

Application of geospatial information systems (GIS) for assessment of the distribution of periodontal disease in Makassar City, South Sulawesi Province, Indonesia

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Abstract

Addressing the presence of periodontal disease requires a high level of expertise to detect the disease as well as effective communication to understand patients' problems. Based on basic health data from 2018, the prevalence of this problem in Indonesia is approximately 74%. This study examined the distribution of periodontal conditions in March 2021 in Makassar City, the capital of South Sulawesi Province. To determine the distribution of periodontal disease, a questionnaire was used to find out the severity of this issue. A descriptive observational method, used with a cross-sectional design and a web-based geospatial information system (GIS) application linked to ArcGIS, was conducted. The results showed that out of the 15 districts in Makassar City, the island district of Sangkarrang had the highest presence of periodontal disease. Three other districts were classified as also

belonging to this low category, while 11 other ones exhibited a medium disease incidence score.

Introduzione

Based on 2018 data, the prevalence of periodontal disease in Indonesia is approximately 74% (Indonesian Ministry of Health, 2018). This issue is particularly dominant in South Sulawesi Province, which ranks 6th with respect to dental problems in Indonesia (Indonesian Ministry of Health, 2018). This high prevalence is largely attributed to lack of individual awareness (World Health Organization, 2013; Chen *et al.*, 2018) and compounded by microorganisms growing in dental plaques. Other contributing factors include sociodemographics (age, gender, education, income, occupation), ailments (diabetes, diseases of the cardiovascular system, kidneys, lungs, joints and stress) and habitat (smoking, tobacco use, liquor oral hygiene practices) (Nazir, 2017; Susanto, 2020).

Identifying periodontal disease is intricate, requiring a significant degree of expertise in terms of communication to comprehend patient concerns, and skilled clinical knowledge to distinguish it from other ailments (Newman *et al.*, 2015; Perry, 2014). Several epidemiological studies have used the community periodontal index of treatment need (CPITN) to identify periodontitis (Geest *et al.*, 2016; Grocock *et al.*, 2019). The community periodontal index (CPI) or the CPITN, issued by the American Dental Association and the Academy of Periodontology under the title "Periodontal Screening Record" (PSR) and by the British Society of Periodontology under the title "Basic Periodontal Examination" (BPE) are used to recognize and grade the disease. These assessment must be conducted by prepared a dental hygienist (Preshaw, 2015; Romano *et al.*, 2020). It has been understood that there are geographical variations of periodontitis and it would therefore be important to map out the location and socioeconomic associations of people with periodontal disease.

Basic periodontal assessment tools, invented for use by staff devoid of specialized clinical skills, can enable non-oral health-care professionals to screen their patients within the facility. Such tools can help assess patient risk of periodontal disease, provide referrals to dental professionals, and raise community awareness about oral health (Hartoyo *et al.*, 2010). A study conducted in Malaysia by Rani *et al.* (2020), assessed periodontal disease through this kind of self-assessment tool. An application with valid questions linked to a mapping system was prepared and used by Rani *et al.* (2020).

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Based on the experience of patient self-assessment approaches, this study was conducted utilizing an application connected to ArcGIS (Hartoyo *et al.*, 2010) to assess periodontal conditions and map their distribution across districts in Makassar City, South Sulawesi Province, Indonesia.

Materials and Methods

Study area

South Sulawesi Province has an area of 46,717.48 km² with a population of 9.07 million people (Delwel *et al.*, 2018; Indonesian Ministry of Health, 2018). Makassar, the provincial capital, was selected as the study location. It is the fourth largest city in Indonesia and the largest in Eastern Indonesia (Central Bureau of Statistics of South Sulawesi Province, 2021). Administratively, the city consists of 15 districts and the population in 2020 was estimated at 1,423,877 people spread over 175.77 km² of land, including three islands in the Makassar Strait that together make up Sangkarrang District (Makassar City Central Bureau of Statistics, 2021a, 2021b).

Selection of study subjects

This study used design cross sectional and observational descriptive. This study used a survey method with a questionnaire distributed to the community we distribute questionnaire randomly in the range of the age. This study was conducted in March 2021 in Makassar using descriptive observation with a cross-sectional design. People living in Makassar and aged between 15 and 75 years were asked to fill out an application survey (Table 1). Individuals who did not completely fill out the questionnaire, or submitted repeated responses, were excluded. The inclusion criteria were those at risk of having periodontal disease as defined by WHO (2013).

The instrument used in this study was the electronic application containing a questionnaire adapted from the Occupational Health Journal (Yamamoto, 2009). This application was linked to the ArcGIS (ESRI, Redlands, CA, USA) to assist the assessment of the local distribution of periodontal disease. The survey was disseminated through WhatsApp, and the geographical location of the

respondents was recorded. The recorded data included respondents who met the inclusion criteria Each district that reached a minimum (445 partisipant) of the required sample was included in the study.

Results

A total of 637 patients were recruited as samples but 192 were excluded from data analysis due to incomplete data, residence outside Makassar, and age falling in the exclusion criteria. The remaining 445 participants were spread across 15 districts, as shown in the map with the distribution of periodontal disease across each district in Makassar City (Figure 1).

Table 2 describes the relationship between the percentage of periodontal disease severity based on the different variables under study among the respondents. The great majority of participants were 15-25 years old females with intermidate level of schooling. Positively, the large majority brushed their teeth more than twice a day. Table 3 shows the disease distribution and the different categories by percentage. The percentage level in each district was obtained from the average value of the questionnaire results. Based on the results, 11 and 4 districts were in the medium and low category respectively. The map showing the percentage of periodontal disease levels across each district in Makassar City is shown in Figure 2. It describes the percentage level of periodontal disease across each district in Makassar City. Sangkarrang District had a high disease proportion, while 11 districts were in the moderate category. These included Biringkanaya, Bontoala, Mamajang, Mariso, Panakukkang, Rappocini, Tallo, Tamalanrea, Tamalate, Ujung Pandang and Wajo. Three districts, Makassar, Manggala, and Ujung Tanah, had a low proportion of the disease. Table 4 shows the number of cases and proportions of the districts investigated as reflected by the education level, frequency of brushing teeth and gender.

Discussion

Based on the results, a total of 445 respondents participated in the survey, consisting of 172 (39%) males and 273 (61%) females.

Table 1. Questionnaire to evaluate periodontal disease.

Questions	Answers
1. Are you a smoker/have you smoked before?	Yes/No
2. Have your gums been bleeding recently?	Yes/No
3. Do you feel your gums are swollen?	Yes/No
4. Do you have loose teeth?	Yes/No
5. Do you think your teeth look longer than before?	Yes/No
6. Do you feel you have gum disease?	Yes/No
7. Have you ever been informed by your dentist that you have gum disease?	Yes/No
8. Have you ever been informed by your dentist that you have deep gum pockets?	Yes/No
9. Have you ever been asked to have gum treatment done?	Yes/No
10. Have you ever undergone gum treatment surgery?	Yes/No
11. Have you ever felt like your breath smells?	Yes/No
12. Has anyone ever told you that your breath smells?	Yes/No

Table 4 shows that the average score for periodontal disease was higher in males than in females with percentages of 24% and 19.21% respectively. This was in line with the study conducted by Setiawan *et al.* (2020) stating that women tend to take greater responsibility in maintaining their health compared to men. Women often seek healthcare services such as public health center to monitor their health conditions. Madi *et al.* (2021), also reported that men were at greater risk of developing periodontal disease compared to women. Although the exact gender-related causes remain unclear, this distinction may be attributed to the lower readiness among men to practice dental hygiene. A similar study by Chen *et al.* (2018) established a connection between periodontal status among teenagers and gender. This was attributed to higher mindfulness about oral wellbeing among young females. The better oral hygiene practiced by young females could potentially clarify the distinction between the genders.

Table 2. Distribution of periodontal disease in Makassar City in 2021.

Variable	Characteristic	No.	%
Gender	Man	172	24
	Woman	273	19
Age	15-25 years old	373	20
	26-45 years old	58	28
	46-65 years old	14	29
Teeth brushing habit	<twice a day	29	27
	≥twice a day	416	21
Level of education	Low	34	29
	Intermediate	246	22
	High	165	21
Smoking habit	Smoker	201	29
	Non-smoker	244	15

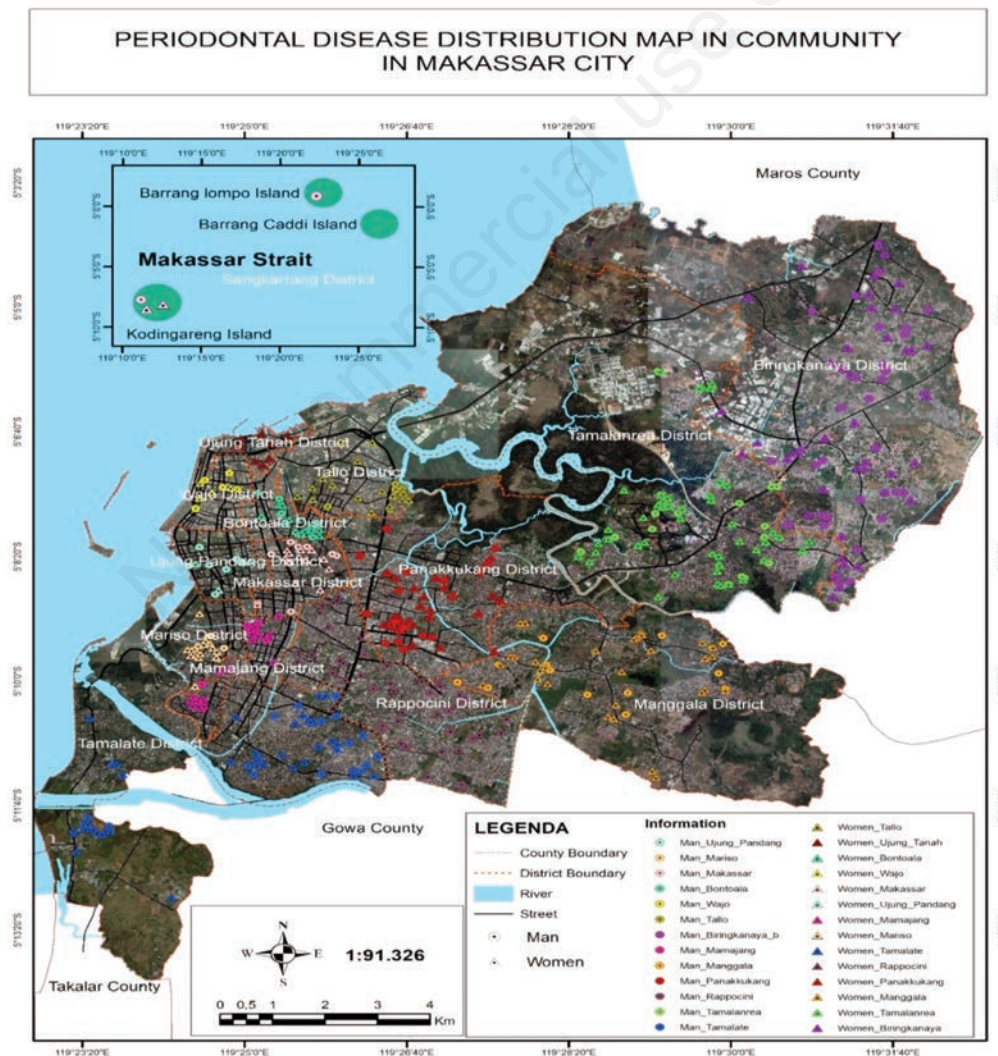


Figure 1. The distribution, gender and location of periodontal disease found by district in Makassar City in 2021.



Based on the distribution of periodontal disease in Makassar city, Sangkarrang District had disease score in the high category, while 11 districts had moderate scores. These included Biringkanaya, Bontoala, Mamajang, Mariso, Panakkukang, Rappocini, Tallo, Tamalanrea, Tamalate, Ujung Pandang, and Wajo district. For low scores, 3 districts were identified namely Makassar, Manggala, and Ujung Tanah. This research in line with the research done in Lebanon (Mihaela *et al.*, 2017; Diab *et al.*, 2017). The data obtained show that there seems to be a relationship between the level of education and the incidence of periodontal

disease in Sangkarrang District. As shown in Table 4, respondents from this district predominantly had generally only basic education due to the few schools providing higher education. Based on the Central Bureau of Statistics of Makassar City, there are 5 private kindergartens, 7 public elementary, 5 public junior high schools, 1 private junior high school, and 2 private high schools divided across the three islands. Our results with respect to the relationship between education and periodontitis is in line with a study conducted by Aremu *et al.* (2023), (Kim *et al.*, 2018; Suratri & Notohartoyo, 2016), who point out a low education level as a

Table 3. Distribution and severity of periodontal disease in Makassar City 2021.

No.	District	No. of cases (%) Sample (n)	Incidence (%) Population (N)	Category
1	Mariso	17 (4)	22.43	Medium
2	Ujung Pandang	8 (2)	23.44	Medium
3	Ujung Tanah	9 (2)	17.36	Medium
4	Biringkanaya	66 (15)	21.78	Medium
5	Makassar	22 (5)	16	Medium
6	Panakkukang	46 (10)	20.24	Low
7	sangkarrang	4 (1)	28.13	Medium
8	Wajo	8 (2)	23	Medium
9	Mamajang	16 (4)	20.31	Low
10	Tamalanrea	51 (11)	21.08	Medium
11	Manggala	42 (9)	19.94	Medium
12	Tamalate	54 (12)	21.36	Low
13	Tallo	38 (9)	21.38	Medium
14	Bontoala	15 (3)	21.25	Low
15	Rappocini	49 (11)	22.83	Medium

Table 4. Characteristicsof survey respondents in each district in Makassar Cityin 2021.

District	Education				Brushing teeth		Gender		Category of disease severity
	Elementary n (%)	Junior high n (%)	Senior high n (%)	University n (%)	< Twice a day	≥ Twice a day	Male	Female	
Mariso	0 (0.0)	0 (0.0)	15 (88)	2 (12)	2 (11.8)	15 (88.2)	3 (17.6)	14 (82.4)	Medium
Mamajang	0 (0.0)	0 (0.0)	12 (75)	4 (25)	1 (6.3)	15 (93.7)	4 (25)	12 (75)	Medium
Tamalate	3 (6)	0 (0.0)	27 (50)	24 (44)	3 (5.6)	51 (94.4)	25 (46.3)	29 (53.7)	Medium
Rappocini	9 (18)	0 (0.0)	18 (37)	22 (45)	2 (4.1)	47 (95.9)	13 (26.5)	36 (73.5)	Medium
Makassar	1 (4)	0 (0.0)	12 (55)	9 (41)	2 (9.09)	20 (90.91)	8 (36.4)	14 (63.6)	Low
Ujung Pandang	0 (0.0)	0 (0.0)	7 (87.5)	1 (12.5)	0 (0)	8 (100)	5 (62.5)	3 (37.5)	Medium
Wajo	0 (0.0)	0 (0.0)	5 (62.5)	3 (37.5)	0 (0)	8 (100)	5 (62.5)	3 (37.5)	Medium
Bontoala	2 (13.3)	0 (0.0)	11 (73.3)	2 (13.3)	1 (6.7)	14 (93.3)	6 (40)	9 (60)	Medium
Ujung tanah	0 (0.0)	0 (0.0)	5 (56)	4 (44)	0 (0)	9 (100)	0 (0)	9 (100)	Low
Sangkarrang	2 (50)	0 (0.0)	1 (50)	0 (0)	3 (75)	1 (25)	2 (50)	2 (50)	High
Tallo	5 (13)	1 (3)	19 (50)	13 (34)	2 (5.3)	36 (94.7)	13 (34.2)	25 (65.8)	Medium
Panakkukang	2 (4)	0 (0.0)	27 (59)	17 (37)	2 (4.3)	44 (95.7)	21 (45.7)	25 (54.3)	Medium
Manggala	2 (5)	0 (0.0)	19 (45)	21 (50)	2 (4.8)	40 (95.2)	22 (52.4)	20 (47.6)	Low
Biringkanaya	5 (8)	1 (2)	30 (45)	30 (45)	2 (3)	64 (97)	29 (43.9)	37 (56.1)	Medium
Tamalanrea	2 (5)	0 (0.0)	26 (63)	13 (32)	4 (7.8)	47 (92.2)	16 (31.4)	35 (68.6)	Medium

potential risk indicator for the state of oral health. Education provides a basis for making informed decisions related to oral health practices. The Sangkarrang district has limitations in education which may lead to low public understanding of dental and oral health (Makassar City Central Bureau of Statistics, 2021a, 2021b; Nyorobi *et al.*, 2018).

The three districts with low scores regarding periodontal incidence, namely Makassar, Manggala, and Ujung Tanah can be attributed to the degree of education and the frequency of brushing the teeth. These three districts had less than 5% primary school education as well as 95% secondary school and high education levels and their frequency of cleaning teeth averaged above 90%.

Limiations

The present research is more descriptive than dynamic. A main reason is that we did not have access to a sufficiently large group that could be tested by application of a larger set of variables with regard to presence and/or severity of periodontal disease. Cluster analysis, a statistical technique used in data analysis to group simi-

lar data together, which means that the total dataset can be partitioned into clusters based on similarities or dissimilarities. This would reveal whether or not there is autocorrelation and hotspots, which could provide new insights into the causes and prevalence of periodontal disease. We intend to continue our research in this area.

Conclusions

Sangkarrang was found to be the district most affected by severe cases of periodontal disease in Makassar City. This district is situated within an archipelago, facing challenges of inadequate health facilities and availability of clean water. The scarcity of educational institutions, both private and public here affect the level of community knowledge, specifically regarding dental and oral health. In addition, the results show that the determinant variables, such as gender, age, education level, frequency of tooth brushing, and behaviour associated with tobacco, are significantly associated with the severity of periodontal disease.

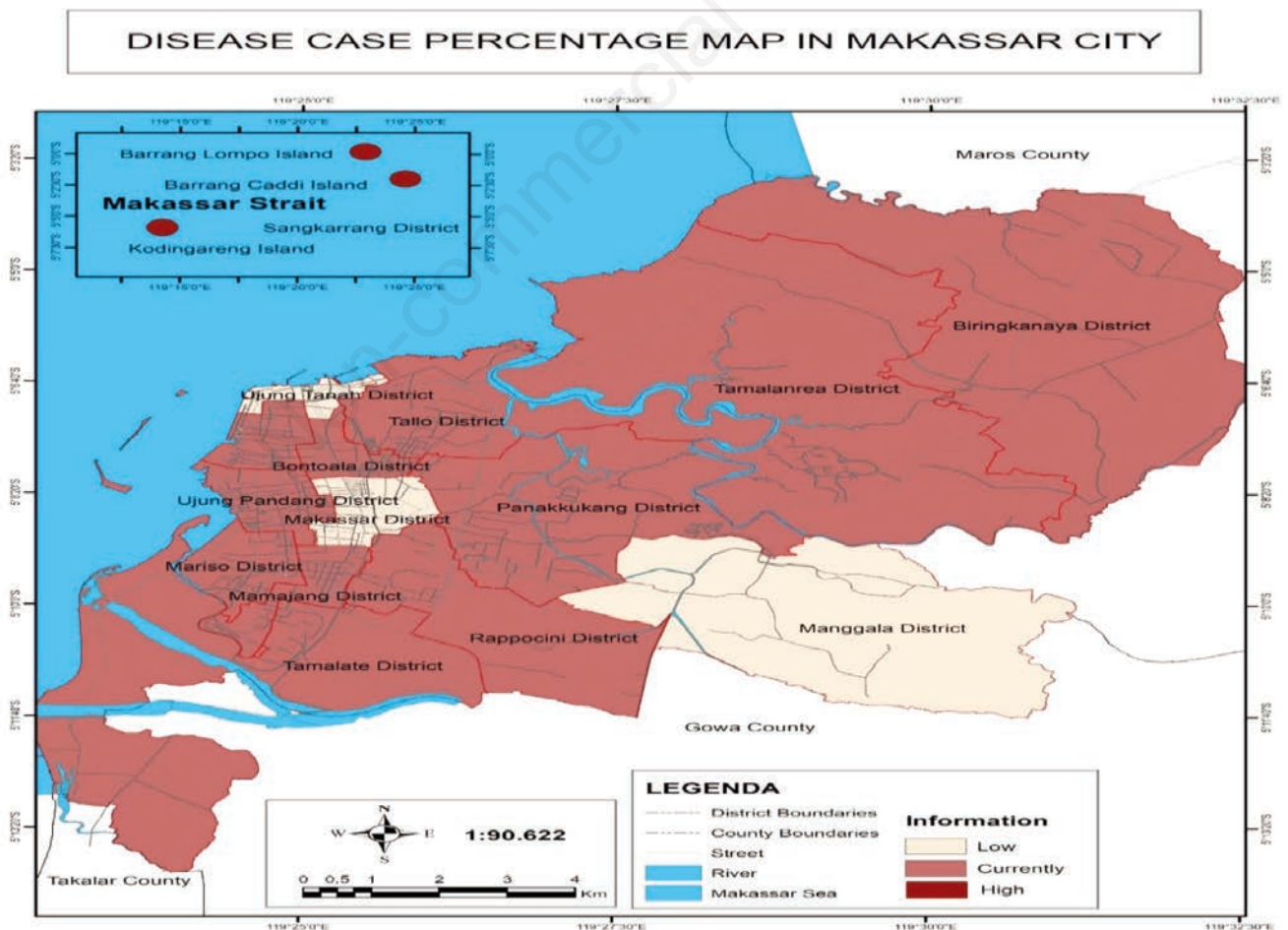


Figure 2. Map of the severity level (Low, Moderate, High) percentage of disease found by districtin Makassar City in 2021.



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