure 3. Data from the map Figure 3 demonstrates five different ranges of the number of HIV/AIDS infections as follows: 13 provinces and cities having a very low number of infected cases in the range of 204 to 778 cases, 12 provinces haing a low number of infected cases in the range of [804, 1312], 13 provinces having an medium number of infected cases in the range of [1376, 2354], 12 provinces having a high number of cases in the range of [2360, 3750] and 13 provinces having a very high number of cases in the range [4044, 47303], respectively. The spatial distribution of HIV/AIDS infections in Figure 3 shows that a high number of HIV/AIDS cases was mainly concentrated in the provinces of the north central region, Da Nang and some provinces in the south of Vietnam.

Spatial distribution of deaths from AIDS

The data in the histogram shown in Figure 4 illustrate the distribution of the number of deaths due to AIDS in Vietnam in 2017. The histogram shows that the red and orange columns represent the provinces/cities having high and very high number of deaths due to AIDS, meanwhile, the yellow and blue columns represent provinces/cities having low and medium numbers of deaths due to AIDS, respectively. Ho Chi Minh was the city having the highest number of deaths with 10,404 cases, then followed by the number of deaths in Quang Ngai provinces (5,379 cases), An Giang (5,038 cases), and Hanoi (4,748 cases), Hai Phong (4703 cases) and Nghe An (3942 cases). Meanwhile, the provinces/cities having very low numbers of AIDS deaths were Quang Tri (94 cases), then followed by Phu Yen (116 cases), Quang Binh (119 cases), Kon Tum (169 cases), Dak Nong (172 cases), and Ninh Thuan (190 cases), respectively.

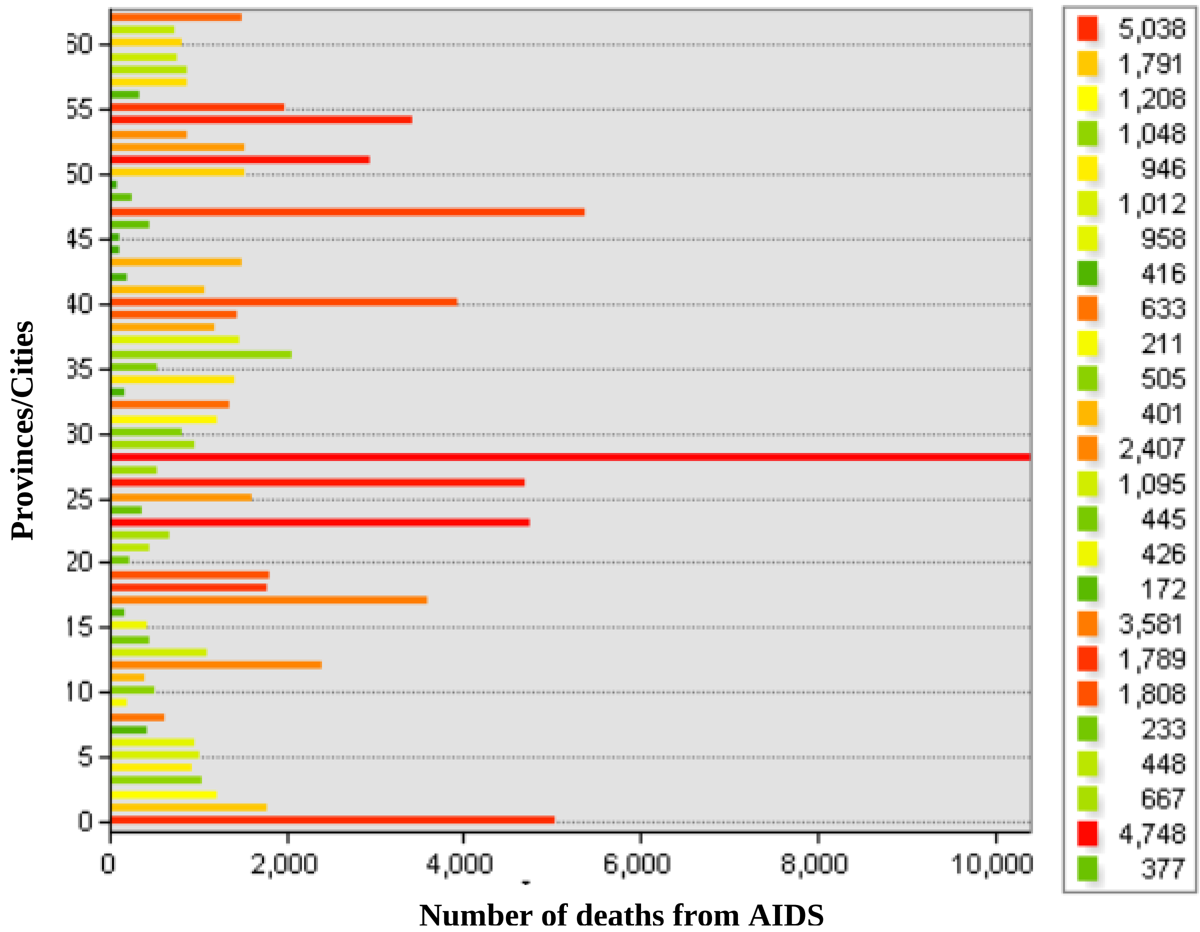

Figure 4. A histogram of deaths due to HIV/AIDS in 2017.

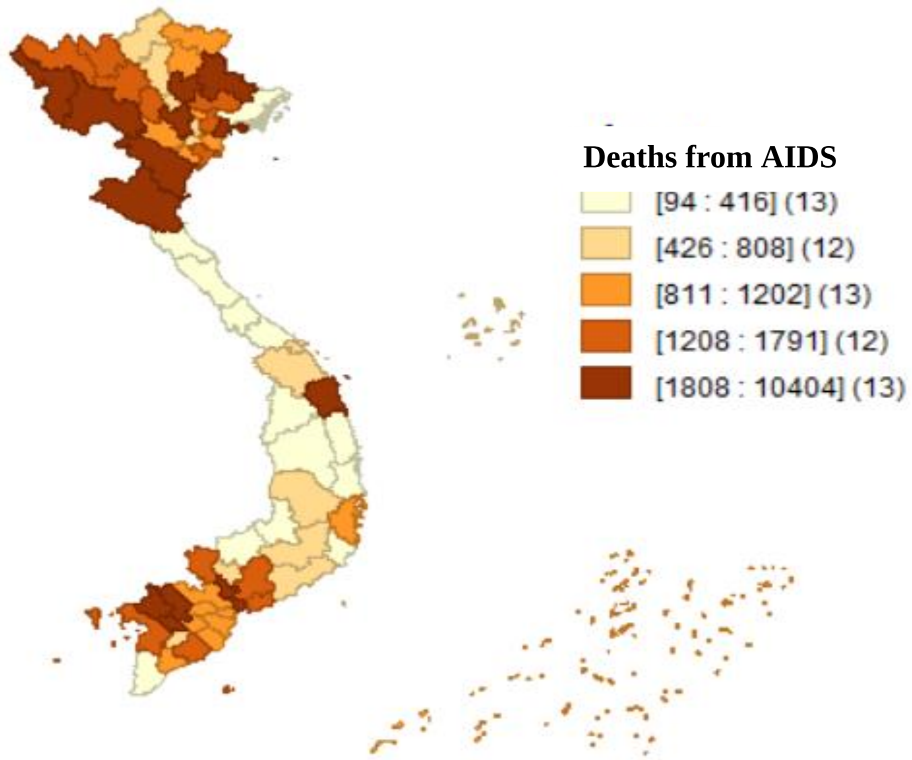

Figure 5. Spatial distribution of deaths from AIDS in 2017.

The spatial distribution of the number of deaths due to AIDS in 2017 was shown in the map in Figure 5. Data from the map Figure 5 demonstrates the 5 different ranges of the number of deaths due to AIDS as follows: 13 provinces and cities having the number of deaths in the range of [94, 416], 12 provinces having a low number of deaths in the range of [426, 808], 13 provinces having medium number of infections in the range of [811 , 1202], 12 provinces having a high number of deaths in the range [1208, 1791] and 13 provinces having a very high number of deaths in the range [1808, 10404], respectively. The map of spatial distribution of the number of deaths due to AIDS in Figure 5 shows that the high number of deaths due to AIDS was mainly concentrated in the provinces/cities of the northeast and north central regions of Vietnam. Meanwhile, low and very low numbers of deaths due to AIDS were mainly found in the south central and south central regions of Vietnam.

CONCLUSION

This study sets out to investigate spatial distribution of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 by means of histogram and GIS. Datasets of HIV/AIDS cases and deaths from AIDS in Vietnam in 2017 were first collected from website of the Vietnam Ministry of Health. The histogram was then used to study distribution of HIV/AIDS cases and deaths from AIDS. It will go on to analyze the spatial distribution of HIV/AIDS cases and deaths from AIDS. Finally, the results will be discussed and concluded. It was found that a high number of HIV/AIDS cases was mainly concentrated in the provinces of the north central region, Da Nang and some provinces in the south of Vietnam. High number of deaths due to AIDS was mainly concentrated in the provinces/cities of the northeast and north central regions of Vietnam. Meanwhile, low and very low numbers of deaths due to AIDS were mainly found in the south central and south central regions of Vietnam. For the purpose of mapping the spatial distribution of HIV/AIDS cases and AIDS-related mortality, histogram and GIS-based mapping techniques can be helpful tools. The results of this investigation can potentially shed light on how HIV/AIDS spreads.

Declaration by Authors

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