EFFICACY OF THE INDIANA SCHOOL WATER FLUORIDATION PROGRAM

by

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

Dental caries has long been a major health concern among the pediatric population. Fortunately for children and adults alike, caries prevalence in the US has been decreasing over the last 40 years. The dental community has worked diligently to treat oral disease and to educate patients about maintaining proper oral hygiene. As a result our population has become aware of the basic necessities in oral hygiene, understanding the rationale behind it in order to foster the ideals of prevention rather than oral rehabilitation.

Increased coverage of dental insurance has helped to ensure that individuals are not deprived of this basic necessity due to its high cost. Approximately two-thirds of US children were covered by private insurance plans in 1996.[1,2] These statistics become even more significant as those covered children are 2.5 times more likely to obtain dental care. Those not covered by dental insurance are 3 times more likely to have unmet dental needs.[3]

Many federal efforts have taken place since 1997 to improve and expand dental care for children as well. Advanced pediatric dental programs nationwide have been enlarged to address the growing need for care amongst youth. Additionally, legislation has accepted more dental coverage for patients on Medicare and Medicaid services. By passing the balanced budget in 1997, Congress provided $24 billion in health care to as many as 5 million uninsured children over a five-year period.[4] Medicaid coverage in states like Indiana has risen to the needs of the public while addressing the concern dentists have in serving this population. Prior to the change, dentists frequently lost money while providing care to those who needed care most. With Indiana's reimbursement rates rising to 100 percent at the 75th percentile, those individuals who lacked the resources for care in the past now have the opportunity to receive dental treatment and become educated about proper oral care, a privilege not always provided to Medicaid recipients. Education and prevention remain to be the most important tools in dentistry, regardless of the population being treated.

A discussion of the role of prevention in the dental profession and its success in decreasing prevalence of dental caries would be vastly incomplete without the mention of fluoride. "Fluoride has long been recognized as the most reliable preventive measure for caries control."[5] Healthy People 2000 states, "widespread exposure of fluorides through drinking water and dental products appears to be the primary cause of the declining in prevalence of dental caries in school aged population." It is generally accepted that fluoride reduces caries by 20 percent to 40 percent, an astounding percentage considering its ease in use and overall low cost.

The Healthy People 2000 Report issued by the US Department of Health and Human Services, Public Health Survey indicates that strategies to expand the use of effective and efficient preventive health measures should be initiated. It states that community water fluoridation should be given the highest consideration for communities hoping to achieve better oral health conditions. The target is the more than 100 million people in the US who aren't fortunate enough to have water supplies adjusted to optimal levels.[5]

Schools in rural communities not having access to city water lines are a potential location for preventive intervention. First, schools are among the few locations that attract large numbers from numerous, well-separated communities. Second, children spend about 20 percent to 25 percent of their awake, water ingesting hours, at school. Finally, and most importantly, the program supplies the individuals who can benefit most from fluoridated water, the youth.[6]

The cost for running a school fluoridation program is similar to any public water supply system supplying a population of around 1000. In 1988, the average annual cost of school water fluoridation was $4.52 per student per year. In 1999 dollars, this cost would be $6.37 per student.[7]

While the review of literature clearly shows the benefit of water fluoridation in caries reduction to children of rural communities, the concept has lost support. In the 1980s, 13 states were participating in the school fluoridation programs with 470 schools serving 170,000 students.[8] Despite its loss of popularity, the school fluoridation program should not be prematurely discouraged. While the CDC has indicated that fluoridating stand-alone water systems that supply individual schools is of limited necessity, it maintains that continuing the programs should be based on an "assessment of present caries risk in the target school(s), alternative preventive modalities that might be available, and periodic evaluation of program effectiveness."[9] Most importantly, in reference to the state of Indiana, a well-regulated and effectively run school fluoridation program can still be beneficial to those children who need it the most. Groups of children living in rural non-fluoridated communities are still seriously affected by dental caries. The school fluoridation program may remain to be one of the safest, cheapest, and most effective measures to ensure caries protection to the at-risk population.

The purpose of this study was to assess whether the Indiana School Fluoridation program leads to fewer decayed, missing and filled surfaces in permanent teeth (DMFS) and decayed, extracted due to caries, filled surfaces in primary teeth (defs) while not leading to higher fluorosis rates compared with those not participating in the program.

REVIEW OF LITERATURE

The era of community fluoridation began January 25, 1945 when Grand Rapids, Mich., became the first city in the world to adjust the fluoride level in the drinking water to a level that was expected to promote dental health (1.0 ppm). Since then, fluoride tablets, dentifrices, oral rinses, varnishes and lacquers have been adopted as acceptable vehicles for fluoride administration. The incorporation of varying concentrations of fluoride into these products has been successful in decreasing the initiation and progression of dental caries. Initially it was theorized that fluoride only had an intrinsic effect, protecting against tooth decay by incorporating the fluoride ion into the hydroxyapatite crystalline structure during amelogenesis to create fluorohyroxyapeptite or fluoroapatite, a more acid-resistant crystalline structure with greater reduction in solubility.[10] Aasenden and Peebles found that fluoride supplementation during amelogenesis not only resulted in elevated enamel fluoride content but also in a very significant reduction in caries as compared with a non-fluoridated population.[11]

It has since been shown that fluoride also has an inherent effect on the interface between the tooth structure and the oral plaque fluid as the acidogenicity of the plaque is reduced by the presence of fluoride.[12,13] Through the systemic and topical presence of fluoride, salivary flow rich in fluoride has been shown to aid not only in the slowing of lesion formation but additionally in remineralization of white spot lesions.

Ten Cate et al. observed *in vitro* enamel remineralization in the presence of a supersaturated fluoride solution in the continuous presence of fluoride and after short-term fluoride application.[14] With fluoride present in solution in both studies, mineral deposition increased at all levels of the lesion, but most pronounced at the lesion surface.[15,16] Fluoride presence also aids in the rate of remineralization. Koulourides et al. observed a three-to five-fold increase in the rate of hardness recovery when acid treated enamel specimens were immersed in a 1-ppm fluoride remineralizing solution.[17]

Fluoride presence in the oral environment has also proven to have a multitude of effects on the oral microbiota. Jenkins found that the inhibition of bacterial acid production is greater at a lower pH, thus fluoride's peak effect is at a time when the microorganisms are most acidogenic.[18] A major target for fluoride within the bacterial wall is enolase, a metalloenzyme that converts 2-P-glycerate (2PGA) to P-enolpyruvate (PEP) in the glyocolytic pathway. Without PEP, lactic acid production is decreased, and glucose uptake is reduced. Analysis has shown that inclusion of fluoride in intact cells of *Streptococcus salivarius* has resulted in rapidly increased intracellular 2PGA and decreased PEP.[19]

The role of fluoride in post-eruptive tooth maturation has aided caries resistance as well. Epidemiological studies on caries susceptibility have shown that the newly erupted tooth enters the oral environment in a vulnerable state. Crabb has shown that although human enamel erupts in a highly mineralized state, its surface mineralization is not complete.[20] Kotsanos and Darling determined that as the tooth ages in the oral environment, the intracellular pores, which provide an access opening for microorganisms, diminish in diameter. Furthermore, as the tooth aged, the fluoride content with the crystalline structure increased, accenting the value of post-eruptive exposure to fluoride.[21]

Early research in the effects of fluoride in post-eruptive teeth was conducted in the laboratory using rats as the model. Rats ranging in ages were given fluoride prior to placing them on a cariogenic diet. Analysis showed fluoride presence within the mineral structure of the molar dentin and enamel. As the caries presence was less in those rats exposed to fluoride at a younger age, there was strong evidence that the fluoride exposure brought an appreciable resistance to caries attack.[22] Hayes, Littleton, and White further assessed this relation on permanent first molars of children in Grand Rapids, Mich. In Grand Rapids, there were children whose first permanent molars had erupted prior to the initiation of their community water fluoridation program in 1945. These children were compared with children in Muskegon, who had not been exposed to fluoride prior to the examination date in April 1956. Their data indicated that the Grand Rapids children consistently had fewer caries than those in Muskegon. For all surfaces, the mean score was 17 percent lower in Grand Rapids, specifically 14 percent lower on approximal surfaces, 31 percent lower for buccal and lingual surfaces, and 11 percent lower for occlusal surfaces. Their results indicated that fluoride could aid in caries resistance in post-eruptive teeth.[23]

A CDC publication, Morbidity and Mortality Weekly Report, discussed the recent changing paradigm dentists are faced with in regard to the benefits of fluoride.[9] It reports a paradigm that although evidence has shown the cariogenic effects of fluoride incorporation into the developing enamel, the recent data are showing that fluoride's predominant effect is post-eruptive and topical. This recent trend illustrates the need to provide constant sources of fluoride to the tooth structure even after its eruption.

Appropriate fluoride levels must be maintained, however, as excessive fluoride ingestion can lead to morphologic variations in tooth structure. Excessive fluoride exposure during amelogenesis and tooth maturation leads to fluorosis, a hypo-mineralization of tooth surface enamel. Clinically, the appearance of enamel fluorosis can range from faint white lines in the mildest form, to mottled enamel or pitted enamel in severe forms. In recent years, the prevalence of fluorosis has increased, yet the source of supra-optimal levels of fluoride is still debatable. One concern is the lack of knowledge and communication regarding the levels of fluoride supplied to children. As the consumption of packaged foods with varying levels of fluoride content continues to increase, the likelihood of uncontrolled exposure to fluoride will increase. Another major concern is the controlled overexposure to fluoride due to a lack of communication and knowledge among health care professionals.

Woolfolk et al.[24] evaluated the prevalence of fluorosis in schoolchildren living in a non-fluoridated rural community in Michigan. In the study, the Tooth Surface Index of Fluorosis (TSIF) was used to assess the bilateral presence of fluorosis in permanent teeth. Questionnaires were distributed to obtain information regarding previous fluoride exposure. Of the 412 children who had returned questionnaires, only 22.3 percent showed evidence of fluorosis. Of all the permanent tooth surfaces examined, 6.9 percent had evidence of fluorosis with 6.1 percent showing the mildest form (score = 1). Woolfolk et al. found through patient questionnaires that dietary supplementation was the only vehicle of fluoride that significantly related to fluorosis among their population. Of those in the fluorosis group, 88 percent had their fluoride supplement prescribed by their physicians. While the physicians' responsibility to assure fluoride supplements is well-supported by the dental community, the concern is the improper use of the protocol.

Horowitz reported that the complexity of the dosage schedule significantly hindered the appropriate dosage prescriptions.[25] While difficult to compile, specific information must be obtained in order to properly prescribe fluoride supplements. Factors such as fluoride concentration in drinking water, patient age, caries risk, ability to expectorate toothpaste, and breast or formula feeding are needed to safely prescribe fluoride. Thus, health professionals should be more educated and provide more guidance in the effort to supply additional fluoride in the developing youth.

Fluorosis, however, has not been the only concern regarding fluoride ingestion. There remains widespread speculation that fluoride ingestion contributes to birth defects and biochemical and genetic alterations despite the vast literature stating otherwise. Erickson et. al evaluated the incidence of congenital malformations in areas with fluoride supplementation in a community with fluoridated water in comparison with communities without. Results from the analysis showed no consistent patterns in this comparison. While two abnormalities were identified as having a statistically greater incidence in the fluoridated areas, three abnormalities were observed to be statistically greater in the non-fluoridated areas.[26] Of greatest significance was the greater proportion of children born with Down Syndrome in the non-fluoridated community, a finding that challenged Rappaport's suggestion in 1956 that fluoridated drinking water had a correlation to the syndrome.[27]

Li et al. examined the genotoxic effects of chronic exposure to sodium fluoride on sister-chromatid exchange (SCE) in bone marrow cells. Following ingestion of increasing concentrations of sodium fluoride, humeri and plasma cells were analyzed. Results showed no significant difference in frequency of SCE in test hamsters in comparisons with the negative controls. [28] Dunipace et al. further assessed fluoride exposure in medically compromised animals. While the fluoride ingestion, excretion, and retention was significantly greater in diabetic rats, there was no evidence that the fluoride exposure had any physiologic, biochemical, or genetic affects.[29] Dunipace et al. also assessed the effects of fluoride exposure in uremic rats. In spite of significantly higher levels of fluoride in the tissue of rats surgically induced with renal insufficiency, there were no clinically adverse, fluoride-induced extra-skeletal physiologic, biochemical, or genetic effects.[30] Thus, for those who support the use of fluorides, the challenge remains the accessibility of daily fluoride intake.

While fluoride supplementation is still utilized, the safest and most beneficial administration of low levels of fluoride remains with community water fluoridation. At a low fluoride level of 1 ppm, it has been well-documented that its presence leads to a 20-percent to 40-percent decrease in dental caries. The effect of this public health measure is maximized through continuous exposure and ingestion, thus providing a topical effect in addition to a systemic absorption and subsequent secretion in salivary fluids.

In 1973 the state of Indiana initiated a program to fluoridate the water in the school systems. The school programs, operated from the State Board of Health under a grant from the Center for Disease Control in Atlanta, Ga., were headed by a full-time fluoridation consultant and staffed with three full-time field consultants.[31] The timing of this program coincided with the consolidation of rural schools into large physical plants with individual water systems. The participation requirements for elementary schools included the presence of private water wells and water systems and a strict necessity to have less than 0.7 ppm of fluoride in its water.[32] In this manner, Indiana set out to continue its dedication to providing individuals with the public health service of fluoridated water. Based on the disadvantage that students spend about 180 days a year in school for approximately 6 to 7 hours, drinking water for maybe 1 to 2 minutes, schools were supplied with 4.5 ppm of fluoride in their water system. Today, the current optimal fluoride level supplied in Indiana's school water systems is 3.5 ppm

The Indiana State Department of Health initiated the statewide school fluoridation program by installing equipment designed to strictly maintain the prescribed fluoride concentration.[33] Softened water is allowed to trickle upwards through an up-flow sodium fluoride saturator with constant fluoride strength. A small feed pump, which only operates when water is supplied to the school, delivers the fluoride solution to the school's water supply at a rate of one gallon of fluoride solution for about every 5,000 gallons of well-supplied water (Appendix 1, 2). This proportion supplies the school with a fluoride content of 3.5 ppm.

In order to provide the safest delivery of fluoridated water, multiple safety devices have been installed. An anti-siphon valve, found at the point of fluoride injection, prevents siphonage through the fluoride pump into the water system (Appendix 3). The vacuum breaker, found on the inlet to the saturator, provides for adequate cross-connection (Appendix 4). When the system is in operation, water flows out of the sodium fluoride bed through the vacuum breaker. When water stops flowing, the valve within the vacuum breaker drops, opening the atmospheric vent and allowing air to be drawn in, rather than pulling fluoride solution into the line. A thermally actuated flow sensor ensures that the fluoride feed pump only operates when the well is pumping water (Appendix 5). In some schools a flow sensor is not used, rather a pace meter automatically feeds fluoride in proportion to the rate of water flow.

A trained custodian conducts daily surveillance of the individual water system. The inspection begins by filling the tank with sodium fluoride and closing the tank once the proper amount has been added. This procedure ensures a constant fluoride concentration is not exceeded. Following an inspection to check for leaks, the fluoride meter and master water meter readings are recorded on the data sheet to ensure the correct proportion of 1 gallon sodium fluoride to 5,000 gallons of well water are maintained (Appendix 6). The final daily test is performed using a small amount of SPADNS Reagent, a red dye, which reacts with any fluoride in the water supply. By means of a colorimetry test kit, the color of the school water is compared with a 3.5-ppm standard. The color ranges from a deep red in the absence of fluoride to a light red with high levels of fluoride. Results of the SPADNS are then recorded in the data sheet. Once a week, half the sample prior to adding reagent is sent to the Indiana State Department of Health to confirm similar results.

In the event of a daily test resulting in high fluoride content, custodians are instructed to call the Indiana State Department of Health Fluoridation Staff. If actions are necessary, custodians are instructed to discontinue any drinking or cooking with the water. Water samples are collected from drinking fountains and kitchen faucets prior to disconnecting the fluoridation unit. All lines are flushed until repeated tests show the baseline level of fluoride in the well water. If all surveillance procedures, however, have been taken on a daily basis, safe levels of fluoride should be provided to the students of these participating schools to allow them access to a public health measure most rural students don't receive.

Since their initiation, the school fluoridation programs have had only a handful of studies evaluating their success. Herschel S. Horowitz, former chief of Research and Development in the Public Health Service, conducted many of these studies. Horowitz, et al., evaluated the efficacy of the first school fluoridation program initiated in 1954 in St. Thomas, Virgin Islands. Private water wells were supplied with appropriate fluoridation equipment for two schools in 1954 at a level of 2.3 ppm. Four dentists from the Public Health Service conducted clinical examinations in 1962, eight years following program initiation. Total test group showed an average decrease of 21.9 percent decayed, missing and filled teeth (DMFT) in comparison with the control group. Also significant was the difference seen in permanent teeth that underwent maturation during the period of fluoride exposure. The total reduction of DMFT in seventh-grade students was 17.6 percent lower in comparison with the control group in the same grade.[34] The study was the first to document the success of a school fluoridation program.

Horowitz, et al. evaluated the effect of school fluoridation in Elk Lake, Pa., 12 years after the initiation of its program. School water systems in this rural consolidated school (grades 1-12) were supplied with 5 ppm (4.5 times the optimum levels recommended for community water system). Baseline examinations were conducted prior to the initiation of the programs, followed by an interim study four years and eight years after its initiation, and finally 12 years after fluoride was supplied to its water system. Compared with the overall average of 7.72 DMFT on the baseline, children examined 12 years later averaged 4.71 DMFT, a reduction of 39 percent. Analysis of children with varying exposure times to fluoridated water showed a step-like decrease in DMFT as exposure time increased. Late erupting teeth (canines, premolars, and second molars), which were still calcifying after the entrance to first grade, showed half as many caries compared with early erupting teeth. Overall, proximal surface caries was reduced by 53 percent, occlusal surface caries was reduced by 34 percent, and buccal-lingual caries was reduced by 29 percent. Even the rate of extraction of first molars, early erupting teeth, decreased 60 percent displaying the benefit of post-eruptive exposure to topical fluoride supplied in water. The Horowitz et al. study showed a clear benefit to school fluoride.[35]

Heifitz et al. evaluated the effects of school fluoride in Seagrove, N.C. in 1978, where the water was supplied with 6.3 ppm, seven times the optimum level. Baseline dental exams were conducted on students enrolled in grade 1 through 12 by two dentists from Public Health Services. Dental fluorosis was also evaluated using the Dean's Index. Average DMFS among all children decreased 39.6 percent compared with the baseline study, declining from 9.08 DMFS to 5.48. In comparison with the finding in Elk Lake, Pa., Seagrove showed only a marginal improvement in caries prevention despite its higher ppm level. Similarly, a stepwise decrease in DMFS was seen as school children ages increased. Dental fluorosis was evaluated on late erupting teeth, which had had higher fluoride exposure during amelogenesis. None showed definite signs of fluorosis, and 8.2 percent were classified as having questionable fluorosis.[36]

Mallatt et al. evaluated the effect of a 4.5-ppm fluoridated school water supply in a rural public school in Indiana in 1983. One hundred and ten students seven to 10 years of age were examined two years after the induction of fluoridated water. Caries examinations were conducted by a single examiner using conventional diagnostic procedures and bitewing radiographs. The examiner using the Radike criteria for caries presence. The results of the examinations showed an almost 30-percent decrease in caries incidence after only two years of school water fluoridation.[37]

In order to determine school water fluoridation's significance in caries reduction, a study was conducted in North Carolina with partial funding from the Preventive Health and Health Services Block Grant in 1995. Four calibrated dentists conducted DMFS and defs examinations on 3669 students in fifth and sixth grade. Categories of analysis included students receiving school water fluoridation (SWF), weekly 0.2-percent NaF mouth rinses (FMR), school water fluoridation with fluoride mouth rinses (SWF + FMR), and a control. Mean DMFS scores were: SWF=1.27; FMR=0.99; SWF+FMR=1.22; and control=1.43. Children attending schools with FMR alone or in combination with SWF had lower DMFS than the control children. Those receiving SWF alone did not significantly differ from the control children. On the basis of these results the state of North Carolina discontinued its school water fluoridation.[38]

Despite the success historically of the school fluoridation program, its support, as it has in North Carolina, has faded. In 1976, 383 schools had school fluoridation programs.[39] In the mid 1980s that number had risen to 470 schools.[8] Today, only the state of Indiana, with 52 schools and over 24,000 students participating, still supports the program. Concerns regarding fluorosis and fluoride toxicity remain. A case of acute fluoride toxicity was reported at an elementary school in rural Stanley County, N.C. in 1974. Two hundred and one students and 12 adults became ill after drinking orange juice prepared with school-fluoridated water. While all the children and seven of the adults became nauseous, none experienced effects longer than one hour, and none was hospitalized. Orange juice analysis showed a fluoride concentration of 270 ppm resulting from a fluoride feeder pump, which continuously ran over an extended holiday period.[40]

As a whole, support for fluoride supplementation in non-fluoridated areas has declined due to the rising prevalence of fluoride in our beverages and foods, the "halo effect." Today fluoride is available for ingestion in most foods and beverages we consume, simply because of the location in which these products are prepared and packaged. Fluoride is also readily available in dentifrices and topically applied at most dental check-ups. Additionally, for a majority of the population, the caries process is fairly well-controlled. Even Horowitz has stated that "[b]ecause of the national decline in caries that has occurred among US schoolchildren, the need for initiating school fluoridation and dietary fluoride supplement programs in school is less compelling than it once was."[41]

METHODS AND MATERIALS

Human subject clearance was obtained from Indiana University's Institutional Review Board. School participation was initiated by contacting the Indiana State Department of Health to identify schools that participate in the school water fluoridation program and schools that do not participate in the program. The Indiana State Oral Health Director (Mark E. Mallatt, D.D.S., M.S.D.) and the author established the following criteria in school selection. None of the school corporations considered had access to community water fluoridation. All school corporations considered had an enrollment of over 600 students to ensure adequate student participation. Fluoridated schools were eliminated from consideration if fluoridation had only been established within the last five years. Schools were also eliminated if any discontinuity in fluoridation had occurred within the school year in the last six years. Non-fluoridated schools were eliminated from consideration if they participated in any supplemental fluoride program (i.e. weekly fluoride mouthrinse program). The director recommended potential school corporations that would be willing to participate based on past participation in oral health studies. The oral health director eliminated all school corporations that had shown previous reluctance to participate in oral health studies. The director compiled a list of potential school corporations for the author to contact. Examination site approval was obtained by contacting superintendents of the school corporations (Appendix 7,8). Superintendent approval for participation was obtained from the Northwestern Consolidated School Corporation and North Knox School Corporation.

The Northwestern Consolidated School Corporation is located Shelby County in central Indiana. According to the 2000 Census, the median household income in Shelby County was $40, 915. Seven-and-a-half percent of Shelby county citizens live below the poverty line and 10.5 percent of the children live below the poverty line.[42] In June 2001, 4 percent of the population participated in the government-assisted food stamp program.[43] Exams were conducted at Triton elementary (564 students) and Triton middle school (509 students). Students receiving free lunches at these schools were 9 percent and 10 percent, respectively.[44] The rural communities surrounding the Northwestern Consolidated School Corporation have had no access to community-fluoridated water (1 ppm). The school corporations water fluoridation program was initiated in 1976 in Triton elementary school and in 1979 in Triton middle school. Since their initiation, fluoridation has been constant during the school year. As a result of its continuity in fluoridation and student enrollment (projecting at least 200 students participating), the Northwestern Consolidated School Corporation was selected as the test group.

North Knox School Corporation is located in Knox County in southwestern Indiana. According to the 2000 Census, the median household income in Knox County was $30,709. Fourteen-and-a-half percent of Knox County citizens live below the poverty line, and 20.6 percent of the children live below the poverty line.[45] In June 2001, 9.3 percent of the population participated in the government-assisted food stamp program.[44] Exams were conducted at North Knox West elementary (282 students), North Knox Central elementary (297 students), and North Knox East elementary. Students receiving free lunches at these schools were 27 percent, 54 percent, and 27 percent respectively.[46] The rural communities surrounding North Knox School Corporation have had no access to community-fluoridated water (1 ppm). The school corporation has never participated in a school water fluoridation program or a fluoride mouthrinse program. As a result of its fluoride status and student enrollment (projecting at least 200 students participating), the North Knox School Corporation was selected as the control group.

Examinations were scheduled and initiated by contacting the school nurses. Parental consent was obtained from the student's parent by distribution of informed consent forms and questionnaires by the school nurse (Appendix 9, 10). All examined subjects had parental approval, no acute symptoms, and no medical conditions that would warrant subacute bacterial endocarditis prophylaxis. Student participation was voluntary as the student had the option of declining the exam at any time.

The survey team used portable equipment set up on location at the individual schools. A thorough visual examination was performed using conventional mouth mirrors, a dental light, and sterile gauze. The examiner was trained for the purpose of calibration of caries and fluorosis detection by an experienced examiner from the Indiana State Department of Health (Mark E. Mallatt, D.D.S., M.S.D.). The author with the aid of a data recorder conducted all examinations. Universal precautions were used.

Caries examinations were conducted utilizing the criteria established by Radike et al. for clinically diagnosing carious lesions (Appendix 11).[47] For this survey both permanent and deciduous teeth were scored for decayed, missing, and filled surfaces (DMFS, defs). The presence of a sealant was also noted.

Dental fluorosis data were collected using the Tooth Surface Index of Fluorosis (TSIF) which uses a 0-to-7 scale [47](Appendix 12). Dental fluorosis was recorded for the entire dentition, recording a single score.

Each examination was recorded on a data sheet designed to analyze all study specific criteria (Appendix 13). Exam results were distributed to all study participants with general recommendations for parents or guardians (Appendix 14).

The study sample consisted of 460 students in grades 1 through 6. Two hundred and thirty attended a fluoridated school, while 230 attended a non-fluoridated school. Sixty-nine students enrolled at their school after the first grade. These students were deleted from statistical analysis. A total of 391 students were analyzed statistically: 204 from the fluoridated school, and 187 from the non-fluoridated school.

Summary statistics were provided for each variable (number, mean, standard deviation, standard error, maximum, and medians for continuous variables; number and percentage for categorical variables). Summary statistics were also provided for continuous variables grouped by fluoridated status, fluoride supplements status, gender, and grade.

For permanent teeth, the response variables are DMFS (permanent teeth), number decayed, number missing, number of fillings, number of sealants, and fluorosis. For primary teeth, the response variables are defs (primary teeth), number decayed, number extracted due to caries, and number of fillings. Because these represent count data, Poisson regression was used to model each of the responses except fluorosis and number missing. A model was not fit for either of these variables, because they contain mostly zeroes. All response variables were over-dispersed, thus a scale parameter was estimated using the square root of Pearson's Chi-Square/DOF.

RESULTS

Three hundred and ninety-one students were statistically analyzed: 204 fluoridated, and 187 non-fluoridated students. One hundred ninety-seven students were male, and 194 were female (Table I). Of the 391 students analyzed, 36 received fluoride supplementation, and 19 of them attended the fluoridated school.

The mean DMFS score for students attending the fluoridated schools was 0.95 compared with 1.32 at the non-fluoridated school. There was no significant effect of fluoridation status on DMFS ($p = 0.669$). The score for mean decayed surfaces was 0.43 in the fluoridated school and 0.99 in the non-fluoridated school. There was no significant effect of fluoridation status on decayed surfaces ($p = 0.065$), although this value was tending toward significant. The scores for mean filled surfaces in the permanent teeth were 0.50 and 0.32 in the fluoridated and non-fluoridated school, respectively. There was no significant effect of fluoridation status on filled surfaces ($p = 0.244$) (Table II).

Cohort analysis showed lower mean DMFS scores in the fluoridated students in comparison with students in the same grade level in the non-fluoridated schools, with the exception of the sixth grade (Table III, IV). The mean number of decayed surfaces was lower in the fluoridated school compared with the cohorts of the non-fluoridated school, with the exception of the sixth grade. The mean number of filled surfaces was higher in those students attending the fluoridated school in comparison with their cohorts at the non-fluoridated school.

The mean defs score for students attending the fluoridated schools was 5.05 and 5.37 in the non-fluoridated school. There was no significant effect of fluoridation status on defs (p = 0.233). The score for the mean primary tooth surfaces decayed was 1.94 in the fluoridated school and 2.60 in the non-fluoridated school. There was no effect of the fluoridation status on primary tooth surfaces decayed (p = 0.102). The score for mean primary teeth extracted was 0.50 in the fluoridated school and 0.29 in the non-fluoridated school (p = 0.240). The score for mean primary teeth filled was 2.62 in the fluoridated school and 2.49 in the non-fluoridated school. There was no effect of fluoridation status on primary tooth surfaces filled (p = 0.727) (Table V).

Cohort analysis showed lower defs scores in the fluoridated students in comparison with students in the same grade level in the non-fluoridated school, with the exception of the second and sixth grade (Table VI). The mean number of decayed surfaces was lower in the fluoridated school compared with the cohorts of the non-fluoridated school. The mean number of primary tooth missing surfaces was higher in all fluoridated grade levels in comparison with the non-fluoridated grades. The mean number of filled surfaces was lower in students attending the fluoridated school in grades 2, 3, and 6 in comparison with their cohorts at the non-fluoridated school.

The frequency of fluorosis at the fluoridated school was eight students (3.92 percent). Five of the students at the fluoridated school had mild fluorosis; four students had a TSIF score of 1 (1.96 percent); one student had a score of 3 (0.49 percent). Three students at the fluoridated school had severe fluorosis; two students had a score of 4 (0.98 percent), and one student had a score of five (0.49 percent). The frequency of fluorosis at the non-fluoridated school was 19 students (10.16 percent). Nineteen students at the non-fluoridated school had mild fluorosis (9.16 percent). Sixteen students had a score of 1

(8.56 percent); two students had a score of 2 (1.07 percent), and one student had a score of 3 (0.53 percent) (Table VII and VIII).

The mean number of sealants was 0.84 at the fluoridated school and 0.66 at the non-fluoridated school (Table II).

The present study showed a 28-percent reduction in DMFS at the fluoridated school compared with the non-fluoridated school (Table IX). The reduction falls within the range of reduction noted in the previous published school fluoridation studies. The mean DMFS at the fluoridated and non-fluoridated school are both substantially less than those seen in the previous studies dating back to 1962.

TABLES

Table I

Frequencies and percents*

		Frequency	Percent
Fluoridated Status	No	187	47.83
	Yes	204	52.17
Fluoride Supplements Taken	No	355	90.79
	Yes	36	9.21
Gender	Female	194	49.62
	Male	197	50.38
Grade in School	1	91	23.27
	2	93	23.79
	3	72	18.41
	4	40	10.23
	5	49	12.53
	6	46	11.76

*Statistical evaluation of subjects of the school water fluoridation study.

Table II

Summary statistics by fluoridation status in permanent teeth*

Status	Variable	N	Mean	Std Dev	Std Error
No	DMFS Permanent Teeth	187	1.32**	2.07	0.15
	Number Decayed	187	0.99***	1.73	0.13
	Number Missing	187	0.00	0.00	0.00
	Number Filled	187	0.32****	0.98	0.07
	Number of Sealants	187	0.66	1.50	0.11
Yes	DMFS Permanent Teeth	204	0.95**	1.66	0.12
	Number Decayed	204	0.43***	1.13	0.08
	Number Missing	204	0.01	0.14	0.01
	Number Filled	204	0.50****	1.26	0.09
	Number of Sealants	204	0.84	1.50	0.11

*Statistical analysis of the DMFS rates, and sealant presence among students attending the fluoridated school compared with the non-fluoridated school.

** $p = 0.669$
*** $p = 0.065$
**** $p = 0.244$

Table III

Summary statistics by grade for permanent teeth in non-fluoridated students

Fluoridated Status	Grade	Label	N	Mean	Std Dev	Std Error
No	1	DMFS Permanent Teeth	50	0.62	1.61	0.23
		Number Decayed	50	0.58	1.60	0.23
		Number Missing	50	0.00	0.00	0.00
		Number Filled	50	0.04	0.28	0.04
	2	DMFS Permanent Teeth	40	1.15	1.81	0.29
		Number Decayed	40	0.80	1.29	0.20
		Number Missing	40	0.00	0.00	0.00
		Number Filled	40	0.33	0.89	0.14
	3	DMFS Permanent Teeth	26	2.46	2.64	0.52
		Number Decayed	26	2.19	2.53	0.50
		Number Missing	26	0.00	0.00	0.00
		Number Filled	26	0.27	1.00	0.20
	4	DMFS Permanent Teeth	21	1.29	1.85	0.40
		Number Decayed	21	0.95	1.28	0.28
		Number Missing	21	0.00	0.00	0.00
		Number Filled	21	0.33	1.11	0.24
	5	DMFS Permanent Teeth	31	1.55	2.13	0.38
		Number Decayed	31	1.03	1.68	0.30
		Number Missing	31	0.00	0.00	0.00
		Number Filled	31	0.52	1.23	0.22
	6	DMFS Permanent Teeth	19	1.63	2.34	0.54
		Number Decayed	19	0.84	1.54	0.35
		Number Missing	19	0.00	0.00	0.00
		Number Filled	19	0.79	1.47	0.34

Table IV

Summary statistics by grade for permanent teeth in fluoridated students

Fluoridated Status	Grade	Label	N	Mean	Std Dev	Std. Error
Yes	1	DMFS Permanent Teeth	41	0.41	1.18	0.18
		Number Decayed	41	0.32	1.15	0.18
		Number Missing	41	0.00	0.00	0.00
		Number Filled	41	0.10	0.37	0.06
	2	DMFS Permanent Teeth	53	0.70	1.25	0.17
		Number Decayed	53	0.21	0.53	0.07
		Number Missing	53	0.00	0.00	0.00
		Number Filled	53	0.49	1.15	0.16
	3	DMFS Permanent Teeth	46	1.09	1.71	0.25
		Number Decayed	46	0.61	1.24	0.18
		Number Missing	46	0.04	0.29	0.04
		Number Filled	46	0.43	1.20	0.18
	4	DMFS Permanent Teeth	19	0.84	1.34	0.31
		Number Decayed	19	0.26	0.56	0.13
		Number Missing	19	0.00	0.00	0.00
		Number Filled	19	0.58	1.12	0.26
	5	DMFS Permanent Teeth	18	1.22	2.56	0.60
		Number Decayed	18	0.22	0.55	0.13
		Number Missing	18	0.00	0.00	0.00
		Number Filled	18	1.00	2.52	0.59
	6	DMFS Permanent Teeth	27	1.89	2.01	0.39
		Number Decayed	27	1.00	1.94	0.37
		Number Missing	27	0.00	0.00	0.00
		Number Filled	27	0.89	1.19	0.23

Table V

Summary statistics by fluoridation status in primary teeth*

Status	Variable	N	Mean	Std Dev	Std Error
No	defs Primary Teeth	187	5.37**	7.08	0.52
	Number Decayed	187	2.60***	4.00	0.29
	Number Extracted	187	0.29****	1.04	0.08
	Number Filled	187	2.49*****	5.34	0.39
Yes	defs Primary Teeth	204	5.05**	7.40	0.52
	Number Decayed	204	1.94***	4.56	0.32
	Number Extracted	204	0.50****	2.08	0.15
	Number Filled	204	2.62*****	5.57	0.39

*Statistical analysis of the defs rates among students attending the fluoridated school compared with the non-fluoridated school.

** $p = 0.233$
*** $p = 0.102$
**** $p = 0.240$
***** $p = 0.727$

Table VI

Summary statistics by fluoridated status and grade in primary teeth*

	Fluoridated Students		**Non-Fluoridated Students**	
Grade	**Mean defs**	**Std Error**	**Mean defs**	**Std Error**
1	4.02	1.32	6.20	1.02
2	7.30	1.22	7.13	1.20
3	6.11	1.00	6.69	1.44
4	5.21	1.59	4.00	1.41
5	3.06	0.83	4.19	1.28
6	1.59	0.57	1.11	0.72

*Statistical analysis of the defs rates among students within similar grade levels attending the fluoridated school compared with the non-fluoridated school.

Table VII

Frequency and percentage of fluorosis status among permanent teeth*

Fluoride Status	**Frequency**	**Percent**
Yes	8	3.92 %
No	19	10.16 %

*Statistical analysis of fluorosis in permanent teeth among fluoridated and non-fluoridated students

Table VIII

Frequency and percentage of intensity of fluorosis among permanent teeth*

Fluoridated School System

Fluorosis Score TSIF	Frequency	Percent
0	196	96.08 %
1	4	1.96 %
2	0	0.00 %
3	1	0.49 %
4	2	0.98 %
5	1	0.49 %

Non-fluoridated School System

Fluorosis Score	Frequency	Percent
0	168	89.84 %
1	16	8.56 %
2	2	1.07 %
3	1	0.53 %
4	0	0.00 %
5	0	0.00 %

*Statistical analysis of intensity fluorosis using TSIF in permanent teeth among fluoridated and non-fluoridated students.

Table IX

Comparisons with past school water fluoridation studies*

Past Study Analysis	St. Thomas, V.I.	Elk Lake, PA	Sea Grove, NC	Present Study Indiana
Date	1962	1972	1978	2002
Fluoride Concentration	2.3 ppm	5 ppm	6.3 ppm	3.5 ppm
Fluoridated	2.47 DMFT	4.71 DMFT	5.63 DMFS	0.95 DMFS
Non-Fluoridated	3.21 DMFT	7.72 DMFT	9.34 DMFS	1.32 DMFS
Total Caries Reduction	21.9% DMFT	39% DMFT	39.6% DMFS	28% DMFS

*Statistical comparison of decayed, missing, and filled teeth and surfaces (DMFT and DMFS) presented in previous school water fluoridation studies and the present study.

DISCUSSION

While the study evaluated 460 students, only 391 students were statistically analyzed. Sixty-nine students were dismissed statistically, because they had not attended the school consecutively from grade 1 through 6. These 69 students had at some time transferred to their respective school and thus were not evaluated regardless of the years that they attended the studied school.

Of all those statistically analyzed, there was no significant difference in the number of students, because 47.83 percent attended the non-fluoridated school, and 52.17 percent, the fluoridated school. As a result, the data are not weighted toward one particular group. Additionally, no significant difference was found between the numbers of females and males. Males consisted of 50.38 percent of the studied group, and females, 49.62 percent.

Interestingly, only 36 students received fluoride supplementation. Fluoride supplementation for this study was considered to be supplemental daily systemic fluoride, in addition to fluoride rinses and gels prescribed by their dentist. Of the 36 supplemented, 19 (52.78 percent) attended the fluoridated school. These over-exposures to supplemental fluoride demonstrate the need for improved awareness in our medical and dental communities of the fluoride status of our patients. Woolfolk et al.[25] found 88 percent of schoolchildren with fluorosis had supplementation provided by their physicians. With many Indiana dentists unaware of the rural school systems that provide fluoridated water, the medical community could have difficulty staying informed about these methods of supplementation. The number of children with fluorosis was greater in the non-fluoridated school system; however, an explanation for this is not readily available. Among those 19 children receiving supplements at the fluoridated school, only two exhibited fluorosis (which was classified as mild).

Caries rates were assessed for permanent and primary teeth separately. Primary teeth in children at the fluoridated school should have benefited from the supplemental fluoride topically, while the permanent teeth should have had an extra benefit of fluoride being incorporated into the crystalline structure of the enamel.[12]

School-fluoridated water did appear to have an effect on the caries rates in the permanent dentition. Fluoride status, however, did not have a significant effect on caries. The children attending the fluoridated school showed a 6-percent decrease in defs and a 28-percent decrease in DMFS. Although not statistically significant, in the author's opinion the 28-percent difference in DMFS may be clinically significant.

The 28-percent DMFS reduction falls within the range of 23.1 percent to 39 percent found in the previous studies.[35-38] While the reduction was similar, the caries rates were much higher in those school water fluoridation studies dating back to 1962. This disparity is not surprising because of increased fluoridation. The halo effect is a factor. Packaged foods and beverages containing fluoridated water often are consumed by individuals living in "non-fluoride" areas. Fluoridated toothpastes are now the rule rather than the exception, and oral hygiene products have become a major industry. Advertising has helped to increase individual oral hygiene awareness. While the benefit of the fluoridation is shown in this Indiana survey, the state of North Carolina discontinued its school water fluoridation program based on similar results.[39]

In the analysis of fluoride status and grade level, the students in the fluoridated school showed a trend of lower decayed surfaces and higher filled surfaces compared with the non-fluoridated school, with the exception of the sixth grade (which had a higher score for mean decayed surfaces). Additionally, comparing the percentage of filled surfaces to total DMFS showed 53 percent of the total DMFS at the fluoridated school were filled, with only 23 percent at the non-fluoridated school. A trend of a higher percentage of filled surfaces can suggest a stronger dedication to dental care. The individuals who participated in this study with higher filled surfaces may be members of families that place more emphasis on oral hygiene and dental care. Additionally, the mean numbers of preventive sealants found were higher at the fluoridated school (0.84 versus 0.66). This trend may support the idea that those individuals at the fluoridated school dedicated more time and money to oral hygiene and dental care. Additionally, according to the 2000 Census, the socioeconomic status of the fluoridated school's community is higher.[43-46] Thus a lower mean DMFS score for these individuals (fluoridated school) could be expected regardless of fluoride supplementation.

Cohort analysis showed lower DMFS in caries rates among fluoridated students in all grades except the sixth grade. Sixth graders at the fluoridated school showed a mean DMFS of 1.89, while those at the non-fluoridated school showed a lower value of 1.63 DMFS. These results are somewhat surprising. Because all children statistically included in the study had never attended another school, the process of advancement through elementary school would provide topical and systemic fluoride supplements to an individual, and a sixth-grade student would receive the greatest exposure through the years. While the difference in DMFS seen in the sixth graders was not significant, it was lower in the non-fluoridated students. A possible reason for this could be that the group in the number of non-fluoridated students was one of the smallest collected (n = 19). Of these 19, 11 were completely caries-free. Therefore, each student's result had a greater power to it and thus more influence on the overall results.

Primary teeth caries rates followed a similar pattern as the permanent dentition. Fluoridated defs scores were 6 percent lower than the non-fluoridated group. Primary surfaces decayed were lower and filled surfaces were higher in the fluoridated individuals. This trend may support the notion that the families whose children attended the fluoridated school placed more emphasis on dental care by seeking treatment for their dental caries.

Fluorosis rates did not show a significant difference between the two groups. Only 3.92 percent (n = 8) of the children attending the fluoridated school displayed fluorosis. Among those only 1.47 percent (n = 3) showed severe fluorosis, and 2.45 percent (n = 5) displayed mild. None displaying severe fluorosis received additional fluoride supplementation. Two individuals displaying mild fluorosis received supplementation. To further compare, 10.16 percent (n = 19) of those attending the non-fluoridated school displayed fluorosis, and all cases were of the mild form. Fluoride supplements were taken by 1.6 percent (n = 3) of the mild fluorosis group. These fluorosis rates are much lower than what Heifetz found in Sea Grove, N.C.[37] Fluoride supplementation was higher, however, in Sea Grove (5 ppm) in comparison with Indiana's fluoride level (3.5 ppm). These results, however, are lower than most fluorosis rates in the most recent fluorosis surveys. The author is uncertain of the reason for the lower fluorosis rates noted in this study.

Because the author was aware of the schools' fluoridation status, examinations were neither randomized nor blind. However, the author gained no benefit from presenting results that supported or rejected the benefit of school water fluoridation. The results from the study do support the necessity to further assess the Indiana School Water Fluoridation Program. Statewide blind examinations conducted at numerous school systems are necessary to more conclusively show the benefit of the school fluoridation program.

SUMMARY AND CONCLUSION

Indiana remains the only state utilizing the school water fluoridation program to provide supplemental fluoride to those not exposed to community-fluoridated water. Since its initiation in 1973, the program has been managed effectively and safely. To date, there have been no published case reports of mismanagement of the individual fluoridation units or any episodes of acute fluoride toxicity related to the program. The recent CDC publication on current fluoride recommendations has placed greater significance on the post-eruptive topical fluoride effects. Thus, reaching rural populations with fluoridated water remains a major caries-preventive measure, particularly for newly erupted teeth. While the CDC has downplayed the success of school fluoridation programs, it has not issued a request to discontinue their use. Rather, each program is to be periodically assessed to determine its effectiveness based on caries risk. The present study showed that children who participate in the fluoridation program are gaining a clinical benefit from the topical effects of fluoride with no increased risk of fluorosis. Further analysis is required. Statewide blind examinations will need to be conducted at multiple school corporations to determine its effectiveness throughout Indiana to gain evidence of its efficacy.

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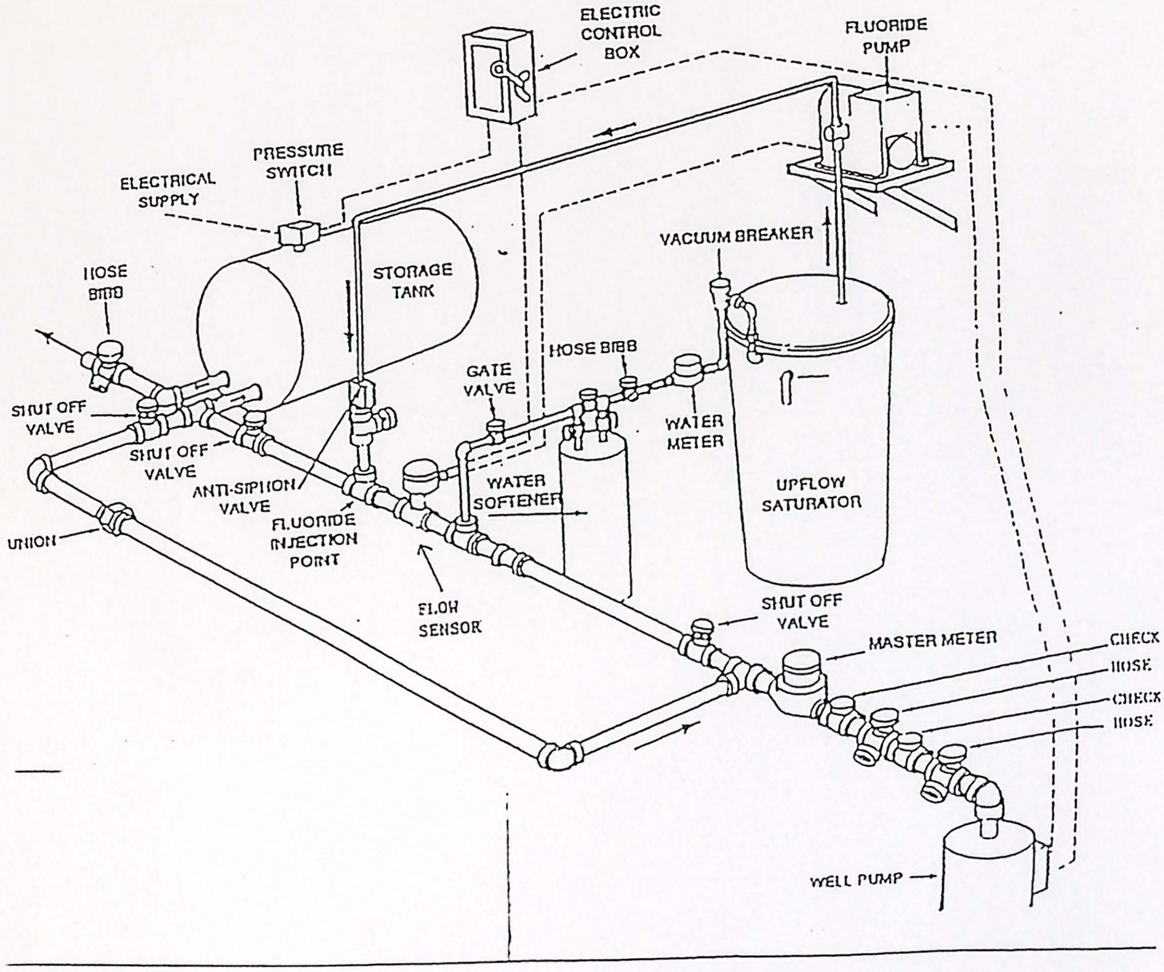
APPENDIX

Appendix I

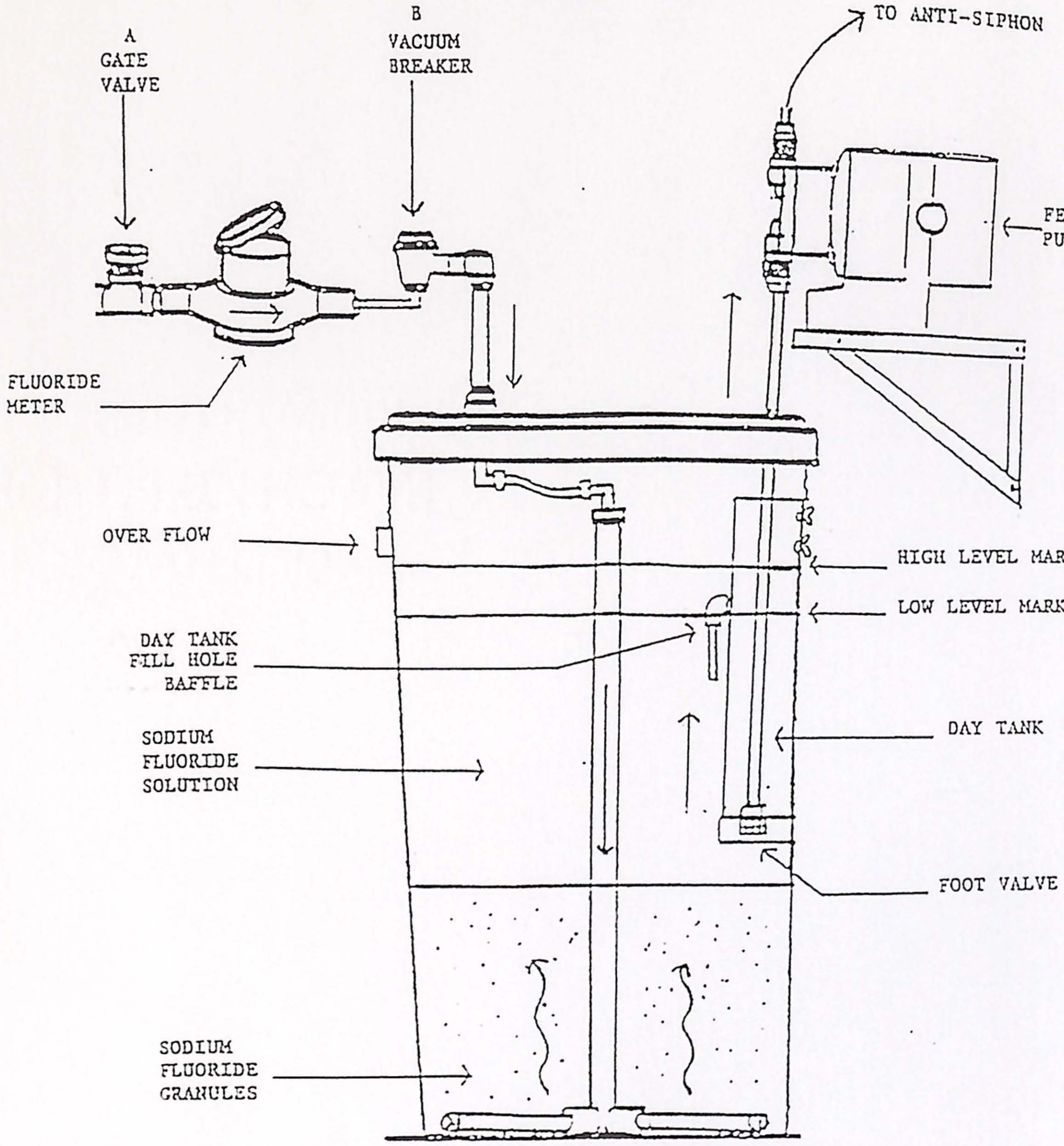
School water fluoridation system*



*The Indiana State Department of Health began placing water fluoridation systems in rural schools that used well water and had no access to community water systems in 1973.

Appendix II

Upflow sodium fluoride saturator*



*Softened water is allowed to trickle through the up-flow sodium fluoride saturator to obtain a constant fluoride concentration of 3.5 ppm. Sodium fluoride solution is delivered at a rate of 1 gallon per 5,000 gallons of well-supplied water.

Appendix III

May 10, 2001

Dr. Larry Moore, Superintendent
Northwestern Consolidated School Corporation
4920 W. 600 North
Fairland, IN 46126

Dear Superintendent,

The Indiana University School of Dentistry has always made a commitment to the children of the state of Indiana. I am a pediatric dentistry resident of the Indiana University School of Dentistry in Riley Hospital currently initiating a study to evaluate the efficacy of the school water fluoridation program in Indiana. The school fluoridation program was set up in 1973 to provide children access to fluoridated water in those communities not on city water lines. It was designed to reach those individuals who benefit most from a program like this in an environment where they spend a majority of their time. This program, effectively run as it is in Indiana, can dramatically aid our Hoosier children in maintaining low caries rate at a critical time in their lives.

In my survey I will be conducting routine dental examinations to identify the prevalence of dental decay. Examinations will be conducted using standard dental instruments and portable dental equipment. To minimize any irritation to soft tissues, the screening will be only visual and will not include the use of x-rays. Also, you can be assured the strict use of infection control (disposable instruments, gloves, masks, etc.) will be used at all times. It is anticipated that the screenings should only take a few minutes.

The state of Indiana has been a leader across the United States in its diligent efforts to provide its citizens with the most important public health measures. Among these efforts has been its dedication to provide fluoridated water to as many communal water systems as possible. The Indiana State Department of Health proudly runs one of the most highly regulated, maintained, and effective fluoridation programs in the country.

Our survey is designed to further assess its effectiveness. We hope to obtain data that will assess the efficacy of school fluoridation programs with regards to caries prevalence.

During the fall of 2001 I am planning to conduct this survey and would like your support for this program. I would like to conduct the survey in an elementary and middle school (grades 1-8) in your school corporation since it currently participates in the school fluoridation program. If possible, we would like a letter of endorsement from you, which we could then send to the selected schools that agree to participate in this survey.

We are confident that with your support and the cooperation of the school, the oral health survey will be successful and we will able to identify the present dental health needs of our children, and thus better direct statewide emphasis to improve their health and well-being. Should you have any questions, please do not hesitate to call.

Sincerely,

Andrew H. Garabedian, D.D.S.
Indiana University School of Dentistry
Pediatric Dentistry resident
317-639-2750

Appendix IV

September 6, 2001

Tim Lavery, Superintendent
North Knox School Corporation
11110 N SR 159
Bicknell, IN 47512

Dear Superintendent,

As you know the Indiana University School of Dentistry has always made a commitment to the children of the state of Indiana. I am a pediatric dentistry resident of the Indiana University School of Dentistry in Riley Hospital currently initiating a study to evaluate the efficacy of the school water fluoridation program in Indiana. The school fluoridation program was set up in 1973 to provide children access to fluoridated water in rural communities. It was designed to reach those individuals who could benefit most from a program like this in an environment where they spend a majority of their waking hours. This program, effectively run as it is in Indiana, can dramatically aid our Hoosier children in maintaining low caries rate at a critical time in their lives.

In my survey I will be conducting routine dental examinations of the oral hard tissues to identify the prevalence of dental decay. Examinations will be conducted using standard dental instruments and portable dental equipment. To minimize any irritation to soft tissues, the screening will be only visual and will not include the use of x-rays. Also, you can be assured the strict use of infection control (disposable instruments, gloves, masks, etc.) will be used at all times. It is anticipated that the screenings should only take a few minutes.

The state of Indiana has been in leader across the United States in its diligent efforts to provide its citizens with the most important public health measures. Among these efforts has been its dedication to provide fluoridated water in most major city water systems. Indiana proudly runs the most highly regulated, maintained, and effective programs in order to reach the children of these communities. Statewide the goal has been to gain access to those citizens living in low populated rural communities.

Our survey is designed to validate its effectiveness. We hope to attain data that will prove an effectively run school fluoridation program can in fact lower caries susceptibility in these children. Your school corporation does not participate in the school water fluoridation program nor fluoride rinse program and thus would aid in identifying the true efficacy of those programs.

During the fall of 2001 I am planning to conduct this survey and would like your support for this program. I would like to conduct the survey in an elementary and middle school (grades 1-6) in your school corporation. All parents that wish their children to be evaluated will receive a report following the exam in addition to educational information and a toothbrush.

If possible, we would like a letter of endorsement from you. We are confident that with your support and the cooperation of the school, the oral health survey will be successful and we will able to identify the present dental health needs of our children, and thus better direct statewide emphasis to improve their health and well-being. Should you have any questions, please do not hesitate to call.

Sincerely,

Andrew H. Garabedian, D.D.S.
Indiana University School of Dentistry
James Whitcomb Riley Hospital
Pediatric Dentistry resident
317-274-9604

Appendix V

IUPUI and Clarian Informed Consent Statement
Efficacy of the Indiana School Fluoridation Program

Dear Parents and Students,

Your child is invited to participate in a dental health research study of children residing in selected communities of Indiana. The purpose of this study is to assess our school water fluoridation program and to evaluate the current prevalence of tooth decay in approximately 300 school children. The research study will be conducted in the fall of 2001.

If you and your child agree to participate, a licensed dentist from the Indiana University School of Dentistry will perform a dental examination of the oral hard tissues (teeth) during regular school hours. It is anticipated the examination will only take a few minutes. The examinations will be conducted using disposable instruments and portable dental equipment. As with any dental exam, irritation of the oral soft tissue (gums, cheeks) is a possibility as is the potential for the spread of germs. To minimize this, the screening will be only visual and will not include the use of x-rays.

Also, you can be assured that strict use of infection control procedures (disposable instruments, gloves, masks, etc.) will be used at all times. To be eligible to participate, your child must return this completed consent letter to their school.

Benefits that your child will receive include a thorough dental examination, a toothbrush, and a report of our findings so that treatment may be sought if necessary. Refusal to participate will involve no penalty or loss of benefits to which your child is otherwise entitled. If you choose for your child to participate he/she may refuse or discontinue participation at any time.

We emphasize that this research study does not involve restorative dental treatment (fillings) and we encourage you to continue your child's regular visits to his/her dentist. It should also be noted that participation is strictly voluntary. While the general results of this examination may be published at the end, you are assured that your child's records and information will not be identified personally. If you have any questions, or wish more information, please feel free to call Dr. Andrew Garabedian at (317) 274-9604. Thank you very much for your help with this project.

If you are willing for your children to participate in this research study, please complete the attached form and return it to your child's school within three days. Please contact IUPUI Research and Sponsored Programs at (317) 274-8289 or Dr. Andrew Garabedian or Dr. Mark Mallatt at the telephone numbers below regarding: 1) any questions you may have regarding the study, 2) concerns regarding the safety of your child and, 3) your child's rights as a research participant.

Sincerely,

Andrew H. Garabedian, D.D.S.
Indiana University School of Dentistry
Riley Pediatric Dentistry Resident
(317)274-9604

Mark E. Mallatt, D.D.S., M.S.D.
Indiana State Department of Health
(317)233-7427

Appendix VI

IUPUI and Clarian Informed Consent Statement

ALL QUESTIONS MUST BE ANSWERED & SIGNATURES PROVIDED

CHILD'S NAME_________________________________ SEX_____ AGE______
ADDRESS_________________________________ ZIP________PHONE__________
SCHOOL___________________HOMEROOM TEACHER________ GRADE_______

What is the source of household water supply? City_____ Well (other)_____

1) Does your child presently have a health problem that would prevent participation in this survey? Yes (Explain)_________________________________ No____
2) Has your child ever had rheumatic fever, heart valve replacement, or joint replacement? Yes (Explain)_________________________________ No____

THE FOLLOWING SOCIOECONOMIC/DEMOGRAPHIC INFORMATION WILL BE KEPT CONFIDENTIAL

Has your child attended his/her current school since the first grade? Yes_______ No____

Does your child, or has child ever taken fluoride supplements? Yes_____ No______
If answered yes, please name supplement and identify who recommended their use?____

On the average, how often does your child visit the dentist?
Every 6 months________ For emergency only________
Once a year ________ Never ________

How would you rate your child's oral hygiene (i.e. habits in brushing)?
Excellent ____Good _____Fair ____Poor ____

Does your child routinely receive or use any of the following (Please check all that apply)
Fluoride applications after having teeth cleaned in a dental office ________
Use of fluoride toothpaste ________
Use of fluoride mouthwash ________
Use of fluoride tablets of drops ________
None of the above ________

I have read the description of the dental study and wish my child to participate in the program. Participation is voluntary and my child is able to withdraw at any time.

PARENT'S (GUARDIAN'S) SIGNATURE ______________________ DATE ______

Appendix VII

Criteria of assessment for dental caries

The assessment of dental caries will be conducted utilizing the criteria established by Radike at the Principals for the Clinical Testing of Cariostatic Agents conference held at the American Dental Association on October 14-16, 1968

A. Dental Caries

a. Frank Lesion-The detection of these lesions on the basis of gross cavitation usually does not present a problem in diagnosis. When cavitation is present the diagnosis is positive.
    1. Cavitation in this context may be caused by loss of tooth substance.
    2. Cavitation which is the result of the caries process must be distinguished from fractures and the smooth lesions of erosion and abrasion.

ii. Lesions Not Showing Frank Cavitation-The most difficult part of the examiner's task is the detection of lesions where there is not frank cavitation. These lesions are close to the decision point between caries and sound. The criteria for detection of these lesions are summarized in three categories.
    1. Detection of pit and fissure lesion of the occlusal, facial and lingual surfaces.
        a. Area is carious when the explorer "catches" or resists removal after the insertion into a pit or fissure with moderate to firm pressure, and when this is accompanied by one or more of the following signs of caries:
            i. A softness at the base of the area
            ii. Opacity adjacent to the pit or fissure as evidence of undermining or demineralization
            iii. Softened enamel adjacent to the pit or fissure which may be scraped away with the explorer
        b. Area is carious if there is loss of the normal translucency of the enamel, adjacent to a pit, which is in contrast to the surrounding tooth structure. This condition is considered to be reliable evidence of undermining. In some of the cases, the explore may not catch or penetrate the pit.

(continued)

Appendix VII (continued)

Criteria of Assessment for Dental Caries

2. Detection of lesions on smooth area of facial and lingual surfaces
    a. Area is carious if surface is etched or it there is a white spot as evidence of subsurface demineralization, and if the area is found to be soft by:
        i. Penetration with explorer
        ii. Scraping away enamel with explorer
    b. Area is sound when there is apparent evidence of demineralization (etching or white spots) but no evidence of softness.
3. Detection of lesion on proximal surfaces
    a. For area exposed to direct visual and tactile examination-these are diagnosed as under "b." above for smooth areas.
    b. For hidden area not exposed to direct visual-tactile examination:
        i. Visual examination: if the marginal ridge shows an opacity as evidence of undermined enamel, the proximal surface is carious.
        ii. Tactile examination: any discontinuity of the enamel in which and explorer will enter is carious if it also shows other evidence of decay as under "b." above for smooth areas.

Appendix VIII

Tooth surface index of fluorosis (TSIF)

The assessment of dental fluorosis was conducted utilizing the Tooth Surface Index of Fluorosis. Scores were given based on the specified criteria.

0 Enamel shows no evidence of fluorosis.

1 Enamel shows definite evidence of fluorosis, namely areas with parchment-white color that total less than one-third of the visible enamel surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth ("snowcapping").

2 Parchment-white fluorosis totals at least one-third of the visible surface, but less than two-thirds.

3 Parchment-white fluorosis totals at least two-thirds of the visible surface.

4 Enamel shows staining in conjunction with any of the preceding levels of fluorosis. Staining is defined as an area of definite discoloration that may range from light to very dark brown.

5 Discrete pitting of the enamel exists, unaccompanied by evidence of staining of intact enamel. A pit is defined as a definite physical defect in the enamel surface with a rough floor that is surrounded by a wall of intact enamel. The pitted area is usually stained or differs in color from the surrounding enamel.

6 Both discreet pitting and staining of the intact enamel exist.

7 Confluent pitting of the enamel surface exists. Large areas of enamel may be missing, and the anatomy of the tooth may be altered. Dark-brown stain is usually present.

Appendix IX
School Water Fluoridation Examination Sheet

Name: ______________________________ School: ____________________
Age: ________ Grade: ____________________
Sex: _______M ______F Date: ____________________
School Fluoridation Status: ____Y ______N Examiner: ____________________

I. Decayed, Missing, Filled Surfaces

The assessment of dental caries will be conducted utilizing the criteria established by Radike at the Principals for the Clinical Testing of Cariostatic Agents conference held at the American Dental Association on October 14-16, 1968

Maxillary Right Quadrant | Maxillary Left Quadrant

	2	3	4 A	5 B	6 C	7 D	8 E	9 F	10 G	11 H	12 I	13 J	14	15
Occ														
Bucc														
Mesial														
Distal														
Ling														

Mandibular Right Quadrant | Mandibular Left Quadrant

	31	30	29 T	28 S	27 R	26 Q	25 P	24 O	23 N	22 M	21 L	20 K	19	18
Occ														
Bucc														
Mesial														
Distal														
Ling														

II. Fluorosis

The assessment of dental fluorosis will be conducted utilizing the Tooth Surface Index of Fluorosis. Scores will be given based on the specified criteria.

Maxilla

TSIF	2	3	4 A	5 B	6 C	7 D	8 E	9 F	10 G	11 H	12 I	13 J	14	15
Score														

Mandible

TSIF	31	30	29 T	28 S	27 R	26 Q	25 P	24 O	23 N	22 M	21 L	20 K	19	18
Score														

AHG 2/01/01

Appendix X

Dear Parent,

Thank you for allowing your child to participate in the Indiana University School of Dentistry School Flouridation Survey. Your cooperation helps to provide valuable information which helps to provide the best insight into identifying the dental needs and appropriate preventive programs for Indiana children.

This survey examination is not intended to replace a complete examination by your family dentist. If your child is receiving regular dental check-ups, your family dentist may already be aware of the following:

☐ No obvious problems- regular checkups are recommended

☐ Questionable area(s) on teeth which should be examined by a dentist in the near future, or at your child's next check-up.

☐ Oral condition in need of care by a dentist. Please make an appointment as soon as possible.

☐ Better daily brushing and flossing is recommended.

Comments:

Your Child was:

☐ Not examined because of a medical condition.

☐ Absent at the time of the examination.

You are encouraged to make appointments for your child with a dentist for regular checkups. Thank you again for your participation in the school fluoridation survey .

Sincerely,

Andrew H. Garabedian, D.D.S.
Project Director

ABSTRACT

EFFICACY OF THE INDIANA SCHOOL WATER FLUORIDATION PROGRAM

by

Andrew H. Garabedian

Indiana University School of Dentistry
Indianapolis, Indiana

In 1973 the state of Indiana initiated a program to fluoridate the water in rural school systems to a concentration of 4.0 ppm. Today, the optimal concentration is 3.5 ppm. When it was initiated, school water fluoridation was a popular method of providing fluoride supplementation to children who didn't have access to community-fluoridated water. Today, only Indiana runs a school water fluoridation program, and the CDC has stated that continuation of these efforts should be based on caries risk, alternate preventive measures, and periodic evaluation of program effectiveness. The purpose of this study was to assess the efficacy of the Indiana school water fluoridation program in

order to determine if children participating in the program develop less caries with no increased risk of fluorosis. Four hundred sixty students were examined from Northwestern Consolidated School Corporation in Shelby County (fluoridated school) and North Knox School Corporation in Knox County (non-fluoridated school). Three hundred ninety-one students were statistically evaluated, 204 from the fluoridated school and 187 from the non-fluoridated school. A thorough visual examination was conducted by the same examiner collecting data on DMFS, defs, and fluorosis in grades 1-6. DMFS scores were 28 percent less for fluoridated students compared with non-fluoridated students (0.95 versus 1.32). Although the effect of fluoridation status on caries in permanent teeth is not statistically significant, the author believes this difference may be clinically significant. Analysis of defs scores showed fluoridated students with 6 percent less defs than non-fluoridated students, although the results were not statistically significant. Only 3.92 percent of the students at the fluoridated school showed fluorosis, while 10.16 percent showed signs of mild fluorosis at the non-fluoridated school. Conclusion: While not statistically significant, children attending the school fluoridated with 3.5 ppm of fluoride developed less caries and suffered no increase of fluorosis compared with children attending schools not participating in the school fluoridation program. Further analysis is necessary through statewide blind examinations at numerous school systems to further assess the efficacy of the Indiana School Water Fluoridation Program.

Andrew Hrair Garabedian

May 15, 1973	Born in Spokane, Washington
May 1995	Biology BA University of Puget Sound Tacoma, Washington
May 2000	DDS Indiana University School of Dentistry Indianapolis, Indiana
July 2002	MSD Pediatric Dentistry Indiana University School of Dentistry Indianapolis, Indiana

Professional Organization

American Dental Association
American Academy of Pediatric Dentistry
American Society of Dentistry for Children
Washington Academy of Pediatric Dentists
Spokane Dental Society

Awards and Honors

James E. Humphrey, DDS Memorial Scholarship
National Institute of Health Research Stipend Award
Indiana University Alumni Scholarship