

## Mapping of dental caries incidence based on geographical information system (gis) in elementary school

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### ABSTRACT

**Background:** Dental caries in Central Java, Indonesia is still important problem, around 43.45% even prevalence of caries in early childhood is still high around 82%. As an effort to control and prevent increasing that case, a risk analysis is needed to determine the risk factors supporting caries. Geographical information system (GIS) as a delivery of information on the spread of disease to support planning efforts. Aim of this study is to determine mapping of distribution dental caries incidence based on GIS concerned to analysis of caries risk factors at Elementary School in Semarang.

**Methods:** Using cross sectional analytic survey with spatial vector map data of 31 public elementary schools at Banyumanik district, Central Java and attribute data on distribution of dental caries. Mapping distribution of caries incidence based on secondary data from City Health Office and Community Health Centre using (Quantum GIS QGIS) and Web GIS software.

**Results:** Elementary schools with caries risk factor environment were good ( $n=16$ , 52%) and bad ( $n=15$ , 48%), otherwise those with health services were good ( $n=22$ , 71%) and bad ( $n=9$ , 29%). There was a relationship between caries risk factors and dental caries incidence ( $p$  value=0.004) and OR 19.83 (environment) and  $p$  value=0.027 and OR 7.917 (health services).

**Conclusion:** Mapping distribution of caries incidence based on GIS was in a very high category influenced by bad environmental factors and poor health services.

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## INTRODUCTION

Oral health plays an important role in maintaining quality of life. People should have awareness, willingness and ability to live a healthy life. This is an effort to improve public health status. But there are still many people who ignore their health, one of which is oral health. Based on the Indonesia Basic Health Research, the largest proportion of problems in Central Java are dental caries, that the prevalence of dental caries is still very high, namely 43.45%<sup>(1)</sup>. Province of Central Java, Indonesia has 35 cities including Semarang with prevalence of caries around 37.20%. Based on <sup>(1)</sup>, children the 5-9 year old age group is still high at 53.51%. This indicates that children of this age are very susceptible to oral disease especially at risk of experiencing caries. Dental caries may be prevented early if the main factors are eliminated<sup>(2)</sup>. To eliminate those factors is the main thing in controlling, preventing and treating that dental caries itself. Therefore an analysis of caries risk factors is needed to determine the factors that support or drive that caries. It is necessary to make efforts to provide oral health services resolving this problem immediately.

Implementation of comprehensive and integrated health effort needs to be carried out so as to achieve optimal oral health status. Efforts to maintain oral health in the school age group need special attention because children are in a period of growth and development<sup>(3)</sup>. For this reason, it is necessary to carry out oral health survey in order to prepare health plan properly (that is right on target, effective and efficient). The data that has been obtained through data processing becomes information for the development of health programs in integrated health planning. Utilization of geographic information systems can be an alternative in presenting and delivering information on existing problems. Existing problems are

arranged in a geographic map which contains problems in the form of graphs and tables<sup>(4)</sup>.

Quantum geographic information systems (QGIS) is an application based on an open source geographic information system<sup>(5)</sup>. The output of QGIS is a mapping containing information in the form of a map with indicators adjusted based on needs. This can help in explaining a problem of disease distribution in an area to support planning of health efforts. This application may lead to innovative ways of thinking about and dealing with many problems as well as to provide benefits including better decision making, improved communications, better geographic information recordkeeping, and managing geographically<sup>(6)</sup>. Based on the description of the problem, the authors are interested in researching mapping of distribution of dental caries incidence based on geographic information systems (GIS) concerned to analysis of dental caries risk factors at Public Elementary Schools, Banyumanik District, Semarang City, Central Java.

## RESEARCH METHODS

This study was conducted after approval from the Ethics Committee of Poltekkes Kemenkes Semarang (No.0725/EA/KEPK/2022). Type of research used was an analytic research design survey method with a cross sectional approach. Subject included spatial data 31 maps of public elementary schools and data on the spread of dental caries case in those public elementary schools in Bayumanik District, Semarang City, obtained from the City Health Office and Community Health Centre. Banyumanik district consisted of 11 sub-districts with 4 Community Health Centre namely Sronдол, Padangsari, Ngesrep and Puduk Payung Health Centre.

Analysis of research data using univariate and bivariate analysis. Univariate analysis to

describe the frequency distribution of research variables includes data on the distribution of dental caries incidence, environmental factors, health service factors, mapping the distribution of those caries incidence. Bivariate analysis to determine factors suspected to be related or correlated used statistical test.

The risk factors supporting caries in this research including environment and health service observed. The environment was availability of dental health screening and examinations regularly, existence of "Little Doctor", School Health Effort, availability of cariogenic food and beverage. Type of food and beverage not good or cariogenic for oral health such as chocolate, coloured drinks and sticky foods in canteens around elementary school.

While health service was availability and optimization of School Dental Health Effort programs, implementation of School Dental Health Effort step III or Optimum School Health Effort, accessibility to transportation, duration and distance to health service facilities, referral system activities from school to community health centre. The effective of School Dental Health Effort program may reduce caries rates in children<sup>(7)</sup>.

## RESULT

In this study, dental caries incidence was collected from each public elementary school in Banyumanik District (Table 1.). Data obtained was secondary data from Dental Health Screening reported by Community Health Centre in 2020.

**Table 1.** Spread of Dental Caries Incidence Occurrence at Public Elementary School in Banyumanik District

Public Elementary School	Dental Caries Occurrence				Total	
	Caries		No Caries			
	n	%	n	%	n	%
Banyumanik 01	52	23	179	77	231	100
Banyumanik 02	37	16	200	84	237	100
Banyumanik 03	38	29	92	71	130	100
Banyumanik 04	55	33	110	67	165	100
Gedawang 01	43	33	86	67	129	100
Gedawang 02	83	75	28	25	111	100
Jabungan	153	95	8	5	161	100
Ngesrep 01	137	38	219	62	356	100
Ngesrep 02	59	35	110	65	169	100
Ngesrep 03	59	37	100	63	159	100
Padangsari 01	71	36	126	64	197	100
Padangsari 02	224	45	278	55	502	100
Pedalangan 01	67	47	76	53	143	100
Pedalangan 02	115	65	62	35	177	100
Pedalangan 03	123	86	20	14	143	100
Pudakpayung 01	157	34	305	66	462	100
Pudakpayung 02	98	37	166	63	264	100
Pudakpayung 03	112	58	80	42	192	100
Srondol Kulon 01	87	58	63	42	150	100
Srondol Kulon 02	89	14	530	86	619	100
Srondol Kulon 03	34	20	138	80	172	100
Srondol Wetan 01	28	16	150	84	178	100
Srondol Wetan 02	51	10	446	90	497	100
Srondol Wetan 03	40	9	412	91	452	100
Srondol Wetan 04	57	18	253	82	310	100
Srondol Wetan 05	65	14	415	86	480	100
Srondol Wetan 06	98	24	305	76	403	100
Sumurboto	185	76	60	24	245	100
Tinjomoyo 01	111	46	128	54	239	100

Tinjomoyo 02	48	45	58	55	106	100
Tinjomoyo 03	69	71	28	29	97	100
Total	2645		5231		7876	100
Average	85	34	169	66		

Table 1. showed that based on secondary data of dental health screening report from Community Health Centre, the highest frequency of dental caries cases at Jabungan Public Elementary School with 153 students (95%) and the lowest

frequency in Srandol Wetan 3 Public Elementary School with 40 students (9%). Average frequency of dental caries case at Public Elementary Schools in Banyumanik was 34% (n=85) students experiencing dental caries.

#### 1. Environmental Caries Risk Factors

**Table 2.** Environmental Caries Risk Factors

Category	Environmental Caries Risk Factor	
	n	%
Good	16	52
Bad	15	48
Total	31	100

Based on Table 2, it showed that risk factor for caries caused by environment at Public Elementary School in Banyumanik District with good category (n=16, 52%) and bad category (n=15, 48%).

#### 2. Oral Health Service

**Table 3.** Oral Health Service of Caries Risk

Category	Oral Health Service of Caries Risk Factor	
	n	%
Good	22	71
Bad	9	29
Total	31	100

Based on Table 3, it showed that caries risk factor was caused by oral health service at Public Elementary School in Banyumanik District with good category (n=22, 71%) and bad category (n=9, 29%).

#### 3. Dental Caries Incidence:

Incidence of dental caries is an assessment of dental caries experience suffered, consisted 2

(two) categories low ( $X \leq 50\%$ ) and high ( $X > 50\%$ ).

Formula of dental caries incidence:

$$\frac{\sum n \text{ caries}}{\sum n \text{ examined student}} \times 100\%$$

**Table 4.** Dental Caries Incidence at Public Elementary School in Banyumanik District

Category	Dental Caries incidence	
	n	%
Low	23	74
High	8	26
Total	31	100

Table 4. showed that the most frequency of caries incidents at Public Elementary School in Banyumanik District was in low category (n=23, 74%) while 26% in bad category (n=8).

#### 4. Mapping Distribution of Dental Caries at Public Elementary Schools in Banyumanik District

Mapping distribution of dental caries incidence was output of problem data in an area map accompanied by graphs and tables of dental caries incidence.

a. QGIS Mapping distribution of dental caries incidence was carried out using an equal interval classifier with Potential Class Formula:

$$= \frac{N_{max}-N_{min}}{\sum n \text{ Class}} = \frac{224-28}{5} = 39,2 = 39$$

Potential class categories for caries incidence were divided into 5 classes:

Class 1: 28-67 (very low), Class 2: 68-106 (low), Class 3:107-146 (medium), Class 4:147-185 (high) and Class 5:186-224 (very high)

Data on distribution of caries incidence at Public Elementary School in Banyumanik district were processed using GIS with QGIS and presented in map form (Figure 1.)

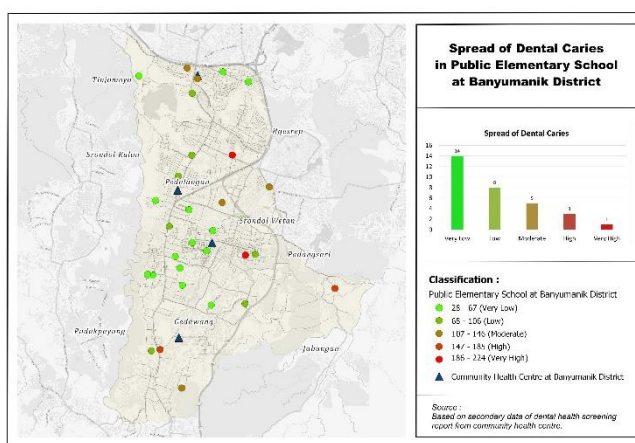
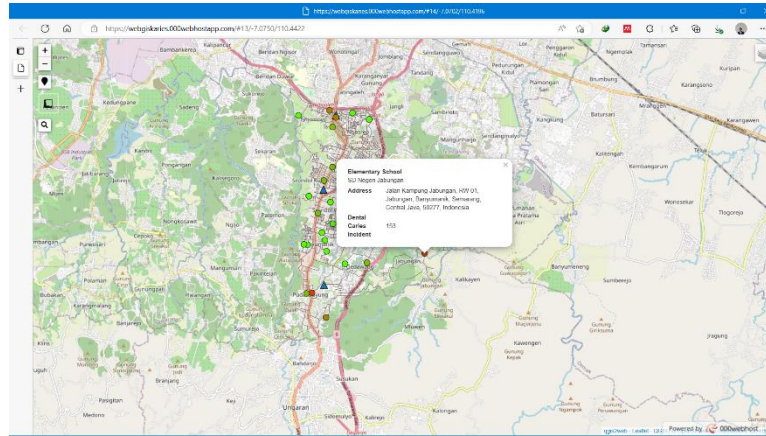


Figure 1. Map of Distribution Caries in Public Elementary Schools in Banyumanik District

b. Web Geographic Information System (Web GIS)

The distribution map of dental caries incidence that has been made using QGIS is published using Web

GIS accessed on Web GIS. Spread of Dental Caries Incidence at Public Elementary School in Banyumanik District (000webhostapp.com) with appearance of web page as follows (Figure 2.)



**Figure 2.** Display of Web GIS Map of Distribution of Caries Incidence at Public Elementary Schools in Banyumanik District

5. Relationship of Environmental Factor with Caries Incidence

**Table 5.** Environmental Factor on Caries Incidence

Environmental Factor	Dental Caries Incidence				Total	p value	OR (CI 95%)
	Low		High				
	n	%	n	%	n	%	
Good	17	94.40	1	5.60	18	100	0.004 19.83 (2-196.38)
Bad	6	46.20	7	53.80	13	100	
Total	23	74.20	8	25.80	31	100	

(Total by column)

Table 5 showed that 18 schools with good environment, most schools (n=17, 94.40%) had low caries incidence, just 1 schools (5.60%) had high incidence. Meanwhile, 13 schools with bad environment, 7 schools (53.80%) had high caries incidence and 6 schools (46.20%) had low incidence. Based on statistical test with Fisher's

Exact test, it was found that there was relationship between environmental factor and caries incidence (p value=0.004) with an odds ratio (OR) of 19.83. It could be explained that schools with good environment tended to have lower caries incidence of 19 times compared to schools with bad environment.

6. Relationship of Oral Health Service with Caries Incidence

**Table 6.** Oral Health Service on Caries Incidence

Oral Health Service	Dental Caries Incidence				Total	p value	OR (CI 95%)
	Low		High				
	n	%	n	%	n	%	
Good	19	86.40	3	13.60	22	100	0.027 7.92 (1.32-47.51)
Bad	4	44.40	5	55.60	9	100	
Total	23	74.20	8	25.80	31	100	

(Total by column)

Table 6. showed that 22 schools with good oral health service, most schools (n=19, 86.40%) had low dental caries incidence and 3 schools (13.60%)

had high those incidence. Whereas 9 schools with poor oral health service, 4 (44.40%) schools had a low dental caries and 5 (55.60%) schools had high

incidence of dental caries. Based on statistical test with Fisher's exact test, there was relationship between oral health service and caries incidence (p value=0.027) with odds ratio (OR) of 7.92. It was

## DISCUSSION

This study stated that there was relationship between environmental factor and caries incidence significantly. Moreover schools with good environment tended to have lower caries incidence of 19 times compared to schools with bad environment. These result was in line with research by <sup>(8)</sup> that the environment was cause of dental caries. Good environment tended to have a low incidence of dental caries, there was a relationship between environmental factor and dental caries incidence (p value=0.006) with an odds ratio (OR) of 10.5, so it could be explained that schools with a good environment had a low caries incidence tendency of 10.5 times compared to schools with a bad environment.

The environment was a unit of life interaction including physical, biological and social environment that influenced oral health including availability of dental health screening and examinations regularly, existence of "Little Doctor" as a motivator for peer environment, School Health Effort as a health service facility in school, availability of cariogenic food and beverage in canteens around elementary school. According to <sup>(9)</sup> presence of "Little Doctor" became a role model at school and had a role in increasing the actions of peers in maintaining oral hygiene. If the teeth and mouth was clean the risk of caries on the teeth due to plaque built up could be avoided. In addition, research by <sup>(10)</sup> schools through School Health Effort support implementation of a positive attitude towards healthy living and improving skills of students including oral health education. Through oral health education carried out by the School

found that schools with good oral health services had low caries incidence tendency of 7.92 times compared to schools with poor oral health service.

Health Effort, it could be an effort to make students skilled in maintaining oral health. Children having high knowledge have 7.5 times chance to behave well in oral health care. One of predisposing factors influencing oral health behaviour was one's knowledge<sup>(11)</sup>. Dental caries was a disease of hard tissue of teeth caused by several supporting factors that support each other. Dental caries incidence was directly influenced by several external factors that support each other including environment and health service<sup>(12)</sup>.

Result of cross-tabulation between environmental factor and dental caries incidence showed that environment was bad with a high incidence of dental caries because cariogenic food and drinks were available in cafeteria around Elementary School. Those children tended to like sweet foods and drinks like moonlight, shaved ice with various syrups, and soda with candy. These consumption habits were a contributing factor to incidence of caries. This was in line with research<sup>(13)</sup> which stated that risk of dental caries tended to increase due to consumption of cariogenic foods. It was caused by behaviour of consuming bad food and not prioritizing oral health. Type of food that was not good or cariogenic for oral health such as chocolate, coloured drinks and sticky foods.

Risk factors supporting dental caries in this research including environment and health service observed, while health service was availability and optimization of School Dental Health Effort programs, implementation of School Dental Health Effort step III or Optimum School Health Effort, accessibility to transportation, duration and distance to health service facilities, referral system

activities from school to community health centre. Based data causing of dental caries on health service factors, it was known that good health service factors were supported by availability of School Dental Health Effort as an effort to maintain and improve oral health status children, ease of access to transportation, time and distance to health service facilities as an effort to encourage community to be able to take advantage of health services. The location of the community health centre was strategic, such as large road access with good road conditions, located on the edge of the main road so that it could be connected directly to available public transportation, and not too far from crowded settlements so that the community's travel time to health service facilities was not too long. According to<sup>(14)</sup> it was important to implement School Dental Health Effort including promotive, preventive and curative activities as an effort to cut dental caries chain. In addition, research by<sup>(15)</sup> stated that ease of access including distance, time and transportation encouraged people to take advantage of health services.

Result of cross-tabulation of health service factors on caries incidence showed that poor health services with high caries incidence. This happened due to the non-implementation of phase III UKGS or optimal UKS which were adequate health service facilities for children at school and the failure to carry out oral health referral activities from schools to health centre as an effort to deal with cases of oral diseases which might not be carried out at school. Poor health services resulted in not being monitored and treated for existing oral health problems. If this continued, oral health status might deteriorate and those children might be disturbed in carrying out his learning activities at school. According to<sup>(16)</sup> School Dental Health Effort was an effort that must be implemented, efforts to improve oral health status by instilling dental health

education from an early age through School Dental Health Effort. In addition, according to<sup>(17)</sup> the teacher had an important role as a facilitator at school in implementing optimal School Dental Health Effort stage III or School Health Effort. The implementation of oral health services, one of which was oral health referrals to health care facilities (community health centre) if an emergency condition or complaint was found in school children so that the risk of getting worse disease could be avoided.

The results of statistical tests using chi square were carried out, but did not meet the requirements, so an alternative fisher's exact test was used to obtain a p value of  $0.027 < \alpha (0.05)$  that there was a relationship between health service factors and incidence of caries with an odds ratio (OR) of 7.917. From these results it could be explained that schools with good health services had a low caries incidence tendency of 7.9 times compared to schools with poor health services. Optimum utilization of health services could support a person's avoidance of risk of contracting a disease. Individual behavior that was sensitive to their health always strives to maintain their health. If this was not implemented, the risk of disease might get worse. These results were in line with research<sup>(12)</sup> that health services might cause dental caries. Behavior played an important role in oral health status directly. Health services could be influenced by behavior, namely a person's response to pain and disease stimuli as well as the existing health care system. Optimum utilization of health services could reduce exposure to risk of worsening dental caries. If dental caries could be treated immediately, no other problems might arise. For this reason, it was necessary to mobilize community to comply and be willing to carry out routine checks as an effort to detect early caries. The better person's perception of oral health the



lower incidence of dental caries in the clinical examination<sup>(18)</sup>.

In addition to environmental factors and health services, there were other factors that influence risk of caries. These factors were OHI-S, plaque, saliva, behavior (knowledge, attitudes, and actions), heredity and time. OHI-S was a risk factor for caries. Children with poor OHI-S status tended to be 2.7 times at risk of having high caries status when compared to good OHI-S status<sup>(4)</sup>. Plaque index affected severity of caries. Children with a high plaque index had a 4.3 times greater risk of suffering from dental caries than children with a low plaque index<sup>(19)</sup>. Saliva was a factor causing caries. Salivary pH, which tended to be acidic, had a risk of developing caries by 3.3 times normal salivary pH<sup>(4)</sup>. Behavior consisted of aspects of knowledge, attitudes, and actions. A person with bad behavior tended to have oral health problems, and vice versa if behavior was good, oral health was also good. Heredity had a role of risk of dental caries. Genetic inheritance from parents in the form of dental conditions and behavior. The condition of stacked teeth will be difficult to clean, resulting in accumulation of plaque which allows caries to occur<sup>(12)</sup>. Time affects the occurrence of dental caries. The longer the accumulation of substrate on the teeth without any cleaning process, the greater the likelihood of rampant caries in children<sup>(20)</sup>.

From the results of recapitulation of caries risk factor analysis data for caries incidence at public elementary schools in Banyumanik District, it could be used as a reference in compiling and processing data using a GIS. The use of GIS uses QGIS to process existing data into a disease distribution map. Using QGIS was proper choice because it was open source software so it could be accessed free of charge without limits. Process of making a caries distribution map used the latest version of QGIS application 3.24.2. To make a map,

it was needed spatial data in the form of a vector map of the Public Elementary School in Banyumanik District and attribute data in form of dental caries incidence in the elementary school type. Vector data was input in the ESRI shape file (.shp) format in the new shape file tool and then adjusted according to needs (color, shape, size). Furthermore, attribute data was input using open attribute tool then adjusted based on needs (table, column, description, content, data type). To add labels to the map as a description of the area or place, used the labels tool. To add color symbols in regional classification used the symbology tool > Graduated > equal interval. In addition, with the help of the open street map, maps of other areas could be displayed. The mapping that had been made then processed into an output map by adding information (symbols/legends, scale, classification) as needed.

Furthermore, using the plugins that had been installed on QGIS, namely qgis2web, it could be exported to web GIS so the maps that had been made could be published via the website as information to the public about the distribution of disease cases. The map that had been made became a reference in conveying disease information data. Level of disease could be seen from number of cases that existed. Data on the incidence of dental caries was obtained from reports on results of screening and examinations carried out by community health centre in each working area. Dental caries was a problem often found in elementary school. Based on dental caries incidence data at Public Elementary Schools in Banyumanik District, it was found that out of 7.876; 2.645 (34%) children had caries. Class calculations to see level of case size using potential classes obtained 5 classes of disease distribution with a susceptibility of 39 cases per class. The highest incidence of caries was in the red potential class V

(Very High) in Public Elementary School Jabungan with 153 children (95%) and the lowest in potential class I (Very Low), namely Public Elementary School Sronдол Wetan 3 with 40 children (9%). The average incidence of caries at Public Elementary Schools in Banyumanik District is 34% (85) students experiencing dental caries.

## CONCLUSION

Risk factors for dental caries caused by environment (cariogenic snacks, screening and periodic dental health checks, "Little Doctor"), School Health Effort at public elementary school in Banyumanik district with a good category of 16 (52%) and a bad category of 15 (48%), whereas risk factors for caries caused by School Dental Health Effort services, this School Effort stage III or optimized School Health Effort, accessibility, referrals at public elementary schools in Banyumanik district with a good category of 22 (71%) and a bad category of 9 (29%). There was a relationship between caries risk factors and dental caries incidence in students at public elementary school, Banyumanik district, Semarang City with a p value of 0.004 and an OR of 19.833 (environmental factor) and a p value of 0.027 and an OR of 7.917 (health service factor).

The highest prevalence of dental caries was at Public Elementary School Jabungan with 153 students (95%) and the lowest frequency at Public Elementary School Sronдол Wetan 3 with 40 students (9%). Average frequency of dental caries incidence at public elementary schools in Banyumanik district is 34% (n=85) students experiencing dental caries. Mapping distribution of dental caries incidence based on geographic information systems (QGIS and Web GIS) showed that the highest caries incidence based on potential class was in class V (very high), namely Public

Elementary School Jabungan influenced by bad environmental factors and poor health services.

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