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Research Article

Socio-demographic Factors of Caries and Dental Fillings in Indonesia with a Geospatial Mapping Approach

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KEYWORDS

Dental fillings, geospatial information system, sociodemographic., untreated caries

ABSTRACT

Introduction: Untreated caries is one of the oral diseases that poses a significant burden in Indonesia. The perceived need for people to receive dental treatment is influenced by sociodemographic, economic, environmental, and healthcare service factors. The purpose of this study was to determine sociodemographic factors towards untreated caries and dental fillings in Indonesia and then visualize them in geospatial mapping.
Material and Methods: A cross-sectional study used secondary data from Basic Health Research 2018. A sample was 14.031 subjects, then classified based on WHO age group and sociodemographic factors. As gender, residence, educational level, employment status, and frequency of dental visits as independent variables. Then, the number of untreated caries and fillings is the dependent variable. The bivariate analysis was used to determine different factors. QGIS was used to visualize dependent variables in 26 provinces in Indonesia.
Results and Discussions: There was a statistically significant difference ($p<0.05$) in the 35-44 years age group between females, rural residents, those with no schooling, and informal workers concerning untreated caries. Meanwhile, females, urban residents, college diploma holders, formal workers, and those with dental visits showed a tendency toward dental fillings. This result closely aligns with overlay mapping geospatial analysis.
Conclusion: Sociodemographic characteristics had an impact on untreated caries and dental fillings and should be considered to find comprehensive strategies to improve oral health care.

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INTRODUCTION

In many countries, oral health issues represent a significant health burden.[1] Globally, more than 3.7 billion people are affected by oral and dental problems.[2] According to Basic Health Research 2018, the proportion of the Indonesian population with oral and dental problems is 57.6%, and only 10.2% received treatment from dental personnel. The DMFT index in children showed 8.43, and the DMFT index was 7.02 in the 35-44 age group.[3] In addition, this problem negatively impacts a person's quality of life by causing pain, discomfort when chewing, and a lack of confidence.[4]

Oral diseases have a multifactorial etiology, involving biological, social, economic, cultural, and environmental factors that contribute to this condition.[5] Untreated dental cavities are the most prevalent than other oral problems.[6] Several studies have shown that people from lower socioeconomic strata have a disproportionately high burden of dental caries.[5] Contextual and individual factors, such as age, gender, residence, occupation, economic status, and level of education, influenced the disparities in utilization of dental health services.[7]

Studies have shown, people with lower incomes and levels of educational attainment have a more negative attitude toward dental fillings.[8] Determinants influencing the delivery of dental caries treatment services encompass the quantity and geographical distribution of oral health facilities, governmental funding and policies, the cost related to dental equipment and materials, consumer affordability, the availability of human resources, and the perceived need for oral health.[9] Non-regular dental attendance was indicated on the unemployment status. [10]

Exploring the interplay between sociodemographic and dental conditions is essential for developing an intervention strategy. In recent years, spatial epidemiology has developed in data mapping.[11] Epidemiology data visualization is offered by Geographic Information Systems (GIS). Health researchers can utilize the development of epidemiological data mapping to see where diseases or determining factors were distributed.[12] Since 1960, the application of GIS in Dental Public Health has been limited in scope, which includes the ratio of income dentists, community health facility utilization and accessibility, dentists, and dental services distribution mapping.[13] This study aims to analyze sociodemographic factors towards untreated caries and dental fillings in Indonesia with a geospatial mapping approach based on the distribution area.

MATERIAL AND METHODS

This study design was a cross-sectional analytic study using secondary data from Basic Health Research 2018. The target sample, Basic Health Research, who visited by the Central Bureau of Statistics, was 300,000 households from 30,000 census blocks in 34 Provinces in Indonesia with PPS (Probability Proportional to Size) method uses linear systematic sampling with two-stage sampling.

The first stage was implicit stratification of all census blocks as a result population census based on welfare strata. From the 720,000 census block master frame, 180,000 census blocks (25%) were selected using PPS as the sampling frame for census block selection. After that, select a number of census blocks with the PPS method in each urban/ rural stratum per district/city systematically to reach a Census Block Sample List. So, the total number of Census blocks selected is 30,000 according to the General Basic Health Research 2018 data. The second stage selected 10 households in every census block as a nationally representative subsample for dental and oral examination, set at 2,500 census blocks in 26 provinces. Using systematic sampling, the sample obtained was 46,333 samples.

The total number of samples was 14,031, which were used for subsample dental and oral examination. Then classified into the WHO age group, which were 731 samples (5 years), 761 samples (12 years), 700 samples (15 years), 8,220 samples (35-44 years), and 3,619 samples (65+ years). The sociodemographic factors as independent variables were gender, residence, education level, employment status, and frequency of dental visits based on WHO age group. The amount of dental fillings and decay overall is the dependent variable. Tooth decay was represented by an untreated caries.

Ethics approval was obtained from the Dental Research Ethics Committee, Faculty of Dentistry, Universitas Indonesia (Protocol Number: 030750921). The data analysis used the IBM SPSS Statistics 25 version. We conducted a univariate statistical test to describe sociodemographic variables. The Mann-Whitney and Kruskal-Wallis test was used to analyze determinants such as sociodemographic factors. The variables of the number of tooth decay and fillings were mapped into a geospatial clustering mapping. The Quantum GIS software 3.18.1 - Zurich version was used to mapping that variable (https://www.qgis.org/). The Indonesia map was used from (https://www.indonesia-geospasial.com/2020/04/ download-shapefile-shp-batas. html).____Geo-coding involves by transforming survey location data into geographic coordinates with Global Positioning Systems (GPS) to create a spatial dataset. After that, geographic information could be synthesized by overlay analysis techniques to combine several datasets (tooth decay and fillings) into one digital map to present a susceptible risk area.

RESULTS AND DISCUSSIONS

The different determinant factors of untreated caries and dental fillings in 34 provinces in Indonesia (Table 1), the classification factors based on Basic Health Research 2018, and the WHO age group, which were gender, residence, education level, employment status, and frequency of dental visits. Samples were dominated by the age group of 35-44 years old, around 58.6%. The female gender had the largest percentage at age 35-44 (62.3%) and 65+ (52.5%) than males. Elementary-high school grades were the highest percentage among education levels at all age groups. The proportion of informal workers at age 35-44 and 65+ was 56.3% and 50%. More than 50% people were living in urban residences of each age group except age 65+. The proportion of never receiving dental treatment in a year was the highest percentage across all age groups (Table 1).

Table 1. Distribution of sociodemographic characteristics and dental utilization by WHO aged group in Indonesia

Variable	n (%)					Total
	5	12	15	35-44	65+	
WHO age group	731(5.2)	761(5.4)	700 (5)	8,220 (58.6)	3,619 (25.8)	14,031
Gender						
Male	381 (52.1)	384 (50.5)	351(50.1)	3,097 (37.7)	1,718 (47.5)	5,931 (42.3)
Female	350 (47.9)	377 (49.5)	349 (49.9)	5,123 (62.3)	1,901 (52.5)	8,100 (57.7)
Location of residence						
Rural	361 (49.4)	362 (47.6)	310 (44.3)	4,023 (48.9)	1,951 (53.9)	7,007 (49.9)
Urban	370 (50.6)	399 (52.4)	390 (55.7)	4,197 (51.1)	1,668 (46.1)	7,024 (50.1)
Education level						
No school		42 (5.5)	7 (1)	234 (2.8)	904 (25)	1,187 (8.5)
Elementary-high school	-	719 (94.5)	693 (99)	7,418 (90.2)	2,576 (71.2)	11,406 (81.3)
Diploma 3-college		-	-	568 (6.9)	139 (3.8)	707 (5)
Employment status						
Unemployment		180 (23.7)	166 (23.7)	2,670 (32.5)	1,739 (48,1)	4,755 (33.9)
Formal workers	-	-	6 (0.9)	886 (10.8)	54 (1,5)	946 (6.7)
Informal workers		5 (0.7)	22 (3.1)	4,628 (56.3)	1,810 (50)	6,465 (46.1)
Student		576 (75.7)	506 (72.3)	36 (0.4)	16 (0.4)	1,134 (8.1)
Frequency dental treatment a year ago						
Never	629 (86)	648 (85.2)	608 (86.9)	6,807 (82.8)	3,194 (88.3)	11,886 (84.7)
1-3 times	82 (11.2)	91 (12)	63 (9)	1,081 (13.2)	303 (8.4)	1,620 (11.5)
4-6 times	17 (2.3)	18 (2.4)	22 (3.1)	252 (3.1)	96 (2.7)	405 (2.9)
>7 times	3 (0.4)	4 (0.5)	7 (1)	80 (1)	26 (0.7)	120 (0.8)

In all characteristic sociodemographic, the mean of untreated caries was higher than dental fillings (Tables 2 & 3). The results of different factors contributing towards untreated caries can be seen in Table 2. A difference between female (5.3±4.8), rural residence (5.4±4.8), no school (5.6±5.1), and informal workers (5.4±4.8) was statistically significant (p-value <0.05). The results for the age group of 65+ showed a significant difference statistically (p-value <0.05) in students as employment status (7.1±6.1) and the frequency of dental visits more

seven times a year (7.9±5.7). Frequency of dental visit 1-3 times was statistically significantly different between group five (5.5±5.9) and group 15 years (3.4±3.2). The more decay they had on their tooth, the more often they visited the dentist in a year.

Table 2. Determinant factors of untreated caries in Indonesia

Variable	Untreated caries										
	5		12		15		35-44		65+		Total
	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)
WHO age group	8.1 (5.3)		1.8 (2.3)		2.4 (2.8)		5.2 (4.6)		6.4 (5.7)		
Gender											
Male	8.1 (5.4)	0.297[a]	1.7 (2.2)	0.129[a]	2.4 (2.7)	0.073[a]	5.1 (4.5)	0.001[a]*	6.6 (5.9)	0.107[a]	4.9 (4.7)
Female	8.3 (5.4)		2.0 (2.3)		2.5 (2.9)		5.3 (4.8)		6.2 (5.5)		5.0 (5.1)
Residence											
Rural	8.1 (5.0)	0.311[a]	1.9 (2.5)	0.463[a]	2.4 (2.8)	0.463[a]	5.4 (4.8)	0.001[a]*	6.6 (5.8)	0.093[a]	5.2 (5.1)
Urban	8.2 (5.7)		1.8 (2.2)		2.5 (2.9)		5.0 (4.4)		6.2 (5.5)		4.7 (4.6)
Educational level											
No school	-		2.1 (2.7)	0.480[a]	1.1 (1.2)	0.271[a]	5.6 (5.1)	0.000[b]*	6.4 (5.8)	0.003[b]*	6.1 (5.7)
Elementary-high school			1.8 (2.3)		2.5 (2.8)		5.3 (4.6)		6.5 (5.6)		5.2 (4.8)
Diploma 3-college			-				4.0 (3.8)		4.8 (4.6)		4.2 (3.9)
Employment status											
Unemployment	-		1.9 (2.4)	0.843[a]	2.6 (3.0)	0.957[b]	5.2 (4.4)	0.000[b]*	5.9 (5.5)	0.000[b]	5.2 (4.8)
Formal workers			-		2.0 (1.3)		4.5 (4.1)		6.2 (5.2)		4.6 (4.2)
Informal workers			1.0 (1.0)		2.7 (3.1)		5.4 (4.8)		6.8 (5.8)		5.8 (5.1)
Student			1.8 (2.3)		2.4 (2.8)		5.2 (4.9)		7.1 (6.1)		2.3 (2.8)
Frequency dental visit a year ago											
Never	7.9 (5.3)	0.000[b]*	1.8 (2.3)	0.589[b]	2.4 (2.8)	0.021[b]*	5.2 (4.6)	0.087[b]	6.5 (5.7)	0.050[b]*	4.9 (4.9)
1-3 times	10.1(5.5)		1.9 (2.1)		3.4 (3.2)		5.3 (4.4)		5.5 (4.8)		4.8 (4.4)
4-6 times	5.9 (4.9)		2.3 (2.5)		2.7 (2.5)		5.5 (4.5)		6.1 (5.5)		5.2 (4.7)
>7 times	11.3 (6.0)		1.5 (2.4)		1.4 (1.5)		5.2 (4.9)		7.9 (5.7)		5.7 (4.9)

[a]*Mann-Whitney,* [b]*Kruskal-Wallis (p<0,05)*

The analysis of determinant factors resulting in dental fillings can be seen in Table 3. In group 35-44 years, all characteristic sociodemographic variables were female (0.1±0.5), urban (0.1±0.7), diploma 3-college (0.5±1.4), formal workers (0.2±1.0), more than 7 times dental visit (0.4±1.7), statistically significant difference (p-value < 0.05). This result is similar to the group of 65+ years but except that genders weren't statistically different (p-value >0.05). However, only the frequency of dental visits towards tooth fillings in group 15 years showed statistically significant differences between groups (Table 3).

Table 3. Determinant factors of dental fillings in Indonesia

Variable	Dental fillings										
	5		12		15		35-44		65+		Total
	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)	p-value	$\underline{x}$ (SD)
WHO age group	0.0 (0.2)		0.0 (0.1)		0.0 (0.1)		0.1 (0.5)		0.1 (0.4)		
Gender											
Male	0.0 (0.2)	1.000[a]	0.0 (0.1)	0.642[a]	0.0 (0.1)	0.751[a]	0.1 (0.5)	0.000[a]*	0.0 (0.3)	0.095[a]	0.1 (0.4)
Female	0.0 (0.2)		0.0 (0.9)		0.0 (0.2)		0.1 (0.5)		0.1 (0.5)		0.1 (0.5)
Residence											
Rural	0.0 (0.0)	1.000[a]	0.0 (0.1)	0.251[a]	0.0 (0.1)	0.251[a]	0.0 (0.2)	0.001[a]*	0.0 (0.1)	0.000[a]*	0.0 (0.2)

Urban	0.0 (0.2)		0.0 (0.1)		0.0 (0.2)		0.1 (0.7)		0.1 (0.6)	0.1 (0.6)
Educational level										
No school			0.0 (0.0)		0.0 (0.0)		0.0 (0.2)		0.0 (0.1)	0.0 (0.1)
Elementary-high school		-	0.0 (0.1)	0.588[a]	0.0 (0.1)	0.737[a]	0.1 (0.4)	0.000[b*]	0.0 (0.4)	0.000[b*] 0.1 (0.3)
Diploma 3-college				-			0.5 (1.4)		0.5 (1.2)	0.5 (1.3)
Employment status										
Unemployment			0.0 (0.1)		0.0 (0.0)		0.1 (0.5)		0.1 (0.5)	0.1 (0.5)
Formal workers			-		0.0 (0.0)		0.2 (1.0)		0.3 (0.8)	0.2 (1.0)
Informal workers		-	0.0 (0.0)	0.843[a]	0.0 (0.0)	0.233[b]	0.1 (0.3)	0.000[b*]	0.0 (0.3)	0.000[b] 0.0 (0.3)
Student			0.0 (0.1)		0.0 (0.2)		0.0 (0.2)		0.0 (0.0)	0.0 (0.1)
Frequency dental visit a year ago										
Never	0.0 (0.1)		0.0 (0.1)		0.0 (0.1)		0.1 (0.4)		0.0 (0.3)	0.0 (0.3)
1-3 times	0.1 (0.4)		0.0 (0.1)		0.1 (0.3)		0.2 (0.9)		0.2 (0.9)	0.2 (0.8)
4-6 times	0.2 (0.5)	1.000[b]	0.0 (0.0)	0.934[b]	0.1 (0.2)	0.000[b*]	0.3 (1.0)	0.000[b*]	0.1 (0.6)	0.050[b*] 0.2 (0.8)
>7 times	0.7 (0.6)		0.0 (0.0)		0.0 (0.0)		0.4 (1.7)		0.1 (0.6)	0.3 (1.4)

[a]*Mann-Whitney,* [b]*Kruskal-Wallis (p<0,05)*

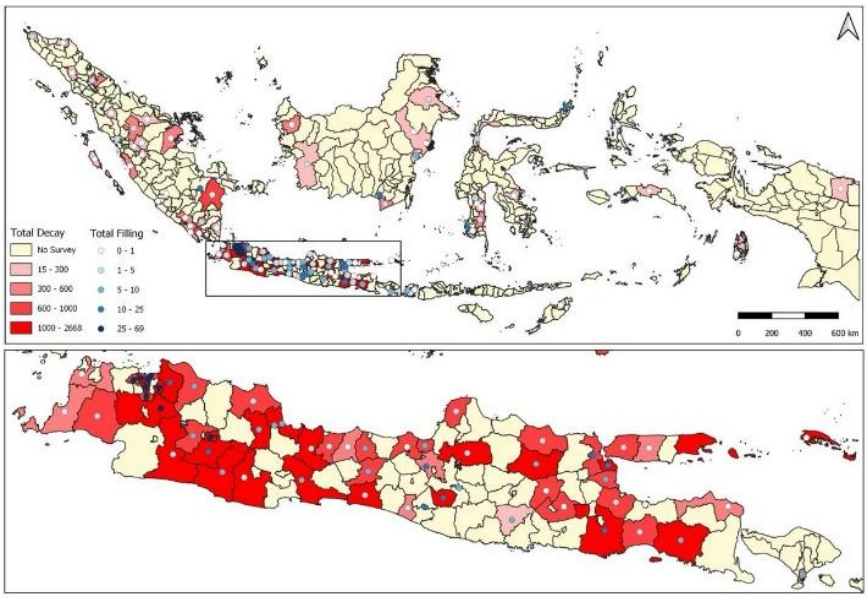

Figure 1. Overlay analysis distribution of untreated caries and dental fillings.

Figure 1 presents of overlay analysis on a map of the distribution of untreated caries and dental fillings. This geospatial map approach to visualization comparison is based on urban and rural areas. According to the survey's spatial distribution, we can see on the map with a red graded legend, which shows the distribution of untreated caries. Almost all areas have a red legend, it's indicates the number of untreated caries more higher than other colors, around 1,000-2,668 untreated caries. Java Island is the capital city, and the majority of respondents came from there. However, the high prevalence of untreated caries was not in line with and proportional to the effort to fill cavities. In some areas, even though the number of untreated caries is very high, no teeth were filled. The overlay analysis on Figure 1 most closely correlated with the result analysis statistics between urban and rural areas towards untreated caries and dental fillings.

Various determinant factors analysis was gender (female and male), residence (urban and rural), educational level (no school, elementary-high school, diploma3-college), employment status (student, unemployment, formal and informal workers), and frequency of dental visit a year ago. From this study, the prevalence of untreated caries is higher than dental fillings in all aspects. In accordance with the results study by Qin et al. that the low number of dental fillings indicates a high level of untreated caries.[14] According to the National Oral Health Survey in Malawi as a low-income country, the prevelance of caries and dental fillings based on WHO age group of 12 years age group is 19.1% and 0.2%, 15 years age group is 21.9% and 1.3%, 35-44 years age group is 49% and 8.7%, 65-74 years age group is 49% and 12.7%. Overall, the prevalence of dental caries is 37.4% higher than dental fillings, only 6.5%.[15]

The low treatment needs for dental caries, such as dental fillings, are influenced by individual characteristics and other factors, including socio demographic, income level, educational, and occupational status, which affect a person's attitude towards dental care. [8] Our study demonstrated that there are burdens and a high prevalence, as well as a statistical difference in untreated caries and dental fillings in the 35-44 year age group. The difference occurs between female, rural residents, with no school, and informal workers, regarding untreated caries. However, the difference in dental fillings occurs in female, urban, diploma 3-college, formal workers, during a dental visit. In Etophia and Malawi, tooth decay often occurs in women.[15] This condition is influenced by the female hormone estrogen. The accumulated effect of estrogen during puberty and pregnancy can reduce saliva and self-cleansing. During pregnancy, women tend to prefer the consumption of sweet food, experience nausea, and vomit. This habit produces acidic conditions in the oral cavity and causes the demineralization process.[16,17] On the other hand, females pay more attention and awareness to their oral health, show greater compliance, and demonstrate improved oral health practices compared to males.[18]

The estimated high prevalence of untreated caries and low dental fillings in rural areas from this study. The findings of this study were consistent with the findings from other studies, dental caries is more prevalent in rural areas. This may be because rural areas are often characterized by poverty, unemployment, low education, and fewer healthcare services.[19] The difficulty in accessing and the limited available health facilities in rural areas cause untreated caries to be higher than in urban areas.[20,21] The perceived need for oral healthcare was greater among rural than urban people, nevertheless, the utilization of oral health services showed the opposite findings in Indonesia.[22] Spatial distribution showed that the highest amount of dental fillings is concentrated on Java Island, as the center of industrial growth and development. This result aligns with Nanda et al.'s study, based on spatial analysis, Java-Bali Island had a greater number of dentists and healthcare services.[23] The unequal distribution of healthcare workers on the map was relatively high in areas with high population density. People in Malaysia find it difficult to access and receive dental care due to this factor, which is disproportionately distributed throughout the country.[24]

Furthermore, people who higher levels of education had a lower risk of developing untreated caries and an increased prevalence of dental fillings. This finding is similar to other studies, people with above college level education had lower rates of untreated caries compared not non-high school graduates.[25] Educational level can predict untreated caries as a health outcome. Higher education levels are associated with increased health literacy, self-health awareness, resource accessibility, and knowledge utilization of the healthcare system.[26–28]

The other lesson from this study was that occupational status can be a risk factor for the highest untreated caries and lowest dental fillings. Both missing and decayed teeth increased statistically significantly among the unemployed. In contrast, the employed significantly greater the mean number of filled teeth of the unemployed.[29] Wealthier individuals are more likely to utilize private sector services, while individuals in poverty are more likely to utilize public sector services based on on income related. Consequently, social disparities are commonly seen in the appearance of poor oral health.[30,31]

CONCLUSION

The findings of this study imply that untreated caries and dental fillings are influenced by individual sociodemographic factors. Females, rural residence, no school, and informal workers reported increased prevalence of untreated caries. At the same time, females, urban, diploma 3-college level of education, and formal workers influenced disparities in dental fillings. This data can be used to create national oral health resources and be strategic to policymakers. Comprehensive strategies at the upstream, midstream, and downstream levels are possible to reduce disparities.

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REFERENCES

1. Shoaee S, Ghasemi E, Sofi-Mahmudi A, Erfan S, Tovani-Palone M, Roshan S, et al. Global, regional, and national burden and quality of care index (QCI) of oral disorders: a systematic analysis of the global burden of disease study 1990–2017. BMC Oral Health 2024; 4(1):116. Doi: 10.1186/s12903-023-03808-z.
2. Jain N, Dutt U, Radenkov I, Jain S. WHO's global oral health status report 2022: Actions, discussion and implementation. WHO 2024;30(2):73–9. Doi: 10.1111/odi.14516
3. National Institute of Health Research and Development. Indonesia Basic Health Research 2018. Jakarta; 2019.
4. Agrawal N, Aggarwal A, Garg A, Gupta N D, Tewari RK, Gupta J. Oral health-related quality of life: current status and future implications. Journal of Oral Health and Community Dentistry 2021; 15(2):87–91. Doi: 10.5005/jp-journals-10062-0101
5. Martignon S, Roncalli AG, Alvarez E, Aranguiz V, Feldens CA, Buzalaf M. Risk factors for dental caries in Latin American and Caribbean Countries. Braz Oral Res 2021; 35(1): e053. Doi: 10.1590/1807-3107bor-2021.vol35.0053.
6. Eid SA, Khattab NMA, Elheeny AAH. Untreated dental caries prevalence and impact on the quality of life among 11 to 14-year-old Egyptian schoolchildren: a cross-sectional study. BMC Oral Health 2020; 20(1): 83. Doi: 10.1186/s12903-020-01077-8.
7. Herkrath FJ, Vettore MV, Werneck GL. Contextual and individual factors associated with dental services utilisation by Brazilian adults: A multilevel analysis. PLoS One 2018; 13(2): 1-17. Doi: 10.1371/journal.pone.0192771.
8. Nyamuryekung'e KK, Lahti SM, Tuominen RJ. Attitudes towards tooth fillings in Tanzanian adults and its association with previous filling experience. BMC Oral Health 2018; 18(1):12. Doi: 10.1186/s12903-018-0474-x
9. Uguru N, Onwujekwe O, Ogu UU, Uguru C. Access to oral health care: a focus on dental caries treatment provision in Enugu Nigeria. BMC Oral Health 2020; 20(1): 145. Doi: 10.1186/s12903-020-01135-1.
10. Al-Sudani FYH, Vehkalahti MM, Suominen AL. Association of current employment status with oral health-related behaviors: findings from the Finnish Health 2000 Survey. Eur J Oral Sci 2016; 124(4): 368–76.
11. Nykiforuk CIJ, Flaman LM. Geographic Information Systems (GIS) for Health Promotion and Public Health: A Review. Sage Journal 2011; 12(1): 63–73. Doi: 10.1177/1524839909334624.
12. Nayak P, Nayak PP, Pai JB, Singla N, Somayaji KS, Kalra D. Geographic Information Systems in Spatial Epidemiology: Unveiling New Horizons in Dental Public Health. J Int Soc Prev Community Dent 2021; 11(2): 125-131. Doi: 10.4103/jispcd.JISPCD_413_20.
13. Broomhead T, Ballas D, Baker SR. Application of geographic information systems and simulation modelling to dental public health: Where next?. Community Dentistry Oral Epidemiology 2019; 47(1): 1-11. Doi: 10.1111/cdoe.12437.
14. Qin Y, Chen L, Li J, Wu Y, Huang S. Greater inequalities in dental caries treatment than in caries experience: a concentration index decomposition approach. BMC Oral Health 2021; 21(1): 564. Doi: 10.1186/s12903-021-01935-z.
15. Msyamboza KP, Phale E, Namalika JM, Mwase Y, Samonte GC, et al. Magnitude of dental caries, missing and filled teeth in Malawi: National Oral Health Survey. BMC Oral Health 2016; 16(1): 29. Doi: 10.1186/s12903-016-0190-3/tables/3
16. Lund AE. Women have more caries than men. The Journal of the American Dental Association. Journal of The American Dental Association 2009; 140(1): 20–1.
17. Shaffer JR, Leslie EJ, Feingold E, Govil M, McNeil D W, Crout RJ, et al. Caries Experience Differs between Females and Males across Age Groups in Northern Appalachia. Int J Dent 2015; 2015(1): 1–8. Doi: 10.1155/2015/938213.
18. Azodo CC, Unamatokpa B. Gender difference in oral health perception and practices among Medical House Officers. Russian Open Medical Journal 2012; 1(2): 0208. Doi: 10.15275/rusomj.2012.0208.
19. Probst JC, Barker JC, Enders A, Gardiner P. Current State of Child Health in Rural America: How Context Shapes Children's Health. J Rural Health 2018; 34(1): s3-s12. Doi: 10.1111/jrh.12222.
20. Rocha DM, Rocha MC, Lima RB, Pereira FA, Menezes VN, Mendonca AAM. Experience of caries and tooth loss in rural citrus workers in Northeast Brazil. J Health Biol Sci 2021; 9(1): 1–5. Doi: 10.12662/2317-3076jhbs.v9i1.3544.p1-5.2021.
21. Dewanto I, Koontongkaew S, Widyanti N. Characteristics of dental services in rural, suburban, and urban areas upon the implementation of Indonesia National Health Insurance. Front Public Health. 2020; 8: 138. Doi: 10.3389/fpubh.2020.00138.

22. Malik NA, Rosalien R, Khalissya N, Badruddin IA, Maharani DA. Perceived need and utilization of dental health care services in Indonesia: A secondary analysis using the national socioeconomic data. Makara Journal of Health Research 2020; 24(2): 121–7. Doi: 10.7454/msk.v24i2.1218.
23. Gofur NRP, Aghasy AZZ, Gofur ARP. Spatial distribution analysis of dentists, dental technicians, and dental therapists in Indonesia. F1000Res 2021;10:220. Doi: 10.12688/f1000research.50869.2.
24. Md Bohari NF, Kruger E, John J, Tennant M. Analysis of dental services distribution in Malaysia: a geographic information systems–based approach. Int Dent J 2019; 69(3): 223–9. Doi: 10.1111/idj.12454.
25. Gupta N, Vujicic M, Yarbrough C, Harrison B. Disparities in untreated caries among children and adults in the U.S., 2011-2014. BMC Oral Health 2018; 18(1): 30. Doi: 10.1186/s12903-018-0493-7.
26. Bashir NZ. Update on the prevalence of untreated caries in the US adult population, 2017-2020. J Am Dent Assoc 2022; 153(4): 300–8. Doi: 10.1016/j.adaj.2021.09.004.
27. Baskaradoss JK. Relationship between oral health literacy and oral health status. BMC Oral Health 2018; 18(1): 172. Doi: 10.1186/s12903-018-0604-1.
28. Dutra L da C, de Lima LCM, Neves ÉTB, Gomes M C, de Araujo LJS, Forte FDS. Adolescents with worse levels of oral health literacy have more cavitated carious lesions. PLoS One 2019; 14(11): e0225176. Doi: 10.1371/journal.pone.0225176.
29. Guerreiro E, Manso AC, Mendes JJ. Employability and dental caries experience. Med Sci Forum 2023; 22(1): 44. Doi: 10.3390/msf2023022044.
30. Corovic S, Janicijevic K, Radovanovic S, Vukomanovic IS, Mihaljevic O; Djordjevic J. Socioeconomic inequalities in the use of dental health care among the adult population in Serbia. Front Public Health 2023; 11. Doi: 10.3389/fpubh.2023.1244663.
31. Griffin SO, Thornton-Evans G, Wei L, Griffin PM. Disparities in dental use and untreated caries prevalence by income. JDR Clin Trans Res 2021; 6(2): 234–41. Doi: 10.1177/238008442093476.