Fluoride and Nonfluoride Enamel Opacities

By EUGENE R. ZIMMERMANN, D.D.S.

DEVELOPMENTAL OPACITIES in enamel associated with fluoride ingestion have been termed "fluorosis." Dean (*1*) has thoroughly studied these opacities and has established criteria for classifying them. There are also enamel opacities, not attributed to fluorine, which occur in low-fluoride areas; these have been described (*2*, *3*) but have not been categorized.

This report compares the prevalence and distribution patterns of enamel opacities in a fluoride area and in a nonfluoride area. The positive signs of fluorosis ("very mild" to "severe") have been identified readily in epidemiological surveys. However, differentiation of questionable fluorosis opacities from the nonfluoride lesions has occasionally been difficult (*4–6*). This study presents several methods of distinguishing between these two types of enamel opacities.

Methods

Aurora, Ill., and Montgomery and Prince Georges counties in Maryland were the areas selected for this study. In each locality continuous resident white children 12–14 years old were examined for dental caries experience and dental fluorosis within a few months of each other. The same forms, procedure, and equipment (mirror and explorer, Castle light) were used in each community. All children in a school were examined and only after completion of the dental examination were residencies checked for continuity. Children who had consumed water from the municipal supply continuously from birth through their 11th year, and whose absences were judged to be only vacation trips, were considered continuous residents.

In Aurora, appoximately 650 children were examined. Of these 352 met the criteria for residency. In the Maryland counties 220 of about 800 students examined fulfilled the requirements.

Water History

Maryland Counties

The study areas in Maryland, adjacent to Washington, D. C., have had as water sources for more than 25 years the Northwest Branch of the Anacostia River and the Patuxent River. The filtration plant for the Anacostia River was completed in 1936; the Patuxent plant was placed in operation in 1944. Water treatment has been the same at both plants since their inception and consists of aluminum sulfate flocculation, prechlorination, sand filtration, alkalization with hydrated lime, and postchlorination. Fluoride determinations have been performed only in the past several years and the average concentration of the raw water has been about 0.2 p.p.m. According to the water engineer (*7*), the fluoride level of the water at the tap was practically zero due to this type of water treatment. There have been no

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Table 1. Comparison of fluorine concentration, community fluorosis index, DMF rate, and number of children examined in the Maryland counties (1953) and in Aurora, Ill. (1941, 1953)

Locality and year	F in p.p.m.	Community fluorosis index	Standard error	DMF [1] rate	Number of children by age last birthday			Total number of children
					12	13	14	
Aurora, 1941 [2]	1.2	0.32	[3] 0.02	2.8	208	225	200	633
Aurora, 1953	1.2	.32	.01	2.9	114	123	115	352
Maryland, 1953	.2	.00	.00	6.4	68	63	89	220

[1] Number of decayed, missing, and filled permanent teeth per person.
[2] Data from Dean, H. T.: Epidemiological Studies in the United States. *In* Dental Caries and Fluorine, edited by F. R. Moulton for the American Association for the Advancement of Science. Lancaster, Pa., The Science Press 1946, pp. 17–23.
[3] Computed from data, footnote 2.

important variations in the inorganic constituents of the tap water over the past 15 years, until 1 year prior to these dental examinations, when fluoridation was instituted (*7*).

Aurora, Ill.

The Aurora water supply, obtained from a number of deep wells drilled into Cambrian "Potsdam" sandstone, has a reliable fluoride constancy back to 1898. Dean found on the average 1.2 p.p.m. F (*8*). There have been no major changes in this water system for the past 40 years, and it is not treated except for chlorination in times of emergency.

Criteria

Enamel opacities have been classified as forms of "hypoplasia" (*3*), "dystrophy" (*9*), and "dysplasia" (*10*). They will be designated in this report as either "fluorosed" (fluoride) or "idiopathic" (nonfluoride) white spots.

Dean's criteria for identifying fluorosed opacities were applied in both groups of children. Dean has described questionably fluorosed anterior teeth as having thin, irregular opaque streaks or flecks on their surfaces while the posterior teeth display opacities, 2 or 3 millimeters in extent, on the tips of their cusps (*5*). He also asserted that these white spots were not sufficiently developed to be classed as "very mild" and were definitely not "normal" (*1*). All enamel lesions not meeting Dean's criteria were classified as nonfluoride. If a child had both fluoride and nonfluoride opacities on the same tooth or in the same dentition, he was classified only as having fluorosis (*5*). Each opacity was classified solely on the basis of its physical appearance.

Findings

The number of teeth present in the Maryland and Illinois children was compared, and the

Table 2. Number of children with normal teeth, and with teeth showing various types of opacities, in Aurora, Ill., and two Maryland counties, 1953.

Locality	Number of children	Opacities by specified types									
		None		Idiopathic		Questionable fluorosis		Very mild fluorosis		Mild fluorosis	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Aurora, Ill.	352	169	48	33	9	92	26	51	15	7	2
Two Maryland counties	220	141	64	79	36	0	0	0	0	0	0

Figure 1. Children with normal teeth and those with tooth opacity in Aurora, Ill., and two Maryland counties, percentage on a child unit basis.

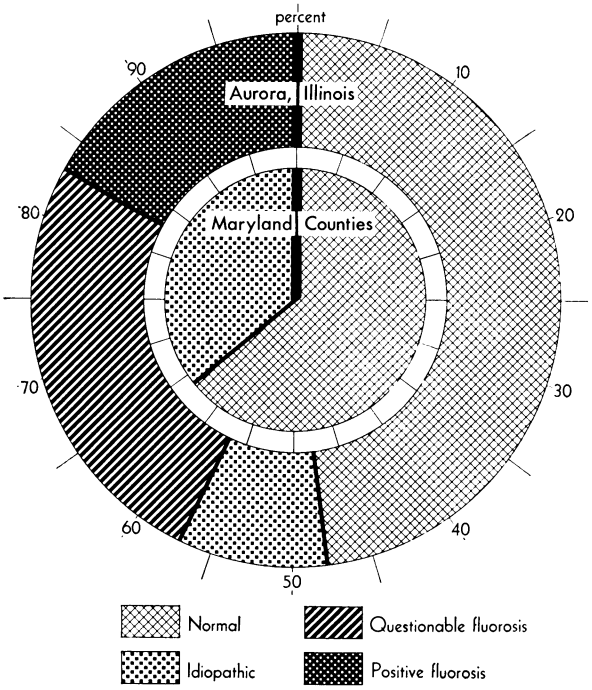


Figure 2. Permanent teeth with normal structure and those with tooth opacity in Aurora, Ill., and two Maryland counties, percentage on a tooth unit basis.

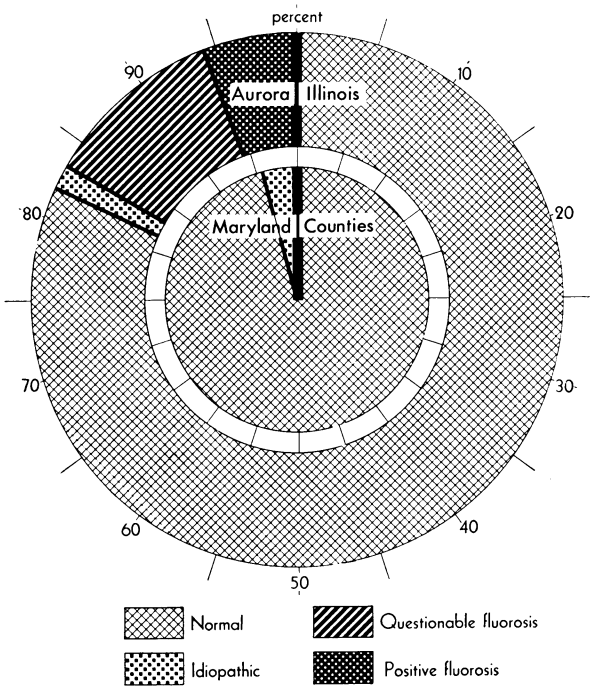
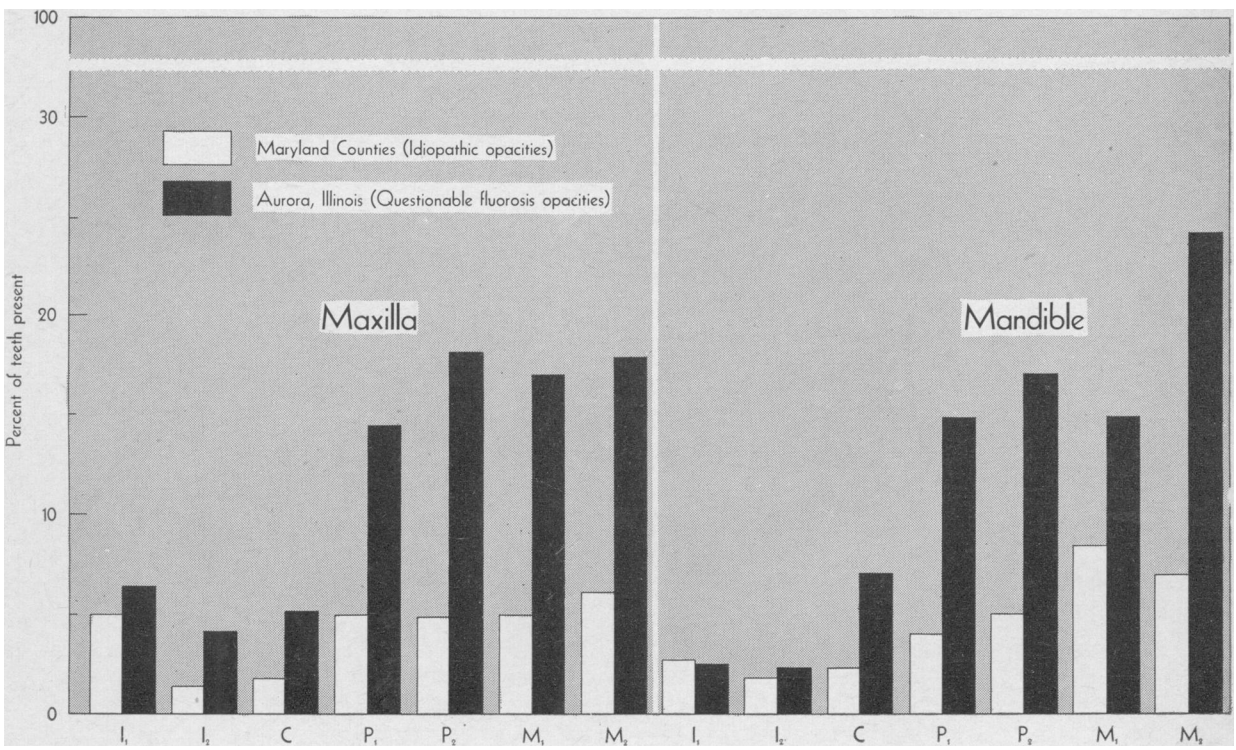


Figure 3. Permanent teeth with opacities in Aurora, Ill., and the two Maryland counties, percentage on a tooth unit basis by tooth type.



small difference was found to be due to chance variation.

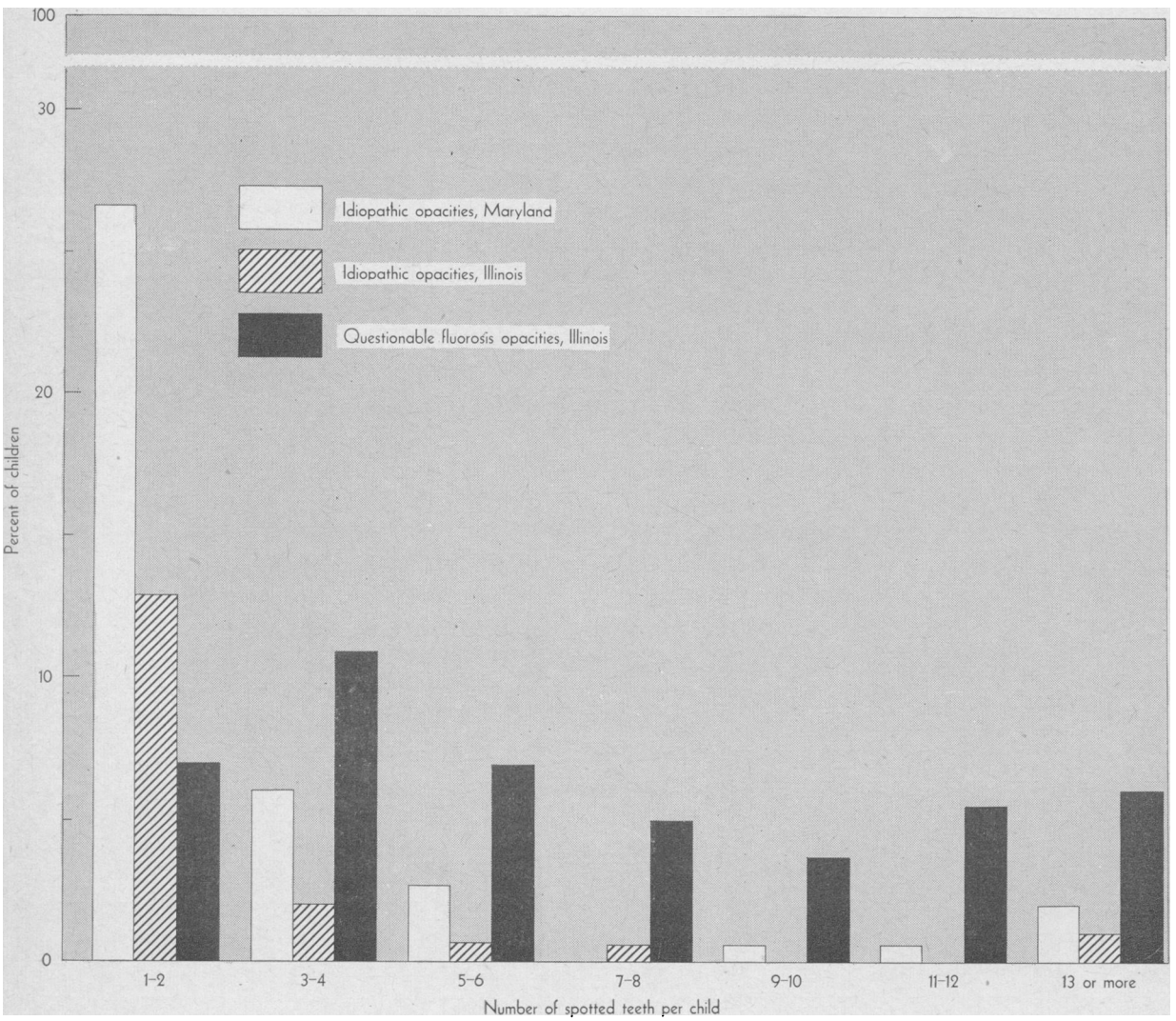
The dental caries experience and the fluorosis indexes in Aurora are similar to previous findings (table 1). The DMF (decayed, missing, or filled permanent teeth) rates offer confirmatory evidence of fluoride exposure. The community fluorosis index was computed from the data in table 2 and this table shows that most of the children with positive signs of fluorosis had the "very mild" form.

According to Dean's criteria, 43 percent of the Aurora children had fluorosed opacities; 9 percent had nonfluoride white spots (fig. 1).

By contrast, in Maryland, only two children with fluorosed opacities were seen, but they were not continuous residents of the study area, hence, not counted. Nevertheless, enamel opacities were seen in 36 percent of the continuous resident Maryland children. These white spots (idiopathic) were not associated with fluoride exposure.

Regardless of the kind of opacity, only a small percentage of the teeth of children in both places were afflicted with enamel lesions (fig. 2), and usually the posterior teeth were most frequently affected (fig. 3). The distributions of idiopathic and questionably fluorosed opacities by morphological tooth type were similar. The teeth with idiopathic lesions in Aurora were

Figure 4. Number of spotted teeth per child with idiopathic opacities in two Maryland counties and with idiopathic and questionably fluorosed opacities in Aurora, Ill.



omitted from this graph due to their small numbers, but their distribution was similar to the Maryland pattern.

The Maryland and Aurora children whose teeth had opacities diagnosed as idiopathic usually had one or two spotted teeth per dentition whereas the children with questionably fluorosed teeth had 3 or more affected teeth per dentition (fig. 4). This frequency of spotted teeth per child was utilized in classifying those Aurora children who had enamel opacities that were difficult to classify solely on appearance. This group, 6 percent of the children examined, was not placed in either category at the time of examination, but the lesions were later classified as idiopathic after their frequency appeared similar to the idiopathic pattern.

Discussion

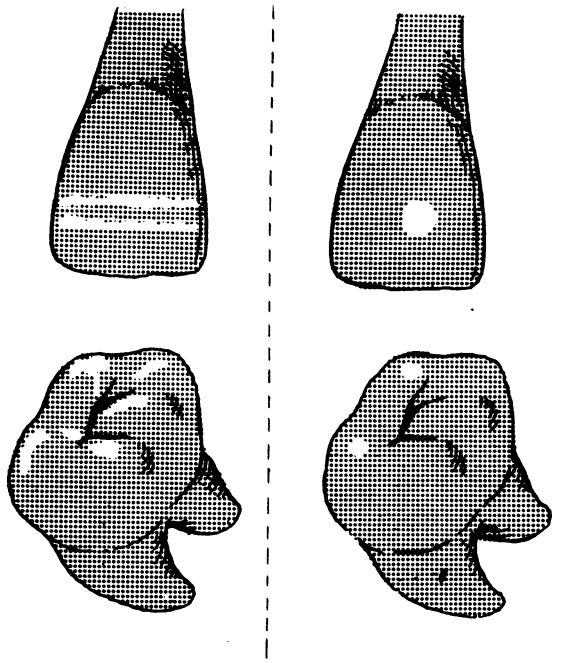
In the present study, if the Maryland opacities were erroneously considered as questionable fluorosis, the community fluorosis index would be 0.17. If the idiopathic opacities in Aurora were classified as "normal," the community fluorosis index would be 0.32; if they were classified as "questionable" fluorosis, the index would be computed as 0.36. In either case, the index would not be raised sufficiently so as to approach the threshold range (*1*) of objectionable fluorosis (0.40–0.60).

In one study the prevalence of nonfluoride opacities has been reported as about 83 percent in a community in which waterborne fluorides were not present (*2*). If these nonfluoride opacities were mistakenly diagnosed as questionable fluorosis, the community index would be estimated at 0.42, which is within the borderline zone of objectionable fluorosis. Therefore, the differentiation of these two types of opacity may be important in evaluating the effects of a fluoridation program in some communities.

Three features of enamel opacities facilitate the differentiation of fluoride and nonfluoride white spots:

The physical appearance of the opacities. The idiopathic opacities are usually more oval in shape and more opaque in appearance than questionably fluorosed white spots, whereas the opacities on questionably fluorosed teeth have

Figure 5. Appearance of questionable fluorosis lesions (left side) and nonfluoride opacities (right side).



a tendency to form horizontal striations. On the occlusal surfaces of posterior teeth the nonfluoride lesions involve the cusp tips, similar to snow-capped mountain peaks, while the striae of questionably fluorosed teeth extend down cuspal ridges. These characteristics are shown in figure 5.

The distribution pattern of the opacities. Questionably fluorosed opacities are usually distributed bilaterally in a dentition; idiopathic lesions are not ordinarily found in a definite symmetrical pattern.

The frequency of the opacities per person. The questionably fluorosed opacities usually involve several teeth per dentition; idiopathic lesions seldom affect more than 1 or 2 teeth.

Summary

1. Continuous resident, white children, 12 to 14 years old, were examined in Aurora, Ill. (water, 1.2 p.p.m. F), and in two Maryland counties (0.2 p.p.m. F) for dental caries experience and fluorosis. The Illinois children had a DMF (decayed, missing, or filled permanent teeth) rate of 2.9 and a fluorosis index of

0.32; the Maryland children had a DMF rate of 6.4, and no fluorosis was observed.

2. Two kinds of enamel opacities were seen: those frequently accompanying fluoride ingestion (positive and questionable fluorosis) and those of unknown or unassociated etiology (idiopathic or nonfluoride). The first kind of opacity, observed only in Aurora, had affected 43 percent of the study group (17 percent were "very mild" or "mild" and 26 percent, "questionably" fluorosed). The second kind of opacity was observed in 9 percent of the Aurora children and in 36 percent of the Maryland group.

3. The differentiation between questionably fluorosed and idiopathic opacities was accomplished by observation of physical appearance in 94 percent of the cases, and by attention to pattern and frequency in the remainder.

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PHS Advisory Council Appointments

Dr. Francis F. Heyroth, Dr. Maurice J. Hickey, and Jack B. Beardwood were recently appointed to the National Advisory Dental Research Council, National Institute of Dental Research, Public Health Service.

Dr. Heyroth, who received his M.D. from the University of Cincinnati in 1925 and his Ph.D. in 1929, is associated with the College of Medicine's department of preventive medicine and industrial health. He has had wide experience in industrial medicine, including the assistant directorship of the university's Kettering laboratory of applied physiology. A biochemist, Dr. Heyroth has specialized in protein chemistry, nutrition, and the toxicology of industrial substances.

Dr. Hickey is associate dean of the faculty of medicine, Columbia University, head of the university's division of oral surgery, and executive officer of its department of dentistry. He is also director of the New York State Board of Oral Surgery, assistant attending surgeon at Presbyterian Hospital, and consultant in oral surgery at Kingsbridge Veteran's Hospital.

Mr. Beardwood, a native of Canada, served as special assistant to the Secretary of Health, Education, and Welfare in 1953. He is now an administrative associate of the architectural firm of Welton Becket and Associates. Mr. Beardwood received a degree in journalism from the University of Washington and has been associated with western newspapers, the United Press, Associated Press, and *Time* and *Life* magazines.

Dr. Irving S. Wright, professor of clinical medicine at Cornell University Medical College and attending physician at New York Hospital, has been appointed to serve on the National Advisory Heart Council, National Heart Institute, Public Health Service. He was president of the American Heart Association during the 1952–53 term and chairman of the First National Cerebral Vascular Conference of the American Heart Association held this year. As a clinician, author, and editor, Dr. Wright has had wide experience in the field of heart and blood vessel diseases. He is a civilian consultant in medicine to the Surgeon General of the United States Army and governor of the American College of Physicians. He served as a member of the National Research Council Committee of the American Board of Internal Medicine from 1940 to 1949.