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Mapping for Tracking Sexually Transmitted Infections by Subdistricts in Surabaya, Indonesia

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Abstract

The 2014 shutdown localization of prostitution in Surabaya City, East Java Province, Indonesia, has given rise to an illegal prostitution industry, resulting in the spread of uncontrolled sexually transmitted infections (STIs). Mapping needs to be done to track the spread of the disease. This study used secondary data on STIs in 2020 from the Surabaya City Health Office. By using biplot analysis, this study sought to offer a detailed understanding of the distribution and dynamics of STI cases in different parts of Surabaya. The early-stage syphilis was found in Tegalsari and Krembangan Subdistricts; then, gonorrheal urethritis was found in Tandes, Karang Pilang, and Pabean Cantian Subdistricts. Meanwhile, gonorrhea was typically found in Tandes, Gunung Anyar, Sawahan, and Karang Pilang Subdistricts. On the other hand, Tegalsari, Krembangan, and Pabean Cantian Subdistricts also had cases of advanced syphilis. This study enables relevant parties, specifically the Surabaya City Health Office, to monitor the method's rapid spread and respond to each case according to the predominant type of STI.

Keywords: biplot, mapping, monitoring, sexually transmitted infections, subdistricts

Introduction

Sexually transmitted infections (STIs) are a group of diseases primarily transmitted through sexual contact, often colloquially referred to as venereal diseases.[1] The primary mode of disease transmission involves the exchange of body fluids and, in some cases, through medical equipment, from mother to fetus, via blood products, or through the transfer of contaminated tissues.[2] The causal agents of STIs encompass a diverse array of microorganisms, including bacteria, viruses, parasites, and genital lice. A noteworthy aspect of STIs is that many infections may not manifest noticeable symptoms, particularly in the early stages, or may exhibit indirect symptoms within the reproductive organs.[1] After being infected with STIs, particularly gonorrhea, the incubation period until clinical symptoms appear is very short, typically between 2-5 days. In addition to affecting the genitals, the bacteria can also infect other parts of the body, including the anus, eyes, throat, and joints.[3]

The latency in symptom manifestation underscores the urgency of regular screening and early detection for effective management. The diagnosis of some STIs could be made through physical examination or microscopic analysis of sores or discharge from the genital area or anus.[4] According to the Surabaya City Health Office, each of the eight distinct types of STIs presents its unique characteristics and potential health implications. These include early-stage syphilis, advanced syphilis, gonorrhea, gonorrhea urethritis, non-gonorrhea urethritis, cervicitis, lymphogranuloma venereum (LGV), trichomoniasis, and genital herpes.[5] The identification and understanding of these various types are crucial for effective prevention, diagnosis, and treatment strategies aimed at curbing the prevalence and impact of STIs within the community.

In East Java, a province inhabited by a population of 39,886,288 people, Surabaya City stands out as the most populous, serving as the capital of the province. This bustling city accommodates 2,904,751 individuals, resulting in a population density of 8,286.5 people per square kilometer.[6] As an illustration, around 8,287 people inhabit every square kilometer of Surabaya. Despite Dolly, once the largest center of prostitution in Surabaya and Southeast Asia, being shut down in 2014 and the crackdown on illegal activities in certain areas, Surabaya continues to grapple with a large number

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of STI cases. The East Java Provincial Health Office recorded a total of 2,526 individuals infected with the HIV/AIDS virus in 2021.[7] According to the data, Surabaya City is the area with the highest number of HIV/AIDS cases, with 323 individuals affected.[7]

This persistent issue accentuates the complex challenges associated with illegal prostitution and its impacts on public health. By using biplot analysis, this study aimed to provide a nuanced understanding of the distribution and dynamics of STI cases across various areas within the city. Findings from this mapping endeavor are crucial for devising targeted interventions and strategies to address the prevailing public health concerns related to STIs in Surabaya.[8]

In light of the information provided, a comprehensive study was undertaken to analyze the patterns of trends of STI cases across various subdistricts in Surabaya in 2020. This investigation employed the biplot analysis[9] to visually represent the data and ascertain the relationship between STI occurrences and the subdistricts in Surabaya. With a total of 13 subdistricts recorded, this study revealed the presence of individuals affected by four distinct types of STIs: gonorrhea, gonorrhea urethritis, early-stage syphilis, and advanced syphilis.

The primary objective of this study was to determine the trend pattern of STI cases within subdistricts of Surabaya. The visualization provided by the biplot analysis would facilitate a more comprehensive relationship of STI occurrences with specific subdistricts. The outcomes of this study would further furnish valuable information, enabling the Surabaya City Health Office to effectively manage and address the prevalence and distribution of STI cases. This, in turn, will contribute to enhancing targeted healthcare interventions and strategies to curb the impact of STIs in the city.

Method

The ground of this study relied on the use of secondary data from the Surabaya City Health Office, specifically focusing on the incidence of STIs in 2020.[10] The variables encompassed two key elements: subdistricts in Surabaya and certain types of STIs prevalent in those subdistricts. Notably, this study identified four distinct types of STIs and considered 13 subdistricts known to have reported STI cases. Data organization was systematically presented through structured tables that delineated the distribution of STI cases across different subdistricts and the prevalence of each particular type of STIs. The subdistricts in Surabaya City examined in this study were Benowo, Gubeng, Gunung Anyar, Karangpilang, Krembangan, Mulyorejo, Pabean Cantian, Sawahan, Semampir, Tambaksari, Tandes, Tegalsari, and Wonocolo. The STIs identified in these areas were categorized into gonorrhea (G), urethritis gonorrhea (UG), early-stage syphilis (ES), and advanced syphilis (AS).

A biplot served as an insightful graphical representation employed in multivariate data analysis, offering a unique perspective by integrating variables, subjects, and principal components onto a single graph.[11] While various types of biplots exist, the most prevalent was rooted in principal components analysis. This statistical technique transforms correlated variables into a set of uncorrelated variables called principal components.[12] The beauty of a biplot lies in its ability to encapsulate complex multivariate information in a comprehensible visual format.

As one of the few graphical methods capable of handling highly multivariate data, biplot analysis plays a crucial role in elucidating relationships within datasets. It accomplishes this by concurrently illustrating both the vector rows and columns on a two-dimensional plane, thereby facilitating a holistic understanding of the interplay between variables and subjects.[10] In essence, a biplot unfolds as a visual synthesis in which variables or attributes and the corresponding objects are cohesively depicted on the same graph. This dual representation enables researchers and analysts to discern patterns, trends, and associations in the data, providing a powerful tool for interpretation and exploration. By showcasing relationships between variables and subjects in a single, accessible visual framework, biplots contribute significantly to elucidating intricate multivariate structures.

This analysis was first introduced by Gabriel in 1971. Suppose a matrix n**Y**p is a matrix of data and n**X**p is A matrix of data corrected with their average scores, **X** = **Y** – **(JY)**/n, which n**J**n is a matrix with the elements of one. The singular value decomposition is as follows:

$$n\mathbf{Y}p = n\mathbf{U}r\ r\mathbf{D}r\ p\mathbf{V}r \quad (1)$$

Where **U** dan **V** are matrices with orthonormal colom ($\mathbf{U}^T\mathbf{U} = \mathbf{V}^T\mathbf{V} = r\mathbf{I}r$), and if **D** is a diagonal matrix with its diagonal element is eigen values, then $\mathbf{U} = \mathbf{D}w^{-1/2}\mathbf{U}$ and $\mathbf{V} = \mathbf{D}q^{-1/2}$ The equation (1) can be expressed as:

$$\hat{\mathbf{Y}} = \tilde{\mathbf{U}}\mathbf{D}_{\beta}\tilde{\mathbf{V}}^{\mathrm{T}} \tag{2}$$

then $\mathbf{G} = \mathbf{I}^{\frac{1}{2}}\mathbf{U}\mathbf{D}_{\beta}$ and $\mathbf{H} = \mathbf{J}^{\frac{1}{2}}\mathbf{V}$

The biplot analysis yielded a graph illustrating the link between the variables by measuring the angle between them. The correlation between the two variable vectors was shown by the angle produced between them; the smaller the angle formed, the stronger the correlation. The matrix of the square approach would provide a better presentation of the information contained in the original data.

The efficacy of biplot analysis in capturing and characterizing the overall variance present in the original data matrix was contingent upon the precision of its representation. In this context, the accuracy level served as a critical metric that gauged how faithfully the biplot encapsulates the intricacies and variability inherent in the multivariate dataset.[9]

$$\eta = \frac{\lambda_1 + \lambda_2}{\sum_{i=1}^{p}\lambda_i} \; ; \; 0 \leq \eta \leq 1 \tag{3}$$

λ_1 = The first largest eigenvalue
λ_2 = The second largest eigenvalue
λ_i = The ith largest eigenvalue, i = 1, 2, …, p

The success of a biplot analysis is often determined by the proximity of the η value to 1. A η value approaching 1 signifies that the information variation encapsulated by the biplot is nearly equivalent to 100% of the total information present in the dataset. In essence, a higher η value indicates a more successful representation of the dataset's variability, emphasizing the effectiveness of the biplot in capturing and conveying a comprehensive portrayal of the underlying data structure.

Results

The initial analysis conducted pertained to the examination of data characteristics. Data characteristics were instrumental in gaining insights into the overall profile of STIs data, encompassing the types of STIs, the distribution of STI types based on subdistricts, and characteristics of ES, AS, G, and UG by subdistricts. The analysis delved into understanding the landscape of STIs data in Surabaya in 2020.

The ES accounted for the highest percentage of cases (31.58%). The following were UG (28.95%), G (24.56%), and the last were AS (14.91%) out of 114 STI cases in Surabaya in 2020. It was quite concerning that the percentages exceeded 10%, in particular since the shutdown of the localization in 2014. Therefore, the Surabaya City Government should be aware of the occurrence and spread of STIs in the city.

Following the initial examination of overall disease characteristics, a more detailed analysis was conducted to explore the specific distribution patterns of each type of disease across the 13 subdistricts of Surabaya. This granular investigation delved into the nuances of disease prevalence and incidence in each subdistrict, shedding light on localized variations. In particular, the characteristics of ES, UG, G, and AS were scrutinized based on subdistrict-level data in Surabaya in 2020. The attributes of STIs across the 13 subdistricts in Surabaya, each of which reported cases of this ailment in 2020, were visually depicted through a bar chart in Figure 1.

The presented Figure 1 aims to offer a comprehensive overview of the distribution and prevalence of different types of STIs, providing a visual snapshot of the landscape of STIs in Surabaya during the specified year. This initial phase of analysis sets the stage for a more in-depth exploration of the intricate patterns and trends within the STIs data, paving the way for a nuanced understanding of the public health scenario related to STIs in the city.

Figure 1 reveals that the Tegalsari Subdistrict experienced the highest incidence of STI cases in 2020, with a total of 36 reported instances. Among the various types of STIs, ES emerged as the predominant ailment in the Tegalsari Subdistrict, contributing to 26 cases. In contrast, Mulyorejo and Tambaksari Subdistricts recorded the lowest occurrences of STI cases in Surabaya City during the same period. Specifically, the Mulyorejo Subdistrict reported only one case, identified as G case, while the Tambaksari Subdistrict documented a singular case of ES.

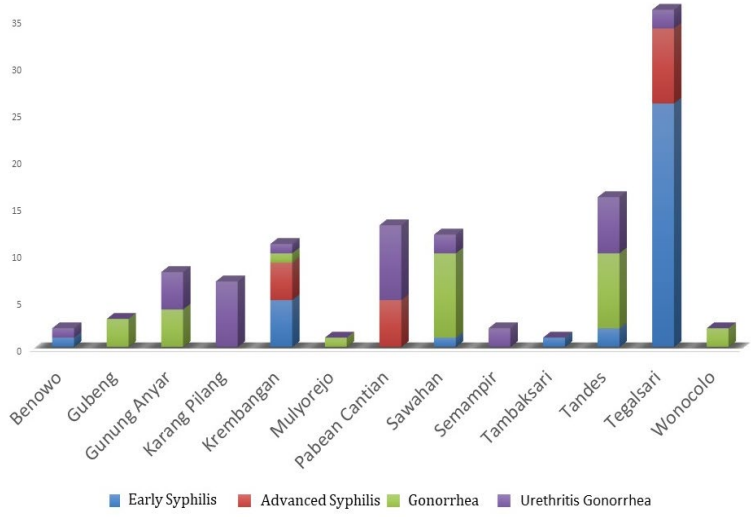


Figure 1. Characteristics of Sexually Transmitted Infections Based on Subdistricts[10]

Out of the total 114 STI cases reported in Surabaya City in 2020, the Tegalsari Subdistrict exhibited the highest percentage of ES cases, constituting a significant 72.22%. Conversely, Benowo, Sawahan, and Tambaksari Subdistricts reported the lowest percentages of ES cases, each accounting for a mere 2.78%. Notably, other subdistricts in Surabaya City did not report any instances of ES throughout the entirety of 2020.

For the AS cases, the Tegalsari Subdistrict maintained its prominence, reporting the highest percentage at 47.06%. In contrast, Krembangan Subdistrict documented the lowest percentage of AS cases, standing at 23.53%. Similar to ES, several subdistricts of Surabaya City did not report any cases of AS in 2020. Shifting the focus to G cases, Sawahan Subdistricts emerged with the highest percentage at 32.14%. In contrast, Krembangan and Mulyorejo Subdistricts reported the lowest percentages, each at 3.57%. Remarkably, several other subdistricts did not record any instances of G cases during the observed year.

Finally, when examining UG cases among the 114 reported STI cases in Surabaya City in 2020, the Pabean Cantian Subdistrict documented the highest percentage at 24.24%. In contrast, Benowo and Krembangan Subdistricts reported the lowest percentages, each at 3.03%. Similar to other STI types, certain subdistricts did not report any instances of UG cases during the specified period.

To monitor the spread of STIs in Surabaya, a mapping needs to be conducted in each subdistrict. The mapping employed biplot analysis, in which the proximity of STI types to subdistricts was depicted based on the angles formed between them. The magnitude of these angles reflected the correlation between them; the smaller the angle formed, the higher the correlation. This implied a close relationship between STI occurrences and the respective subdistrict areas. The accuracy level of a two-dimensional biplot was measured by $\eta = \frac{\lambda_1 + \lambda_2}{\sum_{i=1}^{p} \lambda_i}$ where λ_i was the eigenvalue of i = 1, 2, 3, 4.

$$\eta = \frac{(1{,}94667 + 1{,}08564)}{(1{,}94667 + 1{,}08564 + 0{,}84029 + 0{,}12741)} = 0{,}758 \sim 0{,}76$$

The first two main components contributed 76% of the total correlation information among variables, specifically in the context of STIs. This implied that the analysis could explain 76% of the information related to STIs in Surabaya.

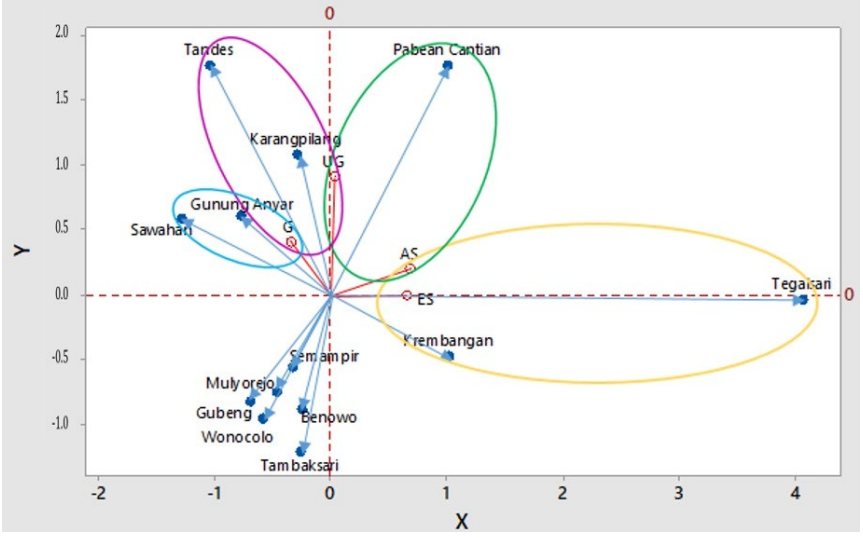
This substantial value exceeded 50%, making it sufficient for marking and serving as an indicator for subdistricts with high correlations that should be monitored cautiously. Figure 2 and Table 1 provide a visual and tabular representation of the subdistrict's position in relation to various types of STIs. The smaller the angle formed between STIs and the subdistrict, the closer the relationship between disease incidence in the subdistrict was concerned. The degrees of the angle formed are shown in Table 1.

Table 1. The Angular Measurements (in Degrees)

Subdistrict	ES	AS	G	UG
Benowo	105.00	122.19	121.30	165.10
Gubeng	128.83	146.02	97.47	141.27
Gunung Anyar	144.28	127.09	**10.58**	54.38
Karangpilang	107.15	89.96	**26.55**	**17.25**
Krembangan	**24.00**	**41.19**	157.70	113.90
Mulyorejo	120.13	137.32	106.17	149.97
Pabean Cantian	61.88	**44.69**	71.82	**28.03**
Sawahan	157.40	140.21	**23.70**	67.50
Semampir	120.03	137.23	106.27	150.06
Tambaksari	101.14	118.33	125.16	168.96
Tandes	122.39	105.19	**11.32**	**32.48**
Tegalsari	**0.88**	**16.31**	132.82	89.02
Wonocolo	120.18	137.38	106.11	149.91

Notes: ES = early-stage syphilis, AS = advanced syphilis, G = gonorrhea, UG = urethritis gonorrhea

The spatial arrangement in Figure 2 is delineated by the angles formed between individual subdistricts and the occurrences of specific STIs. The significance of these angles lies in their ability to convey the degree of correlation or association between each subdistrict and the prevalence of STIs. In this context, a smaller angle signifies a more pronounced correlation or interconnectedness between a given subdistrict and the incidence of STIs. Essentially, the angular measurements in Table 1 serve as a quantitative indicator, with a diminishing angle suggesting an increasingly substantial relationship between the subdistrict and the occurrence of STIs within that specific area.



Notes: G = gonorrhea, UG = urethritis gonorrhea, ES = early-stage syphilis, AS = advanced syphilis

Figure 2. The Biplot of Sexually Transmitted Infections in Surabaya[10]

The angular representations in Figure 2 and Table 1 unveil noteworthy correlations between subdistricts and various types of STIs. The discerned patterns indicate:

- Tandes and Karangpilang Subdistricts: These areas notably correlate with G and UG. The angular measurements signify a robust association between the geographical positioning of these subdistricts and the prevalence of these specific STIs.
- Krembangan, Tegalsari, and Pabean Cantian Subdistricts: These regions are intricately linked with both ES and AS.

Furthermore, Pabean Cantian demonstrates a distinct correlation with UG. The angles formed underscore the geographical significance of these subdistricts in relation to the prevalence of specific STIs.

- Gunung Anyar and Sawahan Subdistricts: These areas are singularly associated with G. The angles formed reflect the geographical specificity of these subdistricts concerning the incidence of G.

Conversely, a distinct group comprising Semampir, Gubeng, Wonocolo, Mulyorejo, Benowo, and Tambaksari Subdistricts does not display a pronounced correlation with the types of STIs, despite the documented cases within these regions. With a commendable accuracy rate of 76%, this analysis demonstrates a robust capability to elucidate the prevailing conditions of STIs in the urban landscape of Surabaya.

Discussion

The analysis conducted using the biplot method for mapping and visually tracking STIs offers a more informative approach, as it provides a direct depiction of the proximity between regions and the prevalence of diseases. A previous study on mapping and trend analysis of STIs in Surabaya City merely provided an overview of the total incidence rates of STIs from year to year. It primarily focused on mapping the subdistricts with the highest total cases of STIs without delving into the specific relationships between types of STIs and subdistricts.[13] In contrast, this study delved into the intricate associations between different types of STIs and specific subdistricts in Surabaya City. This approach significantly contributes to a nuanced understanding of the distribution and potential determinants of STIs in the surveyed area.

By focusing on the relationships between specific types of STIs and subdistricts, this study offers a more targeted and precise analysis to inform public health interventions more effectively. This comprehensive understanding serves as a foundation for developing targeted interventions and public health initiatives to reduce the incidence of STIs in Surabaya City. The comprehensive depiction generated from this study serves as a potent tool for ongoing monitoring of the spatial distribution of STI cases in Surabaya. Government entities and relevant stakeholders can leverage these insights to prioritize vigilant attention and meticulous intervention in subdistricts exhibiting high correlations with STIs. Additionally, a continuous vigilance strategy should be maintained for areas with lower correlations to ensure a controlled and monitored incidence rate.

Conclusion

This study reveals compelling patterns in the distribution of STIs across various subdistricts in Surabaya. The Sawahan and Gunung Anyar Subdistricts exhibit a strong correlation with gonorrhea. Conversely, the Tandes and Karangpilang Subdistricts are closely associated with both gonorrhea and urethritis gonorrhea, while the Pabean Cantian Subdistrict is linked to urethritis gonorrhea and advanced syphilis. Additionally, Tegalsari and Krembangan Subdistricts show a stronger correlation with both early-stage and advanced syphilis. These findings offer valuable insights into the spatial dynamics of STIs, serving as critical indicators for targeted interventions and public health initiatives and providing a foundation for ongoing monitoring and strategic planning by government entities and stakeholders.

Abbreviations

STIs: sexually transmitted infections; ES: early syphilis; AS: advanced syphilis; G: gonorrhea; UG: urethritis gonorrhea.

Ethics Approval and Consent to Participate

This study is based on a research project approved by the Directorate of Research and Community Service at Institut Teknologi Sepuluh Nopember, with Research Implementation Agreement Letter No.2430/PKS/ITS/2023.

Competing Interest

The authors assert that no noteworthy competing financial, professional, or personal interests could have influenced the execution or presentation of the research outlined in this manuscript.

Availability of Data and Materials

This study utilized secondary data from the Surabaya City Health Office, consisting of the number of STI cases based on subdistricts in Surabaya in 2020.

Authors' Contribution

DS provided supervision throughout the project. DSA was responsible for data collection and entry, while BSU and FH conducted the data analysis. Additionally, DS, BSU, FH, and DSA collaborated on manuscript preparation, content refinement, and administrative tasks. All authors participated in result discussions and contributed to the final manuscript.

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