



SPATIAL MAPPING OF PERIODONTAL DISEASE IN PRIMARY HEALTH CARE OF GENUK, INDONESIA: GEOSPATIAL INFORMATION SYSTEMS ANALYSIS

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ABSTRACT

Periodontal disease is a disease characterized by inflammation and degeneration of the soft tissues and bone supporting the teeth. The accumulation of plaque, tartar and calculus bacteria on the teeth is a local factor and the main cause of periodontal disease. Environmental factors also indirectly affect the incidence of periodontal disease. Geographic information systems (GIS) are tools used to work with data that has information about location. The research method used is descriptive observational with cross sectional design to determine the spread of periodontal disease based on determinant factors in Genuk Community Health Center Working Area, Semarang City. The study population comprised individuals diagnosed with periodontal disease at the Genuk Community Health Center. A simple random sampling technique, a probability sampling method, was used. The sample size, determined using the Slovin Formula, consisted of 92 respondents. Data collection involved questionnaires completed by participants and direct observation of oral hygiene. Spatial data, specifically coordinates of periodontal disease locations, were recorded using ArcGIS Earth Geographic Information System software. In light of the fact that no analogous studies have been carried out in this area, this research is projected to yield beneficial information regarding the dissemination of periodontal disease according to its determinants within the service area of the Genuk Community Health Center. The results of the research show that the spread of periodontal disease in the Genuk Community Health Center working area is uneven, with Genuksari Village having the highest number of cases and Terboyo Kulon Village having the lowest number of cases with majority of respondents consume artesian water as their main water source.

Keywords: GIS; periodontal disease; spatial analysis

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INTRODUCTION

Periodontal disease encompasses a spectrum of conditions, including gingivitis, periodontitis, necrotizing periodontal disease, and periodontal abscess. These diseases are characterized by inflammatory and degenerative processes affecting the supporting soft and hard tissues of the teeth (Aliyah et al., 2022), (Rohmawati & Dyah Puspita Santik, 2019). Both local and systemic factors can contribute to the development of periodontal disease (Setiawan et al., 2020). According to the World Health Organization (WHO), the prevalence of periodontal disease in the 35-44 age group ranges from 45% to 75% (Harapan et al., 2020). Contributing factors can be visualized through spatial analysis, which presents data in the form of regional map visualizations (Sutarto et al., 2022). A geographic information system (GIS) is a system designed to store and process spatially referenced geographic data or coordinates, enabling visualization of health service utilization and consideration of location-related constraints (Kurniadin et al., 2023), (Saputra et al., 2023).

A sub-district, headed by a sub-district head, is a subdivision of a district or city responsible for carrying out governmental activities (Waruwu & Silalahi, 2020).

Genuk District, a suburban area of Semarang, covers 414 hectares and has a population of 4,444 (Islami & Pigawati, 2021). This district is frequently impacted by tidal floods and land subsidence (Ayuningtyas & Pigawati, 2019). Well water in Genuk District exhibits pH levels between 4 and 8, TDS levels below 3 ppm, and DHL values ranging from a minimum of 383 ms/cm to a maximum of 4,100 ms/cm. Most wells in this area yield brackish or salty water (Sriyono et al., 2010). This research aims to describe and determine the distribution of periodontal disease within the Genuk Community Health Center Working Area, Semarang City, using a Geographic Information System (GIS) application. The results of this research can inform dentists about the distribution of periodontal disease and its determinants in Genuk District, enabling them to develop strategies to mitigate its spread. Therefore, this research has the potential to significantly positively impact periodontal disease management within the Genuk Community Health Center Working Area, Semarang City.

METHOD

This research employed a descriptive observational cross-sectional design to determine the distribution of periodontal disease and its determinants within the Genuk Health Center Work Area, Semarang City, based on data collected at a single point in time. The study population comprised individuals diagnosed with periodontal disease at the Genuk Community Health Center. A simple random sampling technique, a probability sampling method, was used. The sample size, determined using the Slovin Formula, consisted of 92 respondents. Data collection involved questionnaires completed by participants and direct observation of oral hygiene. Spatial data, specifically coordinates of periodontal disease locations, were recorded using ArcGIS Earth Geographic Information System software. The research was conducted within the Genuk Community Health Center Area, Semarang City, Central Java, from December 2024 to January 2025. The tools and materials used included stationery, respondent biodata sheets, OHI-S forms, Closed-ended questionnaire, oral diagnostic sets, mobile phones, and the ArcGIS Earth application.

The initial step involved individual meetings with respondents willing to participate. Researchers explained the research procedures in detail, from questionnaire completion to oral health examinations. Informed consent, a form outlining complete research information and respondent rights, was obtained from each participant. Subsequent to obtaining informed consent, the respondents participated in a questionnaire that investigated potential causative factors of periodontal disease, with specific regard to water consumption. Subsequently, oral hygiene was assessed using the OHI-S index, a standard measurement tool in dental health research. Researchers also recorded the geographic coordinates of each participant's residence, crucial for mapping periodontal disease distribution. Using the ArcGIS application, these coordinates were plotted on a digital map. This process generated a visual representation of periodontal disease prevalence in the region. Data were analyzed using descriptive statistics, specifically univariate analysis, with IBM SPSS Statistics version 25. Univariate analysis described the characteristics of the research sample, focusing on periodontal disease and its determinants, such as oral hygiene and water consumption. This research has received an ethical certificate from the ethics committee and the number of the ethics certificate is No. 823/KE/11/2024.

Data from questionnaires and coordinate points were transferred to a Microsoft Excel worksheet for analysis. Raw coordinate data were converted into latitude and longitude values, which were then transformed into X and Y UTM (Universal Transverse Mercator) coordinates for more accurate mapping. Regional maps were downloaded from the Indonesian Geospatial Information Agency to serve as the base map. The processed data was then imported into ArcGIS Catalog. The UTM coordinate data, corresponding to the studied variables, was entered into the ArcGIS 10.8 application and displayed as points on the map. The downloaded sub-district maps were also added to ArcGIS 10.8. Finally, a legend was created within ArcGIS to facilitate interpretation of the map's points and colors. These systematic steps resulted in a map that serves as a valuable tool for analyzing the distribution of periodontal disease and its influencing factors.

RESULT

The distribution of periodontal disease in the Genuk Community Health Center Working Area is uneven. Genuksari Village has the highest number of cases, with 39 people (42.2%), followed by Banjardowo Village with 26 cases (28.3%), Gebangsari Village with 11 cases (12.0%), Trimulyo Village with 6 cases (6.5%), Terboyo Wetan Village with 3 cases (3.3%), and Terboyo Kulon Village with the lowest number of cases, 2 people (2.2%). (Figure 1) Based on the results of oral hygiene status examination using the OHI-S index, there is variation across villages. The majority of residents in Genuksari (20.7%) and Gebangsari (10.9%) Villages have good oral hygiene. In Muktiharjo Lor Village, both good and fair categories are equally represented, with 2.2% each. The majority of residents in Banjardowo Village also have good oral hygiene (15.2%). In Terboyo Wetan and Trimulyo Villages, the majority show fair oral hygiene (3.3%), and only a small proportion of residents in Terboyo Kulon Village have good oral hygiene (2.2%). (Figure 2)

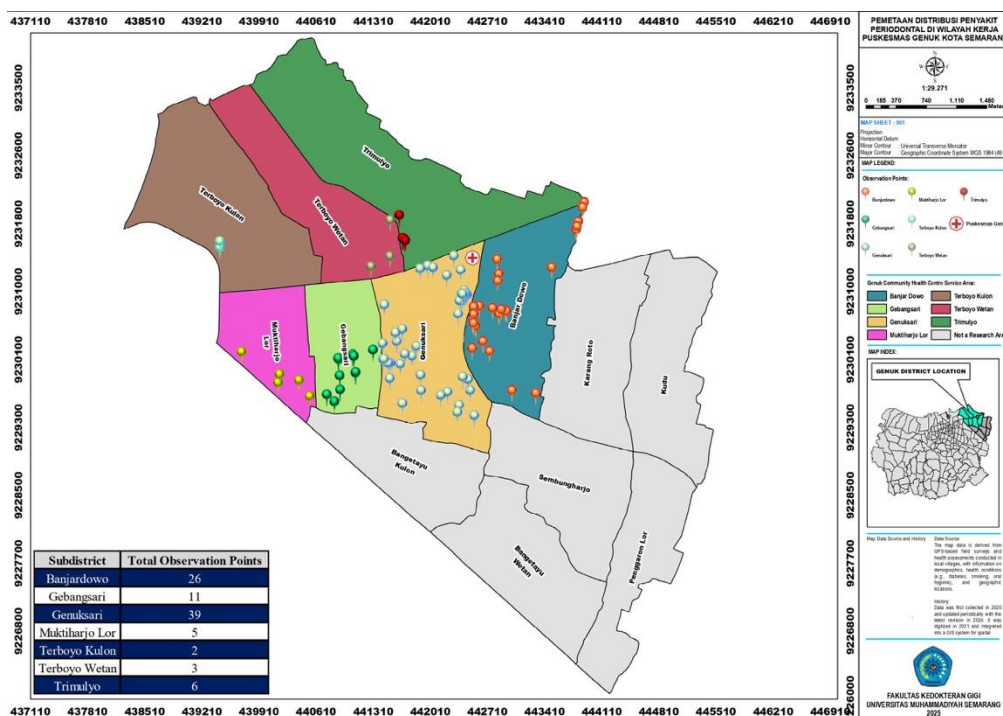


Figure 1. Periodontal Disease Mapping in the Genuk Health Center Working Area (2024)

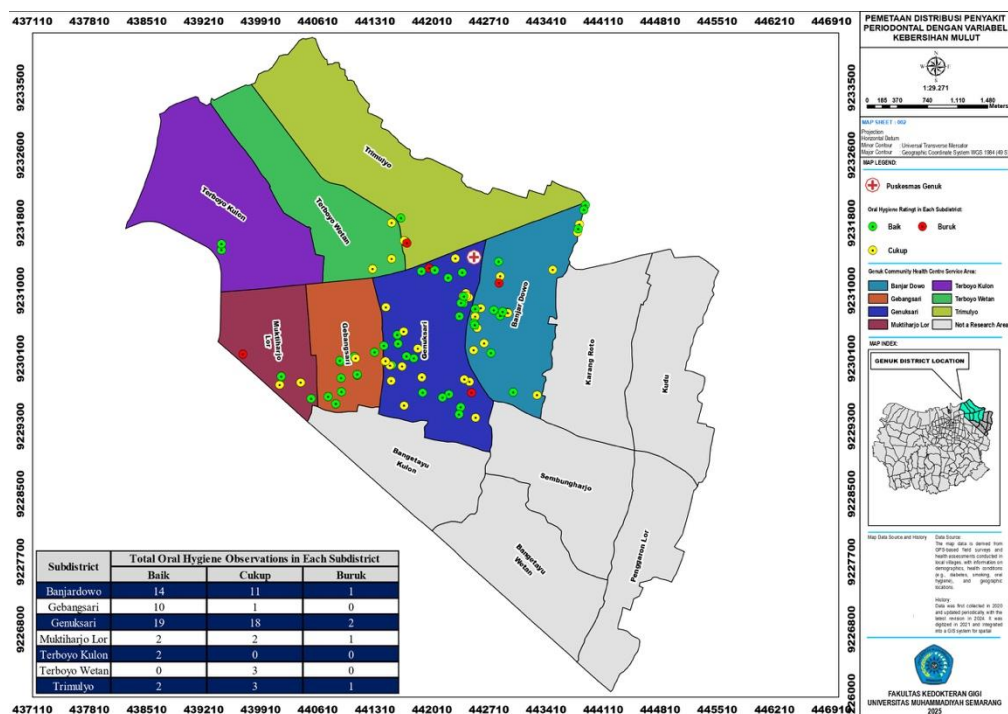


Figure 2. Periodontal Disease Distribution by Oral Hygiene (2024)

Based on water consumption status, respondents were classified into four groups based on their primary water source: bottled water, tap water (PDAM), well water, and artesian water. In Genuksari Village, the majority of respondents (37 people (40.2%)) consumed artesian water. In Gebangsari Village, tap water (PDAM) was the primary choice for 8 respondents (8.7%). Muktiharjo Lor and Banjardowo Villages were also dominated by artesian water consumption, with 5 (5.4%) and 17 (18.5%) respondents, respectively. In Terboyo Wetan and Trimulyo Villages, 3 (3.3%) and 6 (6.5%) respondents used artesian water. In Terboyo Kulon Village, tap water (PDAM) was the primary choice for 2 respondents (2.2%).(Figure 3)

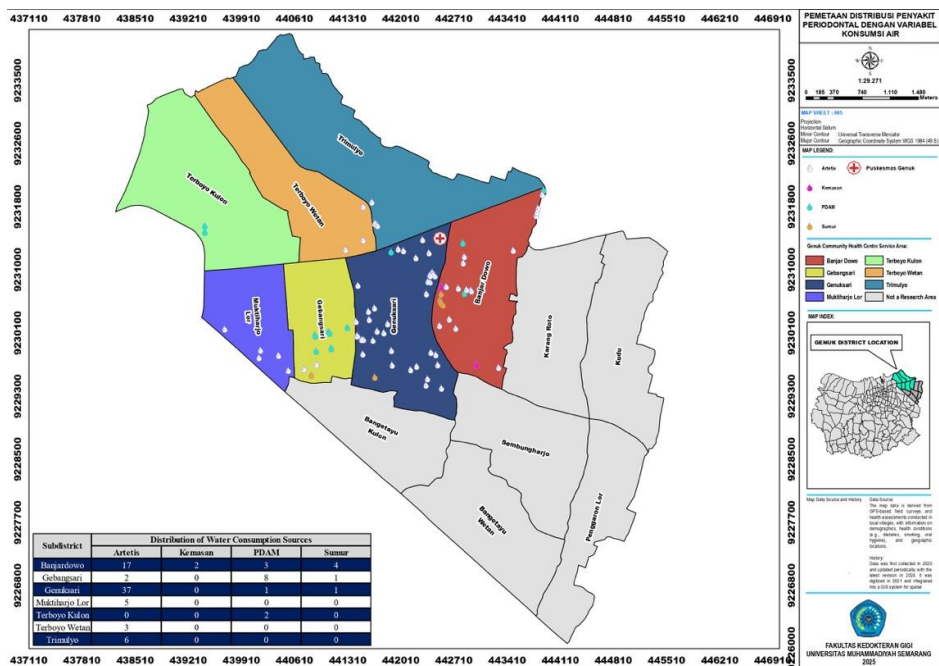


Figure 3. Periodontal Disease Distribution by Water Consumption (2024)

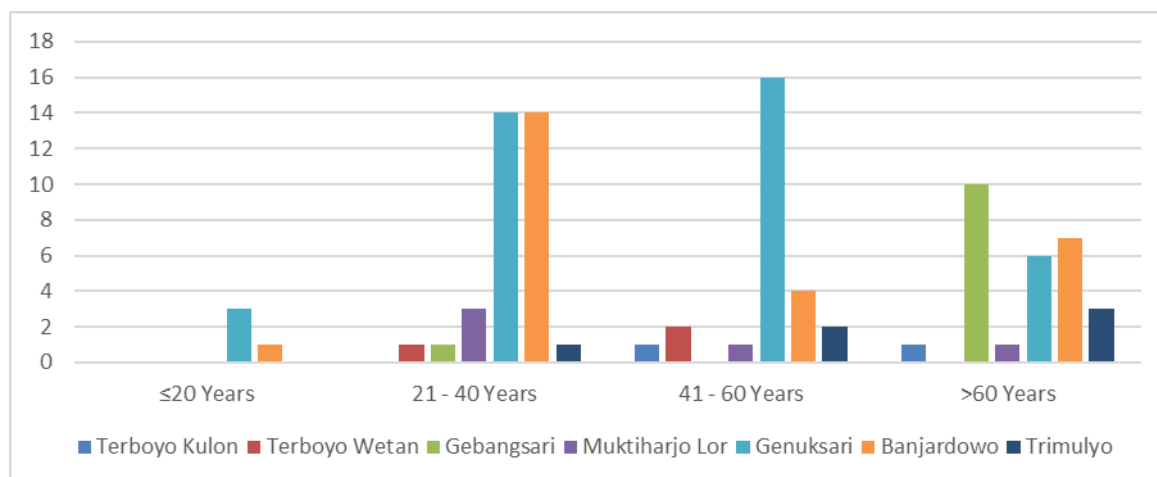


Figure 4. Age Distribution by District

Figure 4 shows In Terboyo Kulon Village, the majority are aged 41-60 years, with 1 respondent (50%), and >60 years, with 1 respondent (50%). In Terboyo Wetan Village, the majority are aged 41-60 years, with 2 respondents (66.7%). In Gebangsari Village, the majority are aged >60 years, with 10 respondents (90.9%). In Muktiharjo Lor Village, the majority are aged 21-40 years, with 3 respondents (60%). In Genuksari Village, the majority are aged 41-60 years, with 16 respondents (41%). In Banjardowo Village, the majority are aged 21-40 years, with 14 respondents (53.8%). In Trimulyo Village, the majority are aged >60 years, with 3 respondents (50%).(Figure 4)

DISCUSSION

Periodontal disease is a pathological condition characterized by inflammation and destruction of the tooth-supporting tissues. Its pathogenesis begins with the accumulation of bacterial plaque on the tooth surface, triggering an inflammatory response. The disease's progression is influenced by the amount and duration of plaque accumulation (Surya et al., 2019). At the cellular level, exposure to bacterial products and lipopolysaccharides stimulates the activation of monocytes and macrophages, which in turn triggers the secretion of inflammatory mediators such as interleukin-1 (IL-1), interleukin-6 (IL-6), and matrix metalloproteinases (MMPs) (Hayati et al., 2023). Dental and oral hygiene is typically assessed using an index, a numerical value derived from measurement. OHI-S scores are calculated by summing the debris index and calculus index scores obtained from examining six index teeth: the first molars of the upper and lower jaws, and the first incisors of the upper and lower jaws. These teeth are selected as representative indicators of oral hygiene in both the anterior and posterior regions of the oral cavity (Solavide Br Sijabat et al., 2020). The results of this study, using the OHI-S index, found that the majority of respondents 49 individuals (53.3%) exhibited good oral hygiene, followed by a substantial portion 38 individuals (41.3%) with fair oral hygiene.

Beyond local factors, environmental conditions, such as water quality, also contribute to the development of periodontal disease. Water with high purity and pH, generally containing high calcium levels, can increase calcium deposition on tooth surfaces, potentially accelerating calculus formation and increasing the risk of periodontal disease (Setiawan et al., 2019). Well water in the Genuk and Gayamsari districts exhibits pH levels between 4 and 8 and TDS levels below 3 ppm. These wells are relatively shallow, less than 4 meters deep, with the shallowest being 0.47 meters. Most wells are heavily infiltrated with water, and suspended

solids are present in nearly all samples. The well water color is often cloudy or black, and the taste is typically brackish to salty (Sriyono et al., 2010). This study found that the majority of respondents (76.1%) in the Genuk Community Health Center working area primarily consume artesian water. Artesian water is groundwater located beneath an impermeable layer of soil at depths of approximately 80-300 meters and often contains varying amounts of fluoride. While artesian water usage can potentially cause both aesthetic and functional tooth damage, impacting an individual's quality of life, untested or contaminated artesian water can lead to oral health problems such as infection or irritation. However, artesian water from a clean and safe source can also have positive effects on oral health (Romanenko Ye H et al., 2019; Souza et al., 2018; Wicaksono et al., 2019). Contributing factors can be visualized through spatial analysis, which presents data in the form of regional map visualizations (Sutarto et al., 2022). A geographic information system (GIS) is a system designed to store and process spatially referenced geographic data or coordinates, enabling visualization of health service utilization and consideration of location-related constraints (Kurniadin et al., 2023), (Saputra et al., 2023). According to the WHO, in healthcare, GIS can be used to identify disease spread patterns, identify at-risk groups, and support decision-making in disease prevention and control efforts. Within the health sector, GIS facilitates the spatial visualization of disease distribution and analysis of relationships between health-related variables. Disease mapping aids in monitoring disease spread within a specific area (Soultoni Akbar et al., 2023).

CONCLUSION

This study aimed to map the distribution of periodontal disease and its determinants within the Genuk Community Health Center working area. Results indicate an uneven distribution of periodontal disease, with the highest concentration of cases in Genuksari Village and the lowest in Terboyo Kulon Village. The majority of respondents were between 21 and 40 years old and male. While most respondents exhibited good oral hygiene, some presented with fair or poor oral hygiene.

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