

# Is Fluoridating Water Beneficial to Our Children: A Dental Perspective

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## Abstract

The addition of fluoride to our water system may not be as beneficial to children as previously thought. While fluoride is effective at preventing dental caries formation, it would be more beneficial if it was administered only as an oral topical treatment and not introduced into the water. This paper will examine research that explains dental caries formation and the cariostatic mechanism of fluoride. Additionally, the adverse effects of fluoride by causing fluorosis will be reviewed. By analyzing studies that compare the prevalence of dental caries and fluorosis in both fluoridated areas and non-fluoridated areas, it can be concluded that while dental caries decrease in both areas, a drastic increase in fluorosis is noticed only in those fluoridated areas.

## Introduction

The Center for Disease Control claims that fluoridating the water is one of the greatest achievements in the twentieth century in terms of preventing disease (CDC, 1999). In fact, it is estimated that by 2005 60% of the country already had access to fluoridated water (Kauffman, 2005). The supposed benefit is that fluoride help reduce dental caries. While the exact mechanism is not fully understood there is a prevailing theory as to why it does work. Indeed, it has been noticed that since the induction of fluoride to water supplies worldwide there has been a downward trend in cavities (Jones, et al. 2005). However, fluoride use is synonymous with fluorosis, the discoloration of teeth. While this isn't a significant health risk, it is unsightly and can make the child feel uncomfortable. Currently, there is limited treatment available for fluorotic teeth ranging from bleaching to crown restoration (Sherwood, 2010). It remains to be seen if fluoridation of the water is the optimal method for delivering fluoride to our children. In fact, given the widespread dissemination of fluoridated products there are other methods to ensure that children have adequate fluoride intake. By examining the data and studying trends associated with fluoride use both in water and as a supplement, scientists can use the resulting information to suggest necessary changes in the child's fluoride intake and modify their diet to achieve the maximized benefit from fluoride intake.

## Method

In conducting this research Touro's online library, and the publications it is affiliated with, specifically PubMed were searched. In addition, Google Scholar and online search engines as well as the resources available at the public library and its computer access to various online journals were utilized.

## Discussion

### Dental Caries

Dental caries, is the most common infectious disease affecting children, both in developed and third world countries (Colak, et. Al. 2013). They are formed primarily in pits and fissure where bacteria cling and metabolize sugars. The tooth is composed of two sections, the crown which is the exposed section, and the root which goes down and is embedded in the bone. The outermost layer of the crown is enamel which is comprised primarily of hard tightly packed rods of hydroxyapatite ( $\text{Ca}_{10}(\text{OH})_2\text{PO}_4$ ). The saliva in the mouth greatly aids in biofilm formation and allows various bacteria to colonize the tooth (Talaro, 2009). In fact, there is a diverse population of bacteria that inhabit the mouth estimated to be up to 300 different species (Loesche, 1986). When carbohydrates are consumed and broken down in the mouth by salivary enzymes into sugar components, oral bacteria will metabolize them and produce acid as a by-product. Current research suggests

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that *S. mutans* are the primary bacteria responsible for dental caries formation (Loesche, 1986). As sugars are broken down in the mouth and acids are produced, the pH gets lowered and shifts the optimal conditions for bacterial growth in favor of these bacteria. Consequently, their metabolic activity will increase and produce even more acid while stunting other bacterial growth which don't produce as much acid and prefer more basic conditions. This will lead to significant acid buildup in the mouth. Caries are then formed over time by the acid in the mouth tunneling into the enamel layer through demineralization. If it is left untreated it can tunnel into the dentin layer and cause serious disease (Talaro, 2009). While it is known that teeth undergo a continuous process of mineralization and demineralization, it is the disturbance of this equilibrium in favor of increased demineralization that causes dental caries (Marsh, 1994)

### History of Fluoride

The cariostatic of fluoride was discovered by in 1901 by Dr. Frederick McKay (NIH, 2014) in Colorado Springs, CO when he moved there to open a dental practice. As soon as he got there he saw that ninety percent of the children had dark spots on their teeth. The locals told him that they suspected that there was something in their diet that contributed to this interesting phenomenon. Although this claim sounded preposterous to him he was intrigued and started doing research to uncover what was causing what was dubbed as the Colorado Brown Stain, which until then was unreported in medical literature. In 1909 dental researcher Dr. G.V. Black went to Colorado to help investigate the cause of this discoloration. He then discovered two interesting facts. First of all this discoloration was only an issue in children, meaning that those adults whose teeth calcified without discoloration weren't at any risk at all and secondly, that there was little prevalence of dental caries within the population of Colorado Springs (NIH, 2014).

In 1923 Dr. McKay went to Oakley, Idaho where he heard that the children there suffered as well from tooth discoloration. He suspected that the water was causing this discoloration. Amazingly, when the water supply was rerouted the discoloration stopped. This convinced Dr. McKay that somehow, the water is responsible for the

discoloration of teeth. A similar phenomenon was noted in Bauxite, Arkansas where discolored teeth were prevalent in children, yet in other towns a mere few miles away their teeth were normal.

This was of great scientific significance as many companies had toxic fluoride waste that they had to get rid of and used this substantiation to dump their fluoride, albeit treated, into public water. Furthermore, this initial validation of the benefits of fluoride is still used today. However, there is much worldwide opposition to fluoridating water from a dental perspective and general health as well (Bryson, 2004).

### Cariostatic Mechanism of Fluoride

How does fluoride work to prevent cavities from forming? We must consider this question from two angles, namely, does it work in pre or post eruptive teeth? Furthermore, what is the pharmacological effect of fluoride on developing teeth.

Rosin-Grget, et. al. concluded that the mechanism of fluoride is more preventative in nature in mature teeth than pre eruptive ones where fluoride changes the crystalline structure and reduces the formation of dental caries (Rosin-Grget, et. al. 2013). They quote a study from LeGeros investigating enamel structure in deciduous teeth where prenatal fluoride supplements were administered. They found that there is less acid etching, higher mineral, and more organized crystalline structures with smaller prisms in the teeth. He concluded that this makes the enamel more perfect and as a result less acid soluble. However Rosin-Grget et al. (2013) refuted this claim because in vitro studies show the effect of fluoride on enamel solubility is minor and it is unlikely that the pre eruptive effect of incorporating fluoride will have any significant contribution, if any, in the reduction of caries.

An interesting study was done to determine the in situ effect of bacteria on shark teeth. Shark teeth, unlike human teeth, are naturally high in fluoride and composed almost exclusively of fluorapatite ( $\text{Ca}_5(\text{PO}_4)_3\text{F}_2$ ). They placed orthodontic bands with 0.2% NaF solution on both sets of teeth which will allow biofilm growth and found the plaque accumulation to be almost identical in both samples. They concluded that the effect of fluoride is influ-

enced primarily by topical, post eruptive effects. However, when treating both sets of teeth with fluoride rinses plaque growth was inhibited (Ogaard, et. al. 1991). We clearly see that the effects of fluoride is topical.

Rosin- Grget et al. proposed that the mechanism of action for fluoride is twofold. When fluoride is introduced into the mouth topically it forms a covering over the teeth in the form of Calcium Fluoride. This will inhibit acid demineralization by secreting fluoride ions which neutralize the acid. Since teeth also undergo a constant mineralization/ demineralization process, the fluoride will be incorporated into the crystalline structures. Normally, the main component of teeth is hydroxyapatite crystals (Ca<sub>5</sub>(PO<sub>4</sub>)<sub>6</sub>(OH)<sub>2</sub>), however fluoride will be exchanged in place of some of the hydroxyl groups and form fluorapatite (Ca<sub>5</sub>(PO<sub>4</sub>)<sub>6</sub>F<sub>2</sub>) which is more resistant to acid breakdown. This is because when acid breaks down the fluorapatite crystalline structures it will release the free fluoride ions which then work similarly to topical fluoride. So while fluoride is important from a remineralization point of view, its efficacy is based on its ability to form crystals which won't dissolve quickly, thereby inhibiting enamel demineralization. Therefore, a constant low level of fluoride ions in saliva reduces the rates of enamel demineralisation during the caries process and enhances the remineralisation of enamel.

Some have suggested that fluoride in the form of HF will affect the bacteria at the metabolic level but further research is necessary to substantiate this claim (Rosin-Grget, Peros, Sutej, & Basic, 2013). However, if this is true that fluoride disrupts bacterial metabolic activity, there is cause for concern that it may alter the body's normal flora equilibrium (Bryson, 2004)

**Fluorosis**

Fluorosis is defined as the discoloration of teeth due excess fluoride. The initial discovery of the efficacy of fluoride was through the discoloration of children's teeth. After McKay's initial work, The National Institute of Health dental department, headed by Dr. H.Trendely Dean, began investigating acceptable levels of fluoride in water supply systems that won't cause fluorosis (NIH, 2014). Interestingly enough, Dean was originally a strong

opponent of fluoridating water for this very reason but later after being promoted to head the NIH he changed his mind. This led critics to question whether there was any reason to believe in the safety of fluoride or if Dean changed his mind for unknown reasons (Kauffman, 2005). After performing various tests he discovered that fluoride levels up to 1.0 ppm won't causes severe fluorosis in most people and only mild fluorosis in many (Science, 1993). Furthermore he compiled an index, famously known as Dean's index which measures fluorosis severity levels and is still used today (Table 1 ). These guidelines are defined by taking the two most discolored teeth and then classifying the tooth in its entirety, not just the discolored spots (Science, 1993)

**Table 1:** Fluorosis classifications. Based on information obtained from the National Institute of Science (Science, Health Effects of Ingested Fluoride, 1993)

Classification	Fluorosis Symptoms
Normal	Clear white surface
Questionable	Small white flecks where fluorosis isn't clear.
Very Mild	Small white flecks that occupy up to 25% of the tooth
Mild	White opaque spots are clearly noticeable but don't occupy 50% of the tooth
Moderate	All surface of the tooth are affected and brown spots are sometimes apparent
Severe	The general structure of the tooth is affected and the tooth can corrode. It is marked by brown splotches

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Fluorosis, while the exact molecular mechanism is still unknown, is known to be caused by the incorporation of fluoride during the mineralization of the enamel during tooth development (Lyyruu, et al., 2014). It arises as a result of long term uptake of fluoride ions and the hypermineralization of fluoride in enamel during tooth development. Consequently, it is a concern for children during development and it won't affect them after their teeth are already formed. In fact, after the teeth erupted they will be caries-free as previously discussed.

### Ireland Water Fluoridation

Dr. Máiréad Antoinette Harding and Dr. Denis Martin O'Mullane reviewed the results obtained from this study (Harding & O'mullane, 2013). In an effort to combat the widespread dental caries plaguing the general population, the government passed a law in 1964 requiring Dublin to fluoridate its water. By 1970 most communities in Ireland had fluoridated their water supply system. The government also mandated that a baseline survey be taken before the fluoridation of the water and compare it with results that would be obtained at a later date. To ensure the study's integrity, the ROI also stipulated that regular surveys of the water fluoride levels be conducted as often as necessary. Furthermore, the fluoridation was carried out by the Department of Sanitation while the Department of Environment is responsible for ensuring optimal fluoride levels are maintained throughout the study. The fluoride levels were kept between 0.8 -1.0 ppm with a target range of 0.9 ppm. Additionally, since this was a government project it is safe to assume that there was a large study pool. Also, because fluoride is introduced directly into the water, patient compliance is a non-issue. Furthermore, because the water wasn't previously fluoridated we know that the data was gathered accurately and reflects the nature of the study.

The method of the study was to measure the decayed, missing, filled teeth (DMF) of children age 5 from both communities that have access to fluoridated water and comparing it to communities that drink unfluoridated water. Results were then recorded using the DMF index. Measurements were taken in 1965 when fluoridation was first introduced and then again in 1983-1984 and 2002.

Another study was conducted as well in Northern Ireland (NI) in 2000 where water fluoridation hadn't been introduced. The same criteria as the 1984 study were used here as well. The purpose of the study was to study the effect of fluoridating water on DMF teeth as well in 5 year olds.

Another component of the study was to measure the prevalence of fluorosis in fluoridated areas versus those areas that weren't fluoridated. They were measured and ranked using Dean's Index and results were recorded with percentages from 0 -100 of those taking part in the study who exhibited fluorosis. It is important to note that only fluorosis data from normal, questionable, and very mild were recorded in the survey. Thus we can't quantify the data with respect to mild- severe with resulting from this survey.

### Results

The following results were obtained in respect with dental caries measured in DMF indices.

**Table 2:** Data showing the prevalence of decayed, missing, filled teeth (DMF) in areas of fluoridated water (Full FL) and non-fluoridated water (Non FL) in the Republic of Ireland (ROI). (Harding & O'mullane, 2013).

ROI 5 yr olds	ROI	NI	
Year	Full FL	Non FL	Non FL
1960	-----	5.6	4.8
1983-84	1.8	3.0	4.5
2002	1.3	1.0	1.8

As we can see from this data, in the year 1960 there is no data between fluoridated and non-fluoridated areas as there was no fluoridation done at this point, but we did see that the DMF is higher than the following years. However, in the year 1983 we see a clear distinction between full FL and non-FL areas which follows the expected results. In the year 2002 we see little difference if any between FL and non-FL areas. Furthermore, when analyzing data in

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non – FL areas alone we see a step decline in the DMF index.

This can be seen as well when analyzing the data from NI. In the year 1960 the DMF is 4.8 and in 1983-84 it is 4.5. Again, we see that although there wasn't any change in the fluoride levels in the water, nevertheless there is a drop in the DMF index. This correlates with data found worldwide that dental caries were on the decline with the advent of fluoridated products especially toothpaste which was introduced in the 1970's (Jones, et. al. 2005).

Perhaps the most intriguing data is from 2002 where all the data is within the same range, both from the FL and non-FL area. Furthermore, even the NI data from 1985 which was slightly higher when compared to non-FL (4.5 vs 3.0) is within 0.1 in 2002. This further solidifies the observation that given the widespread availability and incorporation of fluoridated products in our lifestyle we see a dramatic decline in dental caries worldwide. This is evident where we see no distinguishable difference in the data between fluoridated and non-fluoridated areas. It is important to notice that this study doesn't account for the participants' dietary intake and so it is impossible to make any substantial claim with respect to the effect of fluoridated products alone without drinking fluoridated water.

**Table 3: Percentages of fluorosis in Republic of Ireland (RoI)**

Fluorosis	RoI		NI ( non FL)		2002*
	Fluoridated	non-Fluoridated	1984	2002	
Normal	94	76	98	90	90
Questionable	5	11	2	7	6
Very Mild	1	8	0	2	3
Mild	0	4	0	0	0
Moderate	0	0	0	0	0
Severe	0	0	0	0	0

and Northern Ireland (NI) in both fluoridated areas and non - fluoridated areas. Degrees of fluorosis follow Dean's Index. (Harding & O'mullane, 2013)

It is logical to assume that there will be a similar trend in the data with respect to fluorosis. However, this is not so. In fact, the number of normal teeth in nonfluoridated areas vs. fluoridated areas in 1984 is 98% and 94% respectively, while in 2002 the numbers for non-FL and FL is 90% and 76%. There is no documented data available for 1984 in NI (table 3).

This means that although there is a decrease in the prevalence of dental caries both in fluoridated and non-fluoridated areas, we only see a marked increase in fluorosis in fluoridated areas.

Another interesting observation is when comparing the data within non fluoridated areas. We find that although the DMF index has decreased in 2002 from the year 1984, we don't see a significant increase in fluorosis during that time period. However we do see some increase in fluorosis. This data correlates with data found worldwide that the prevalence of fluorosis increased during this time.

While this study clearly shows the disparity between fluoridated and non fluoridated areas, it alone is inconclusive because we don't know if the people from non fluoridated areas drank water from other sources. Furthermore, we don't know if there was any moderate or severe cases associated with those that lived any of these areas. Additionally, perhaps the reason we find such a drastic increase of fluorosis in 2002 in fluoridated areas is because they too used products containing fluoride and drastically increased their fluoride intake levels. Perhaps if they would not have used these products their fluorosis levels would mirror those from 1984.

Perhaps a possible explanation for the decrease in dental caries in non fluoridated areas is given the availability of dental products that specifically target dental caries. However, since these products are used as directed we won't find a high level of fluorosis accompanying it.

An explanation is available the lower levels of fluorosis in non fluoridated areas versus fluoridated. While they too use fluoridated product, as evident from the decrease in dental caries, it doesn't contribute to fluorosis

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with the same intensity as fluoridated water. This can clearly be seen from another study that was conducted in 1995 in Kingston and Newburgh N.Y. to measure the development of fluorosis and dental caries in children (Kumar, et al., 1998). These two cities were chosen to partake in the study because of their similar demographics and dental lifestyles which can be easily compared. The city of Newburgh was fluoridated in 1945 during Dean’s initial project to fluoridate the public water system (Kauffman, 2005) Newburgh has maintained a fluoride level of  $1.0 \pm 0.2$  ppm except for a slight fluctuation between 1978-1981. In contrast, the city of Kingston has a fluoride content of less than 0.3 ppm. After an initial study was conducted in 1986, another study was done in 1995 to compare the results and note any changes.

The criteria for the study in 1995 were the same as the guidelines set forth in the 1985 study to allow for comparison. These included fluorosis measurements in accordance with Dean’s fluorosis index. However unlike the RoI study fluorosis levels were recorded for severe and moderate cases as well which yields a complete set of data. Children between the ages of 7-14 representing various demographics were examined in this study and data of 1496 children were analyzed which represented a significant percent of the respective populations.

Although an increase in fluorosis was noticed in both communities since 1985, a trend which was noticed worldwide, there was nevertheless a marked increase in the fluoridated Newburgh (table 4).

**Table 4:** Fluorosis levels in percentiles obtained from a study done in 1995 in Newburgh N.Y. and Kingston N.Y. (Kumar et.al., 2005)

Dean’s index levels	Newburgh	Kingston
Questionable	19.4	6.9
Very Mild	13.2	8.3
Mild	5.7	3.1
Moderate/ Severe	0.7	0.3

Perhaps most noticeable was the following data obtained when examining the results closely. The prevalence of fluorosis was compared when fluoridation alone was used and when only supplements were used and the following was found. When fluoride was obtained through fluoridation alone: 17.9%, but when fluoride supplements alone were used fluorosis prevalence was merely 8.8%.

**Conclusion**

We can conclude that while fluoridating water has its benefits by reducing dental caries, it also is solely responsible for the rapid increase of dental fluorosis in children. While many would say that the risk is well worth it, this can be avoided by stopping to fluoridation the water and use of fluoride products instead. As we see from our data, the increase of fluorosis that comes as a side effect from fluoridation isn’t noticed with the same intensity when using fluoridated products alone. While we still do see a slight rise in fluorosis as evident from both studies this can be attributed to our inability to monitor our fluoride intake at optimal levels especially in children (ADA, 2005). This can be due the ubiquity of fluoride in many things, including fruit juice (Kumar, et al., 1998). However, with further modifications we should be able to spare our children from developing fluorosis at all. Furthermore, since fluorosis occurs at the pre-eruptive stage while the efficacy of fluoridation is primarily post eruptive we are exposing our children’s growing teeth to the harms of water fluoridation while the benefits aren’t yet fully effective.

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