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## **RESEARCH REPORT: ESTIMATION OF THE FREQUENCY OF DENTAL CARIES IN CHILDREN LIVING IN THE MIDDLE AGES IN CEDYNIA, POLAND**

*ABSTRACT: The objective of this paper was to estimate the frequency and distribution of dental caries in deciduous and mixed dentition in the Middle Ages based on the examination of child skeletons from the Cedynia cemetery, in Poland. The study material comprised 84 child skulls with deciduous and mixed dentition. The material was split into two age groups: the Infans I comprising individuals from 0 to 7 years and the Infans II comprising individuals from 8 to 14 years of age. The presence of dental cavities was detected with the naked eye and by probing with an explorer. The total frequency of caries in the children medieval population from Cedynia was estimated at 15.5%. The most frequently recorded caries in deciduous dentition in older group was occlusal (4.9%), followed by approximal (1.9%). The data obtained from the study resemble other data for populations living in similar environmental conditions. Symptoms of caries were found most frequently on occlusal surfaces, which agrees with the referenced literature data. Caries was more common in the upper jaw than in the lower one for the deciduous dentition.*

*KEY WORDS: Caries frequency – Medieval – Juvenile individuals – Deciduous teeth – Cedynia – Poland*

### **INTRODUCTION**

Studies describing the disease in various prehistoric and historic periods show that the number of teeth affected by dental caries in populations has been rising steadily along with the development of civilization. The frequency of caries ranged from 3% to 21% in the Bronze Age, reached 40% in the Iron Age, and 40 to 50% in the Middle Ages (Malinowski, Wypych 1966, Lukacs 1992, Littleton, Frohlich 1993, Esclassan *et al.* 2009).

The occurrence of dental caries in the area of Poland was studied in detail starting from the Middle Ages on. Mainly populations of adult individuals were studied, including those from burial grounds in Słaboszewo, Kołobrzeg, and Chełmska Góra (Borysewicz, Otocki 1975), Cedynia

(Stopa, Perzyna 1978), Garbary (Borysewicz-Lewicka, Otocki 1978), and Łąd near Słupca (Otocki, Borysewicz-Lewicka 1986). However, similar studies of teeth in child populations are rare.

The objective of this paper was to estimate the occurrence of dental caries in deciduous and mixed dentition in the Middle Ages based on the examination of children skeletons from the Cedynia cemetery, Poland.

### **MATERIAL AND METHODS**

The study material comprised 84 child skulls with deciduous and mixed dentition. The collection of child skeletons from the Cedynia site is the property of the Adam

Mickiewicz University, Institute of Anthropology, Faculty of Biology, Department of Human Evolutionary Biology. All available skulls whose age could be detected were analysed, although the state of preservation varied from complete skulls to fragments of jaws.

The Cedyňa burial ground is located in the West Pomerania administrative district, in the north of the today's town. The studied bone material comes from the period between the end of the 10<sup>th</sup> century and the first half of the 14<sup>th</sup> century. The Cedyňa cemetery was used by the inhabitants of the town and its satellite settlements, who were involved in agriculture, animal breeding and crafts. Cedyňa was granted town charter only late in the Middle Ages. Studies demonstrated that the Cedyňa necropolis was the place of burial of a group of approximately 320 individuals in the span of some 9 generations. Life expectancy was 27.8 years, mortality among women aged 19–37 years was 68% what was due to hard hygienic and sanitary conditions (Malinowska-Lazarczyk 1982). The individuals' age at death, estimated according to Ubelaker's method, fell within 0–14 age band (Ubelaker 1978).

For the use of the performed analyses and because of the small size of individual age groups the material was split into two age groups, according to the following classification: the Infans I comprising individuals from 0 to 7 years and the Infans II comprising individuals from 8 to 14 years of age (Malinowski *et al.* 1973).

The teeth were examined macroscopically under a bright light by the same dental doctor to ensure comparability. The condition of all the teeth present in their alveoli was described. The description included the types of the teeth, i.e., the distinction between permanent and deciduous and the classification into teeth groups such as incisors, canines, premolars, and molars. Tooth loss was classified as postmortem if there was an evidence of an alveolar socket (Caglar *et al.* 2007).

The presence of dental cavities was detected with the naked eye and by probing with an explorer. Changes involving early forms of caries were disregarded due to diagnostic ambiguity. A carious lesion was considered present if a stained, irregular walled cavity was evident from visual inspection. The number of lesions and their location was noted. The tooth surfaces with carious lesions were classified according to the location on the tooth crown into following categories: occlusal, approximal, buccal, and lingual. Where a lesion extended onto more than one surface, all surfaces were counted.

Based on the data collected, the caries frequency rate (i.e., frequency of caries) was calculated (Jańczuk 1995). Caries frequency was analysed on an individual basis in total as a percentage of all deciduous or mixed teeth and on the tooth type level with regard to upper and lower jaw and tooth surfaces. The results were presented in the following way: only deciduous teeth were compared in both age groups and deciduous dentition in the Infans I group and mixed dentition in the Infans II group.

The statistical significance of the recorded values was tested with the Yates corrected chi-square and V-square test. A *P* value less than 0.05 was considered as statistically significant.

## RESULTS

In 84 examined individuals a thorough analysis revealed that postmortem teeth loss in the Infans I group involved 179 deciduous teeth and in the Infans II group 262 deciduous and 170 permanent teeth. As a result, the actual number of teeth remaining in their alveoli and available for examination included 213 deciduous teeth in the Infans I group, and 245 deciduous teeth and 215 permanent in the Infans II group. Therefore, the total number of teeth studied in the population of children from Cedyňa comprised 458 deciduous teeth and 215 permanent ones. Division into age categories and types of teeth is shown in *Table 1*.

The authors estimated also the number of deciduous and permanent teeth in individual quadrants divided into teeth groups. Among deciduous teeth molars were the best preserved types, with incisors being the most poorly represented group (*Table 2*).

On the basis of deciduous dentition data the frequency of caries on an individual basis in the children medieval population from Cedyňa was estimated at 13.1% as it was present in 11 child individuals (three Infans I and eight Infans II) (*Table 3*). The analysis at the age group level showed higher frequency of caries in deciduous dentition in the older age group (9.5%), compared to the younger age group (3.6%), but there was no statistical difference between groups ( $P > 0.05$ ). Caries frequency for mixed dentition in the Infans II was 18.9%, so total frequency of caries on an individual basis including mixed dentition was 15.5%. There was no statistical difference between the Infans I (deciduous dentition) group and the Infans II (mixed dentition) group ( $P > 0.05$ ).

Total caries frequency as a percentage of all deciduous teeth available for examination was calculated as 4.1%. *Table 4* shows the frequencies of carious lesions related to tooth type in deciduous dentition in the Infans I and the Infans II group. In the Infans I group the total frequency on the tooth type level of carious lesions was 2.8%. Analysis by tooth type revealed carious lesions in incisors in 4.4%, canines in 0% and molars in 2.9%. These differences were nonsignificant for incisors, canines, and molars ( $P > 0.05$ ). In the Infans II group, total frequency on the tooth type level of carious lesions in deciduous dentition was 5.3%. Analysis by tooth type revealed that incisors exhibited carious lesions in 6.3%, canines in 4.0%, and molars in 5.4%. These differences were nonsignificant for incisors, canines, and molars ( $P > 0.05$ ).

*Table 5* shows frequencies of carious lesions related to tooth type in deciduous dentition in the Infans I and mixed dentition in the Infans II group. Total caries frequency as a percentage of all deciduous and permanent teeth available

TABLE 1. Number of analysed teeth by age groups and postmortem loss.

Age group	Side	N of individuals	Teeth present		Postmortem teeth loss
			Upper	Lower	
Infans I	Left	31	53	54	179
	Right		58	48	
Infans II	Left deciduous	53	64	62	262
	Right deciduous		58	61	
	Left permanent		66	37	170
	Right permanent		70	42	
Total	84	673	611		

TABLE 2. The total number of deciduous and permanent teeth available for study in individual teeth groups.

		Right side							Left side						
Upper jaw	Tooth	M2	M1	P2	P1	C	I2	I1	I1	I2	C	P1	P2	M1	M2
	N	9	37	2	4	5	4	9	4	7	1	3	0	43	8
	Tooth			m2	m1	c	i2	i1	i1	i2	c	m1	m2		
	N			46	33	14	11	12	8	10	11	39	49		
Lower jaw	Tooth			m2	m1	c	i2	i1	i1	i2	c	m1	m2		
	N			40	44	18	3	4	5	8	14	44	45		
	Tooth	M2	M1	P2	P1	C	I2	I1	I2	C	P1	P2	M1	M2	
	N	1	23	1	2	2	7	6	8	1	3	1	1	22	1

TABLE 3. Individuals with caries.

Age group	N of individuals	N (%) of individuals with caries
Infans I	31	3 (3.6)
Infans II deciduous	53	8 (9.5)
Infans II mixed	53	10 (18.9)
Total with deciduous teeth	84	11 (13.1)
Total Infans I and Infans II mixed	84	13 (15.5)

TABLE 4. Frequencies of caries lesions of deciduous teeth related to tooth type.

	Age class	I1+I2		C		M1+M2	
		Caries	Total	Caries	Total	Caries	Total
Upper jaw	Infans I	2 (6.3)	32 (100.0)	0 (0.0)	14 (100.0)	4 (6.0)	66 (100.0)
	Infans II	0 (0.0)	9 (100.0)	1 (9.0)	11 (100.0)	9 (8.8)	102 (100.0)
Lower jaw	Infans I	0 (0.0)	13 (100.0)	0 (0.0)	18 (100.0)	0 (0.0)	71 (100.0)
	Infans II	1 (14.3)	7 (100.0)	0 (0.0)	14 (100.0)	2 (1.9)	103 (100.0)
Upper and lower jaw	Infans I	2 (4.4)	45 (100.0)	0 (0.0)	32 (100.0)	4 (2.9)	137 (100.0)
	Infans II	1 (6.3)	16 (100.0)	1 (4.0)	25 (100.0)	11 (5.4)	205 (100.0)

Note: Absolute numbers refer to the number of teeth. Values presented in parenthesis are percentages.

for examination was calculated as 3.1%. In the Infans II group total frequency on the tooth type level of carious lesions in mixed dentition was 3.3%. Analysis by tooth type for mixed dentition in the Infans II group revealed incisors to be affected by carious lesions in 1.8%, canines in 2.8%, and molars in 3.7%. Premolars were free of caries. These differences were nonsignificant for incisors, canines, and molars ( $P>0.05$ ).

Table 6 shows frequency of carious lesions of deciduous dentition regarding the upper and lower jaw. Higher caries frequency in the Infans I group was found in the upper jaw (5.4%). Lower caries frequency was observed in the lower jaw (2.4%) in the Infans II group. There was not a statistical significant difference in the Infans II group between the upper and lower jaw. In the Infans I group, a statistical difference between the upper and lower jaw was on  $P=0.05$ .

TABLE 5. Frequencies of caries lesions of mixed teeth related to tooth type.

Age class	I1+I2		C		P1+P2		M1+M2	
	Caries	Total	Caries	Total	Caries	Total	Caries	Total
Upper jaw	Infans I	2 (6.3) 32 (100.0)	0 (0.0) 14 (100.0)				4 (6.0) 66 (100.0)	
	Infans II mixed	0 (0.0) 33 (100.0)	1 (5.9) 17 (100.0)	0 (0.0) 9 (100.0)			10 (5.0) 199 (100.0)	
Lower jaw	Infans I	0 (0.0) 13 (100.0)	0 (0.0) 18 (100.0)				0 (0.0) 71 (100.0)	
	Infans II mixed	1 (4.5) 22 (100.0)	0 (0.0) 19 (100.0)	0 (0.0) 5 (100.0)			3 (2.0) 150 (100.0)	
Upper and lower jaw	Infans I	2 (4.4) 45 (100.0)	0 (0.0) 32 (100.0)				4 (2.9) 137 (100.0)	
	Infans II mixed	1 (1.8) 55 (100.0)	1 (2.8) 36 (100.0)	0 (0.0) 14 (100.0)			13 (3.7) 349 (100.0)	

Note: Absolute numbers refer to the number of teeth. Values presented in parenthesis are percentages.

TABLE 6. Caries prevalence on upper and lower jaw (deciduous teeth).

		Infans I	Infans II deciduous	Infans I and II deciduous
Upper	Caries	6 (5.4)	10 (8.2)	16 (6.8)
	Total	112 (100.0)	122 (100.0)	234 (100.0)
Lower	Caries	0 (0.0)	3 (2.4)	3 (1.3)
	Total	100 (100.0)	124 (100)	224 (100.0)

Note: Absolute numbers refer to the number of teeth. Values presented in parenthesis are percentages.

TABLE 7. Caries prevalence on upper and lower jaw (mixed teeth).

		Infans I	Infans II mixed	Infans I and II mixed
Upper	Caries	6 (5.4)	11 (4.3)	17 (4.6)
	Total	112 (100.0)	258 (100.0)	370 (100.0)
Lower	Caries	0 (0.0)	4 (2.0)	4 (1.3)
	Total	100 (100.0)	203 (100)	303 (100.0)

Note: Absolute numbers refer to the number of teeth. Values presented in parenthesis are percentages.

TABLE 8. Caries prevalence with respect to tooth surfaces (deciduous dentition).

Age group	Occlusal		Approximal		Buccal		Lingual		All surfaces	
	Caries	Total	Caries	Total	Caries	Total	Caries	Total	Caries	Total
Infans I	0 (0.0)	136 (100.0)	5 (1.2)	426 (100.0)	1 (0.5)	213 (100.0)	1 (0.5)	213 (100.0)	7 (0.7)	988 (100.0)
Infans II	10 (4.9)	204 (100.0)	9 (1.8)	490 (100.0)	2 (0.8)	245 (100.0)	1 (0.4)	245 (100.0)	22 (1.9)	1184 (100.0)

Note: Absolute numbers refer to the number of teeth. Values presented in parenthesis are percentages.

TABLE 9. Caries prevalence with respect to tooth surfaces (mixed dentition).

Age group	Occlusal		Approximal		Buccal		Lingual		All surfaces	
	Caries	Total	Caries	Total	Caries	Total	Caries	Total	Caries	Total
Infans I	0 (0.0)	136 (100.0)	5 (1.2)	426 (100.0)	1 (0.5)	213 (100.0)	1 (0.5)	213 (100.0)	7 (0.7)	988 (100.0)
Infans II	11 (3.0)	362 (100.0)	11 (1.2)	920 (100.0)	2 (0.4)	460 (100.0)	2 (0.4)	460 (100.0)	26 (1.2)	2202 (100.0)

Note: Absolute numbers refer to the number of teeth. Values presented in parenthesis are percentages.

Caries frequencies for the upper jaw in all age classes for deciduous dentition were calculated as 6.8%, and for the lower jaw as 1.3%. Significant differences were noted on tooth type level between the upper and lower jaws for all deciduous teeth ( $P=0.006$ ).

Table 7 shows the frequency of carious lesions of deciduous and mixed dentition regarding the upper and lower jaw. Lower caries frequency was observed in the lower jaw (2.0%) in the Infans II group with mixed dentition, but there was not a statistical significance between the upper and lower jaw ( $P>0.05$ ). Caries frequencies for the upper jaw in all age classes for deciduous and mixed dentition were calculated as 4.6%, and for the lower jaw as 1.3%. Significant differences were noted on tooth type level between the upper and lower jaws for the Infans I and Infans II (mixed dentition) ( $P=0.03$ ).

Table 8 shows the frequency and the distribution of caries with respect to the tooth surface in deciduous dentition. The total of 2172 surfaces of deciduous teeth were examined in children in developmental age from the cemetery in Cedynia. Out of this number 29 dental surfaces, that is 1.3%, showed the symptoms of caries. The greatest number of carious lesions was observed in occlusal surfaces. The highest caries frequency was found in occlusal surfaces in the Infans II group. The lowest caries frequency was seen on occlusal surfaces in the Infans I. Occlusal caries increased from 0% in the Infans I to 4.9% in the Infans II group. Approximal caries increased from 1.2% in the Infans I to 1.8% in the Infans II group. An age-dependent (Infans I vs. Infans II) increase of caries frequencies related to all tooth surface was noted ( $P=0.03$ ). Significant differences in caries frequencies were noted for occlusal surfaces ( $P=0.02$ ). No teeth with root caries were found.

Table 9 shows the frequency and the distribution of caries with respect to the tooth surface in deciduous dentition and mixed dentition. From the total of 3190 surfaces of deciduous and permanent teeth examined in children in developmental age from the cemetery in Cedynia 26 were carious (1.2%). The highest caries frequency of mixed dentition was found on occlusal surfaces in the Infans II group. There were not significant differences between surfaces or age groups ( $P>0.05$ ).

## DISCUSSION

In literature there are few studies referring to the dentition of juvenile individuals based on examination of skeletal material. This is probably due to the fact that such studies require dental examination of at least partially preserved maxillary or mandibular bones which are scarce. Poor preservation of children's skeletons is associated with small size of juvenile bones which also tend to decompose faster due to lower content of minerals compared to adult bones (Krenz-Niedbała 2008). Also because of the structure of both the bones and deciduous teeth many single-rooted teeth are lost postmortem, and as a result molars tend to

be the most frequently preserved teeth (Corbett, Moore 1971, 1973). In own study, the authors were able to assess approximately half of the erupted teeth among which multi-rooted teeth were a majority.

The problem of population size concerns mainly child groups. In order to facilitate the comparison of the data obtained in the study with the data presented in the literature, the authors used a method of caries frequency description used by other researchers working with skeletal material comprising mainly adult individuals not regarding caries correction factors (Borysewicz-Lewicka, Otockki 1978, Caglar *et al.* 2007, Meinel *et al.* 2010). It should be kept in mind that in older children age there can be the difficulty in differentiating between the loss mainly due to exfoliation, but also trauma or caries (World Health Organization 1997). No set standards for calculating dental caries frequency has made it difficult for the investigators to draw reliable conclusions from caries frequencies.

It is known that the incisors and canines and the premolars and molars show different resistance to cariogenic factors. In general, the molars and premolars are involved much more frequently than the canines and incisors (Hillson 2001). In own study the anterior deciduous teeth have a higher caries frequency than the posterior deciduous teeth in the lower jaw in older group but the posterior deciduous teeth have a higher frequency in the upper jaw. However, these tooth classes are lost differentially in postmortem stages due to their anatomical structures. This different postmortem tooth loss distorts proportions between the anterior and posterior tooth classes and can affect the calculation of total caries prevalence. Therefore, the result according to which one teeth group was more frequently affected by caries than the other may be inaccurate due to poor bone preservation.

Symptoms of caries are noted in different degree on surfaces of the teeth. The highest frequencies of caries lesions were seen on occlusal surfaces of deciduous teeth in older age group. Caries cavities were also very frequent on approximal surfaces (mesial and distal), which agrees with other authors' observations (Borysewicz, Otockki 1975, Corbett, Moore 1971, 1973, Otockki, Borysewicz-Lewicka 1986). This location of dental cavities, both in historic and contemporary times, is due to retention of food debris and poorer cleaning of these parts of tooth crowns.

There is also a difference in caries frequency in the mandible and maxilla. Lower teeth are usually affected more than upper, although the condition usually involves the right and left side fairly equally (Hillson 2001). In own study upper teeth both in deciduous and mixed dentition were more affected. Similar findings were reported by Otockki and Borysewicz-Lewicka (1986) for adults from Łąd, Poland, and by Lunt (1972) in the studies of a small group of mediaeval Scottish children. It must be kept in mind, however, that anthropological data from the literature concerning the loss of mineralised dental tissues are often difficult to compare due to different research methodologies used and different sizes of populations studied. It should



be also distinguished if the data from deciduous and permanent dentition are separately calculated or teeth in mixed dentition are treated altogether. The deciduous teeth are longer exposed to the risk factors of dental caries than the permanent ones. The longer exposure also explains why the deciduous molars had higher mean number of dentine caries lesions than the permanent molars. In the study two methods of calculating the data were applied: calculations for deciduous dentition only, and calculations for deciduous and permanent teeth altogether in mixed dentition. Presenting the findings altogether for the deciduous and permanent teeth in mixed dentition is commonly used in the studies of contemporary children (Goyal *et al.* 2007, Grewal *et al.* 2009, Sudha *et al.* 2005).

Environmental factors affect caries incidence, too. Deciduous teeth are at risk of developing caries two years after eruption due to their structure and morphological immaturity. Therefore, the way children are fed as well as the time of a shift from breast feeding to other food may be of significance. Woman's milk includes nutritional elements ensuring optimal growth and immune factors defending the body from infections (Bagińska, Stokowska 2006, Krenz-Niedbała 2006). Children fed on non-breast food show higher digestive and respiratory infections incidence, and they are these diseases which are main reasons for deaths in skeletal populations. It must be remembered about a significant contamination of products introduced to a child's diet, who is no longer protected by immune factors contained in the mother's milk (Krenz-Niedbała 2006). Medieval food had harder and more fibrous consistency than the average western European diet nowadays (Ganss *et al.* 2002). Analysis of diet in the Cedynia settlement proved that the most common occupation of people who were crafts and agriculture with millet (*Panicum miliaceum*) being the most often cultivated crop (Malinowska-Łazarczyk 1982, Kostrzewski 2007). Thanks to the analysis of enamel hypoplasia it is known that children in medieval Poland, in Cedynia and other places, were breastfed until 2–3 years of age, boys approximately one year longer (Krenz-Niedbała 2006, Krenz, Piontek 1996).

Skeletons of children from Cedynia are one of the biggest skeletal collections in Poland for the Infans I and Infans II age groups. Numbers of children's skulls found in other medieval Polish sites divided into age subgroups are smaller.

Otock and Borysewicz-Lewicka (1986), when estimating the frequency of caries on an individual basis in the skulls from the cemetery in Łąd, found dental caries for deciduous dentition in 14% and in 62% in mixed dentition. In the material from Słaboszewo the total frequency of caries was 17.8%, including 7.7% in deciduous and 26.7% in mixed dentition. In the Infans II group in the Kołobrzeg series, the frequency was 37.5% and among children from Chełmska Góra 22.2% for mixed dentition (Borysewicz, Otock 1975). Howorka's research on dentition of individuals from Ostrów Lednicki demonstrated the presence of dental cavities in 3 out of 23 children's skeletons, which accounted for 13.0% of the whole skeletal population (Howorka 1936).

The authors' own research demonstrated lower frequency of caries than in the earlier quoted data at the level closest to the data obtained for the skulls from the cemeteries in Słaboszewo and Ostrów Lednicki. Considerably lower frequency rate, of 1.3%, was noted also by Kozaczek and Miszkiewicz (1969) for the material from Tomice for both age groups. The difference in caries incidence is related to various living conditions in different areas. However, dental caries is a disease that shows a strong relationship with age. A similar rule was observed in the quoted studies.

Undoubtedly, there are many factors contributing to caries prevalence in this sample. More data involving children's bony material would allow a clearer understanding of the influence of diet and environmental factors affecting caries rates in historic populations.

## CONCLUSIONS

1. The analysis of dental cavities incidence in the population of juvenile individuals from Cedynia corroborated the presumptions regarding an increased frequency of the disease in deciduous dentition with age.

2. Symptoms of caries were found most frequently on occlusal surfaces, which agrees with the referenced literature data.

3. Caries was more common in the upper jaw than in the lower one for the deciduous dentition.

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