Wichita/Sedgwick County, Kansas
Alternatives to Standard Community Water Fluoridation

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Healthier Kansans Through Informed Decisions

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Study Purpose

Many communities since the mid-1940s have chosen to use their public water as the principal means of delivering fluoride to their citizens. Wichita/Sedgwick County, Kansas does not currently add fluoride to its water. This study was undertaken to examine the alternatives to standard public water fluoridation for Wichita/ Sedgwick County, and to assess the level of dental health among children in the community. A limited field study was conducted that involved reviewing the dental charts of a sample of children currently receiving private dental care in Wichita/ Sedgwick County.

Findings

An increasing focus at the national level on oral health (Report of the Surgeon General, 2000) (1) identifies poor oral health as a "silent epidemic" affecting vulnerable populations such as children, the uninsured, and the poor.

Fluoridated water has been shown to have a substantial impact on decreasing the rate of dental caries (decay) in more than 100 studies conducted in the United States and internationally. Other factors (e.g., use of fluoridated toothpaste) also have contributed to the decline in dental caries in the past 50 years.

Fluoride is widely accepted as having a substantial and positive influence on preventing dental caries. Although there is a body of literature on both risks and benefits, the weight of scientifically valid research and the majority of the research community agrees that the benefits far outweigh the risks.

Alternatives to public water fluoridation do exist. Each alternative to delivering fluoride offers different advantages and risks that should be considered. No alternative examined is as cost effective, safe, or efficacious as public water fluoridation in providing fluoride to a population irrespective of age, income, education, or other socioeconomic factors.

Alternatives such as delivering fluoride through food products (salt, milk, sugar), vitamins, supplemental drops/tablets, gels, mouth rinses, toothpaste, toothpicks, floss, chewing gum, and varnishes are presented in the report. Each alternative shares the following characteristics when compared to standard public water fluoridation:

- ☑ Lower or unproven effectiveness.
- ☑ Less suitability for community public health approach.
- ☑ Patient compliance issues that put individuals at risk of over-exposure or under-exposure.
- ☑ Dental practice issues that can influence efficacy.
- ☑ Higher cost per person.

There are promising technologies in development that might aid in the fight against dental decay. However, many of these new approaches share the same drawbacks as those of currently available alternatives.

New data on the dental health of children and youth who have seen a dentist in Wichita/Sedgwick County, are presented in this report. About 25% of the children studied had no decayed or filled teeth. The average number of decayed and filled teeth for the other 75% of children studied is 4.55 per child.

We explored whether certain characteristics, such as dental insurance status, socioeconomic factors, receiving fluoride treatment at the dentist's office, and dental sealants, might distinguish children with more cavities from those with less or none. We were unable to detect differences at the broadest level of analysis, and more research using the data needs to be conducted to better understand these potential relationships.

Dentists surveyed in Wichita/Sedgwick County, considered fluoride to be an important issue. All of them recommended the use of fluoride products, but not all choose the same alternatives. Dentists reported that they considered compliance over cost when recommending fluoride to their patients.

Using a set of conservative factors, we estimate savings from cavities that could be prevented by public water fluoridation at more than $2.9 million for Wichita/Sedgwick County, after five years of water fluoridation.

From a national perspective, Wichita is among the 5 largest United States communities without public water fluoridation. The cost of fluoridating the public's drinking water is estimated to be less than the cost savings associated with improved dental health of children.

2 Background and History

Study Purpose

Many communities since the mid-1940s have chosen to use their public water as the principal means of delivering fluoride to their citizens. Wichita/Sedgwick County does not currently add fluoride to its water. This study was undertaken to examine the alternatives to standard public water fluoridation for Wichita/Sedgwick County, and to assess the level of dental health among children in the community.

Fluoride and Teeth

The history of fluoride and dental health began in the early 1900s when Dr. Frederick McKay noticed that the residents of Colorado Springs, Colorado, had an unusual permanent stain or "mottled enamel," then referred to as "Colorado brown stain," on their teeth. The natural trace element, fluorine (in the ionic form as fluoride) was found in drinking water and was determined to be both the cause of the brown stains on teeth (fluorosis) and their associated resistance to decay (2, 3).

As improved analytic methodologies for measuring fluoride were developed, years of epidemiological surveys ensued. Led by H. Trendley Dean, D.D.S., at the National Institute of Health, levels of fluorosis and decayed, missing, and filled teeth (DMFT) scores were studied in more than 20 cities in Colorado, Illinois, Ohio, and Indiana (4). The findings indicated that caries among children were lower in cities with fluoride levels at concentrations greater than 1.0 ppm (parts per million), and that levels of dental fluorosis were low and mostly very mild.

Public Health

The notion that dental public health improvement could be made by artificially introducing fluoride in community drinking water was begun in a prospective field study in 1945. Four pairs of cities (one an intervention and the other a control site) were selected: Newburgh and Kingston, New York; Evanston and Oak Park, Illinois; Brantford and Sarnia, Ontario, Canada; and Grand Rapids and Muskegon, Michigan. A series of sequential cross-sectional surveys were conducted following the introduction of fluoride into public drinking water, and

the results indicated that dental caries rates fell 50%–70% among school-aged children (5). Dental fluorosis was noted at the same frequency as in other areas where drinking water contained natural fluoride at 1.0 ppm. By 1962 the United States Public Health Service set drinking water standards at recommended levels of 0.7–1.2 ppm fluoride concentrations, with lower concentration recommended for warmer climates (where water consumption was higher) and higher concentrations for colder climates (6).

Effectiveness

Rapid adoption of public water fluoridation in the 1960s and 1970s was associated with a decline in average decayed, missing, and filled teeth (DMFT) scores. From the late 1960s to the early 1990s, DMFT scores for 12 year olds declined 68% (7). However, some researchers recorded decreases of only 18% by the 1980s when comparing children in fluoridated and non-fluoridated water communities (8).

Were the early researchers wrong about how effective fluoride was in reducing dental decay? It has been argued that the more modest differences noted between DMFT scores of fluoridated and non-fluoridated populations today are due to diffusion or the "halo effect." That is, even communities without fluoridated water use food and beverage products that are bottled and processed in areas with fluoridated water, and gain additional exposure through other sources (primarily fluoridated toothpaste) (9). Such alternative sources of fluoride will be examined later in this report.

Another factor influencing the trend in decreased dental caries rates is that dental sealant use continues to increase. For example, sealant use doubled from 7.6% of children aged 5–17 years in 1986–1987 to 19% of children in that age group in 1988–1991 (10). Sealants have been shown to be an extremely effective treatment in preventing the most common types of dental caries that occur on the occlusal surfaces of molar teeth.

Finally, higher rates of dental visits and an improved diet also have been attributed to the decline in the dental caries rate during the past 20 years.

3 Surgeon General's Report

"Oral health is essential to the general health and well-being of all Americans and can be achieved by all Americans. However, not all Americans are achieving the same degree of oral health…and many among us still experience needless pain and suffering…in what amounts to a 'silent epidemic' of oral disease that is affecting our most vulnerable citizens, poor children, the elderly and many members of racial and ethnic minority groups." (Report of the Oral Health of America: A Report of the Surgeon General, May 2000). (1)

Findings

In 1998 Secretary of Health and Human Services, Donna Shalala commissioned the first-ever Surgeon General's oral health report. Key elements to be addressed included the determinants of health and disease, with a primary focus on prevention and "producing health" rather than "restoring health;" a description of the burden of oral diseases and disorders in the nation; and the evidence for actions to be taken to improve oral health across the life span (1).

The following abbreviated list identifies current issues relevant to oral health and fluoridation with regard to children and adults:

- ☑ Dental caries (tooth decay) is the single most common chronic disease of childhood. It is five times more common than asthma and seven times more common than hay fever.
- ☑ More than 50% of children 5–9 years old have at least one cavity or filling, and that proportion rises to 78% among 17-year-olds.
- ☑ There are striking disparities in dental disease by income. Poor children suffer twice as many dental caries as their more affluent peers, and their disease is more likely to go untreated. These socioeconomic differences continue into adolescence.
- ☑ Children living below the poverty line ($17,000 annual income for a family of four) have more severe and untreated dental decay.

- ☑ Twenty-five per cent of children entering kindergarten have never seen a dentist.
- ☑ More than one third of the United States population (100 million people) have non-fluoridated water sources.
- ☑ More than 108 million children and adults lack dental insurance—more than 2.5 times the number who lack medical insurance.
- ☑ Most older Americans take both prescription and over-the-counter drugs, which have the common side effect of decreasing salivary flow. This condition increases the risk for oral disease, because saliva contains antimicrobial components as well as minerals (e.g., fluoride) that can help rebuild enamel after attack by acid-producing, decay-causing bacteria.
- ☑ Medicare is not designed to reimburse for routine dental care, so many elderly people may suffer from a variety of oral health conditions that go undetected.
- ☑ Barriers to good oral care may include dental provider shortages as well as lack of access to care because of limited income or lack of insurance, transportation, or the flexibility to take time off from work to attend to personal or family needs for care.
- ☑ The nation's yearly dental bill in expected to exceed $60 billion in 2000.

Recommendation

The Surgeon General's report states that community water fluoridation is safe and effective in preventing dental caries in both children and adults. It supports the addition of fluoride to drinking water as an effective prevention strategy. In addition, it recommends professional and individual measures that include good personal oral hygiene practices (brushing and flossing); the use of fluoride mouth rinses, gels, toothpastes, and dietary supplements; and the application of dental sealants as other effective ways to prevent dental caries.

4 Biological Action of Fluoride

History

The relationship between fluoride and caries-resistant teeth has been thought to be the result of the systemic uptake (via consumption) of the ion into the hydroxyapatitic crystal structure of dental enamel. This biological inclusion process was assumed to occur during ameloblast production of enamel. It also was thought that the inclusion of fluoride resulted in a structural change that resulted in a cariostatic or acid-resistant effect on dental enamel. This biomedical model has been demonstrated to be supported for fluoride and a variety of other elements that, together, result in dental enamel that is resistant to decay; however, the influence of dietary factors is also important in predicting which populations are more or less likely to suffer relatively higher or lower levels of dental caries (11).

Current Understanding

Current research indicates that fluoride not only has a systemic influence on hard tissues, but it also has a primary cariostatic effect when it is topically in contact with those tissues (8, 12). Research now suggests that an important influence of fluoride in reducing dental caries is its effect on the oral bacteria, viruses, and fungi that actually induce dental diseases. This finding continues to be tested, however, with respect to conclusive evidence of effects on all hard tissues. Research in skeletal biology, for example, continues to suggest that the systemic uptake of fluoride into skeletal tissue yields bone with greater density that is more resistant to fracture among those at risk from osteoporosis (13).

Bacterial Cause

Dental decay occurs when bacteria, principally *Streptococcus mutans,* produce acid as a byproduct of their consumption of the carbohydrates found in the oral environment. The acid usually slowly dissolves surface dental enamel (demineralization), and when left untreated, forms dental caries. Documentation of demineralization lends support to an infectious model of dental caries, that is, that individuals can “catch” the bacteria from direct

and indirect contact with others whose oral environments contain them. Fueling the disease process are the patient's tooth anatomy (e.g., depth of pits, fissures, and grooves), high sugar intake and other readily fermentable carbohydrate intake, and poor oral hygiene.

Researchers also now believe that the cariostatic effect of fluoride may be related more to fluoride levels in the saliva and plaque fluids than to the enamel surface itself (14). This finding is important because, if substantiated by additional scientific testing, it would support the hypothesis that fluoride's impact is as important topically as it was once thought systemically.

Systemic Impact

Fluoride is ingested primarily through water, food, and dental products. The average intake of fluoride from food is estimated at 1.76 mg/day (15) or 1.4–3.4 mg/day (16). Fluoride intake through water under conditions of controlled water fluoridation of 1.0 ppm for an average adult is approximately 2.0 mg/day if the individual drinks the recommended eight glasses per day, and would be less in children.

Daily exposure varies substantially based on dietary practices, age, health status, and lifestyle. Fluoride is not easily excreted and is more likely to accumulate in the body in skeletal tissues over time. A large proportion of the literature that is cited by those who oppose community water fluoridation focuses on the health issues associated with systemic fluoride over-exposure. These topics will be discussed in Section 6 on "Fluoride's Risks."

5 Fluoride's Benefits

Benefits

Quite simply, the primary benefit that has been identified for fluoride is the strong relationship between fluoride exposure and lower rates of dental disease. Not only do dental caries rates drop when optimal levels of fluoride exposure occur, but other dental diseases also respond favorably. Gingivitis, periodontal disease, coronal (root) caries in adults, and associated tooth retention rates among the elderly all improve under conditions of optimal exposure to fluoride (5). For these reasons, community water fluoridation is considered to be one of the 10 greatest public health achievements of the twentieth century (17).

Dental Caries

Dental caries rates have been among the most straightforward yet most controversial outcomes measures used to assess the effectiveness of fluoride. It should be noted that while the preponderance of scientific evidence demonstrates a statistically significant relationship between decreased dental caries rates (particularly among children) and the introduction of community water fluoridation, some studies in the literature refute a statistically significant effect of fluoride on dental caries rates (18).

Skeletal System

Osteoporosis is a disease involving a decrease in bone density associated with aging that is most often a health risk for post-menopausal women (19). Prolonged or increased ingestion of fluoride is known to result in increased bone mass, thereby decreasing risks of fractures, a common outcome of the disease. Studies using a variety of fluoride-containing supplements have suggested that, depending on the delivery formulation (e.g., plain sodium fluoride [NaF] versus sodium monofluorophosphate [Na^2FPO_4]), fluoride has been associated with decreased vertebral compression fractures and, *depending on formulation and dosage*, may be an effective treatment of osteoporosis (13).

Summary Fluoride is widely accepted as having a substantial and positive influence on preventing dental caries. It may also contribute to improved health status regarding other hard tissue/bone illnesses. At least 98 professional organizations endorse the use of fluoride in preventing dental decay (20).

6 Fluoride's Risks

Risks

Fluoride's risks are generally attributed to ingesting too much of the element. At relatively low doses, fluoride produces observable beneficial effects; at relatively high doses, the element causes deleterious effects. Like many other naturally occurring elements routinely consumed by humans, fluoride in excessive amounts can be toxic.

The literature on fluoride's risks is matched with a substantial literature that refutes risk for each of the conditions or diseases examined below. Do not attribute the relative length of this section of our report to indicate that a majority of research suggests that fluoride has more risk than benefit. It only indicates the level of attention the element has received in health research.

Fluorosis

The earliest observed, and the most unanimously agreed upon, risk of fluoride is dental fluorosis. This condition, caused by excessive fluoride, is characterized by whitish areas on the teeth (very mild) or brown discoloration and varying degrees of pitting of the enamel (severe). Water fluoride levels in excess of 2.5 mg/L are most usually associated with moderate to severe fluorosis. Dental fluorosis occurs during the developmental phases of dental enamel production when systemic fluoride is present at higher than optimal levels. Although children with dental fluorosis enjoy the benefit of fewer dental caries (12), severe dental fluorosis may increase their risk of tooth loss from increased risk of tooth fracture (21).

Mild fluorosis is estimated to occur nationally at a rate of about 20%, with the most severe forms of fluorosis found in approximately 1%–2% of children who live either in optimally fluoridated communities or in communities with natural fluoride levels in excess of the recommended level (22). The most obvious impact of fluorosis in on the aesthetics of a person's dentition (physical appearance), with some associated psychological issues such as self-consciousness and poor self-image.

Skeletal System

The skeletal literature regarding fluoride risks falls into three primary areas: osteoporosis/osteosclerosis, association with hip fractures, and osteosarcoma.

Osteosclerosis is a disease involving increased brittleness of bone that has been attributed to high doses of fluoride (23). Although some epidemiological studies suggest that fractures among the elderly may be higher in communities with high fluoride levels, other studies have not detected an increased incidence of bone fractures.

Hip fracture is a seriously debilitating condition that occurs most frequently among the elderly. A number of studies have examined the influence of fluoride (in water) and the incidence of hip fractures. These studies have either presented small positive associations (24) or their findings have been unclear because not enough patients were included to be meaningful (25).

Cancer

Osteosarcomas are malignant bone tumors that have not been successfully or consistently linked to high fluoride levels (22, 26). The National Cancer Institute (NCI) conducted a detailed evaluation of osteosarcomas using national age-adjusted incidence data (1973–1987). The incidence rate of osteosarcomas increased (from 3.6 cases to 5.5 cases per 106 population) and appeared to be greater in fluoridated than non-fluoridated areas. Extensive analyses revealed that the pattern was not related to either the introduction or the duration of exposure to fluoridation.

The NCI identified no trends in cancer risk that could be attributed to the introduction of fluoride into drinking water. There are no substantial differences in cancer mortality rates among persons who live in fluoridated versus non-fluoridated water communities (22).

Furthermore, Shepherd and Grubiak (1999) recently completed an assessment of community water fluoridation and cancer mortality in Kansas. The conclusion of the study is that no significant relationship between cancer mortality and community water fluoridation can be identified in the state (20).

Renal Insufficiency

Because fluoride is excreted through the kidneys, people with renal insufficiency may be at risk of toxic effects if the element is introduced at higher than optimal levels (27).

Reproductive Health

A number of animal studies document an association between increased fluoride levels and reproductive cell abnormalities (e.g., 28) while a number of studies do not (e.g., 29). Those studies demonstrating such a relationship used fluorine at a very high dosage (more than 350 ppm) in animal models.

An epidemiological study using secondary data in humans found an association of decreasing total fertility rate with increasing water fluoride concentrations for most, but not all, of the regions studied (30). One criticism that can be leveled at this study is that it could not quantify or control for factors other than fluoridation level, such as socioeconomic factors that could contribute to this pattern.

Neurological Function

One of the most controversial risks identified in the literature is the association of increased fluoride levels to hyperactivity and decreased cognitive function (intelligence quotient). The research identified a variety of changes in rats dependent on whether fluoride was administered prenatally or postnatally, using fluoride doses within the range that humans might receive (31). To date, the results have not been replicated, results were inconsistent among the rats (males affected but not females), nor have studies identified a link between excessive fluoride consumption and human neural function. Human studies have identified possible links to mental sluggishness and memory disturbances for individuals exposed to high levels of fluoride as a matter of occupational or environmental exposure (emissions of hydrogen fluoride, cryolite exposure) (32).

Summary

For more than 45 years, researchers have thoroughly investigated the relationship of fluoride to a variety of human health conditions. This research has used animal models as well as human epidemiological studies. Except for dental fluorosis, little of the research has been able to show a clear association between fluoride and the diseases or conditions just described, and most do not meet scientific standards of replicability or statistical significance. The scientific standards required to consider fluoride a health risk when used at the optimal dose have not been achieved. However, that is not to say that the research community should remain complacent about *potential* risks. Science requires that commonly held beliefs be challenged to push forward the level of knowledge about a

topic. Hypothesis testing, re-evaluating evidence, and the application of sound scientific methods are critical.

7 Alternatives to Water-Delivered Fluoride

Systemic Alternatives A variety of alternatives to fluoridated water can be used to introduce systemic fluoride on an individual basis. This section presents a review of currently available alternatives: (1) salt, (2) milk, (3) sugar, and (4) supplements.

Salt—As in the case of iodine added to table salt, fluoride can be added to salt used for dietary purposes. The main advantage of using salt as a means for fluoride delivery is that it does allow for individual preferential use. Salt fluoridation is used in at least five countries (Switzerland since 1955, France since 1986, Costa Rica since 1987, Jamaica since 1987, and Germany since 1991) and has been well accepted by those populations (33).

The World Health Organization Expert Committee suggests that when there exist either multiple sources of water or a predominance of low fluoride levels in drinking water, and when there is a centralized salt production control mechanism, salt fluoridation is safe and effective. Negative aspects of salt fluoridation include the following: (1) salt consumption is lowest when systemic fluoride would be most beneficial (childhood, specifically before age 6 years); (2) individuals vary in their salt intake, which poses both risk of under-exposure and over-exposure to fluoride; and (3) the use of fluoridated salt in processed food would have to be controlled to prevent over-exposure.

Fluoridated salt currently is not available in the United States.

Milk—Fluoride can be added to milk and has been found in a five-year double-blind study to successfully reduce dental caries by 48% by the fifth year (34). Fluoridated milk requires a community to have a well-developed milk distribution system and the technical processes to allow the inclusion of fluoride (as in Scandinavia). One advantage of milk fluoridation is that it could be selectively offered to children during their developmental years and not

imposed on the entire population. Negative aspects of milk fluoridation are that individuals vary in how much milk they consume and, more importantly, in whether they can consume milk at all because of lactase deficiency. This is of particular importance when reaching minority communities at risk for dental caries, because African Americans and Asian Americans are much more likely to be lactose intolerant and thus unable to digest dairy products.

Fluoridated milk currently is not available in the United States.

Sugar—As counterintuitive as it might seem, the idea of adding small amounts of fluoride to sugar has been debated. Fluoridated sugar is not currently produced, but the logic is based on the fact that adding fluoride at 1.0 ppm diminishes demineralization of enamel that can happen when sugar is ingested. Up to a concentration of 5.0 ppm, no effect could be shown on sucrose-induced plaque pH, supporting the theory that the mechanism of action for these low-fluoride concentrations is through direct involvement in the surface demineralization process (35). The potential advantage of fluoridated sugar (or sugar substitutes) would be particularly appealing to the children's food industry from a marketing perspective.

Supplements—Fluoride drops for young children (up to 6 years of age) and chewable tablets or lozenges for older children have been used for years in an effort to provide systemic fluoride in areas without community water fluoridation. The American Dental Association (ADA) made its first recommendations for supplements in 1958, and the American Academy of Pediatrics (AAP) followed in 1972. By the late 1970s, both organizations agreed on a recommended schedule of supplement use, but fluorosis continued to increase, prompting them to review the recommended doses (36).

The ADA's Council on Scientific Affairs recommends a dosing schedule for four age groups in children: (1) birth to 6 months, (2) 6 months to 3 years, (3) 3 years to 6 years, and (4) 6 years to 16 years of age. The recommended amount of fluoride depends on fluoride levels measured in drinking water (categorized as <0.3 ppm, 0.3–0.6 ppm, and >0.6 ppm) (37). Wichita, Kansas, has a natural fluoride level of 0.32 ppm, according to the Bureau of Water in the Kansas Department of Health and Environment. Therefore, of children in these four age groups, those that should

receive supplementation are the 3–6 year olds (recommendation of 0.25 mg/day) and the 6–16 year olds (recommendation of 0.50 mg/day).

Some researchers oppose the use of supplements because they believe the additional cariostatic benefits to be marginal, and because supplementation carries an increased risk of fluorosis (38). The World Health Organization Expert Committee concurs that fluoride supplements have limited application as a public health measure, particularly because the level of fluoride in a supplement ideally must be adjusted on an individual basis after a complete profile of water, food, and other sources of fluoride. In addition to being impractical on a population-wide basis, this requirement would add substantial cost.

The average retail cost of fluoride drops (e.g., Luride) is $10–$12 for a 50-day supply. Multivitamins with fluoride (e.g., Poly-vi-flor) at either the 0.25 or 0.5 mg level cost $7–$12 for a 30-day supply. Fluoride tablets can be purchased with either a 0.25 or 0.5 mg level for $7–$9 for a 30-day supply. These costs are sometimes covered by health insurance that carries a prescription drug rider so that the cost to the consumer would be a co-payment of as little as $5.

Compliance, both by dentists in recommending fluoride drops and by patients in buying and using this supplement, may limit the effectiveness of this alternative.

Topical Alternatives

If fluoride's primary action in preventing dental caries occurs from its topical effectiveness, solutions that place fluoride in direct contact with dental enamel, dental plaque and/or oral bacteria logically are good candidates for targeted efforts to reduce dental caries. Each of these alternatives generally offers concentrated levels of fluoride rather than the low concentrations found in fluoridated water: (1) gels, (2) rinses, (3) toothpaste, (4) toothpicks and floss, (5) chewing gum, (6) varnishes, and (7) sealants. With each, however, compliance with the recommended protocol may vary among individuals and may be a particularly important factor among children, resulting in accidental over-exposure and under-exposure.

Gels—Professionally available topical fluoride gels are applied using mouth trays that keep the gel in contact with the teeth for several minutes. The gels are most commonly 0.2% or 1% fluoride and are

recommended to be used for various intervals in the dentist's office. Self-application gels are generally of lower concentration and are most commonly used among orthodontic patients or others susceptible to caries attack. However, at least one study has shown that even low-fluoride gels may result in injury to the gastric mucosa if they are swallowed (39).

Costs of dentist-applied gels were unavailable from the participating dentists surveyed. The cost for self-applied gels is $12–$16 for a 30-day supply.

Rinses—Fluoride mouth rinses were developed as early as the 1950s, and continue to be used routinely in school-based preventative programs. More than 13 million school children worldwide now participate in school-based fluoride dental rinse programs (40). The rinse is either a 0.2% sodium fluoride rinse (900 ppm fluoride) used weekly or a 0.05% sodium fluoride rinse (230 ppm fluoride) used daily. School-based fluoride rinse programs have been recommended in low-fluoride communities where dental caries rates are moderate or high. For individuals at high risk of caries (i.e., orthodontic patients), rinses may be particularly beneficial. Fluoride rinses have been found to be more effective in elevating salivary fluoride levels than both fluoride lozenges and fluoride chewing gum. In the same study, fluoride toothpaste-water mixture proved more effective than brushing with toothpaste in elevating salivary levels of fluoride (41).

Risks associated with this approach include the risk of swallowing the mouth rinse. Depending on fluoride concentration in the rinse, ingestion could be harmful. A trained staff member to dispense the appropriate amount of rinse is necessary for this alternative to be effective.

Rinses are sold as unique products (e.g., Gel-Kam, Oxyfresh with fluoride), or they can be as simple as using a toothpaste-and-water mixture as a mouth rinse. The costs, therefore, can range from $9–$18 for a 30-day supply to just pennies per use if a toothpaste-and-water mixture is employed.

School-based mouth-rinse programs have not been widely accepted in the United States.

Toothpaste—No other topical treatment has been as unanimously endorsed as fluoridated dentifrice, better known as fluoride toothpaste. Since 1945 fluoride has been added to toothpaste in the form of sodium fluoride, acidulated phosphate fluoride, stannous fluoride, sodium monofluorophosphate, and amine fluoride, all linked in more than 100 clinical trials to reduced risk of dental caries. Compared to other fluoride supplements, toothpastes have been subject to the most rigorous clinical testing (33). Toothpaste costs range from $1.50 to $3.79 for a 6.0-ounce tube. Manufacturers are reluctant to provide the number of days supplied in a standard tube because people dispense different amounts. However, one adult brushing twice a day should have a 60-day supply in one tube.

The unanimous recommendation from professional dental societies and dental professionals is that everyone should brush daily with fluoride toothpaste. Even though a slight increase in mild fluorosis is associated with early (< 6 years of age) and routine use of fluoridated toothpaste, the advantages for all individuals more than age 6 is substantial (42). Because children under 6 years of age have difficulty spitting effectively and some of their permanent teeth are finalizing crown development thereby at risk of fluorosis, fluoridated toothpastes carry advice to supervise them and to use only a very small amount (less than 5 mm or a "pea-size" amount) (33). This warning reflects the importance of not encouraging children to swallow toothpaste because of the risk of fluorosis, and it further suggests calling a physician or poison control center if a child ingests more than the recommended dose. It is interesting to note that although excessive ingestion of fluoridated toothpaste carries a warning to contact a poison control center, no safety cap requirements are required for the product.

Many researchers agree that it is toothpaste, (and to a lesser extent, supplemental drops/tablets) and not optimally fluoridated water, that is principally responsible for current fluorosis levels observed among children. Manufacturers now are beginning to produce dispensing aids so that a child can only apply the appropriate amount of toothpaste in order to reduce the risk of fluorosis.

Although much less common than fluoridated toothpaste, at least one non-fluoridated children's toothpaste (e.g., Mega Warheads) is now commercially available in the Wichita area. Those choosing not to expose children to any topical alternative could still provide a dentifrice for oral hygiene use.

With a prescription, toothpaste with fluoride at a 1.1% concentration can be purchased. Typical health insurance does not cover this cost, so the consumer would pay a retail cost of approximately $13–$15 for a 56-gram tube (60-day supply). Over-the-counter fluoridated toothpaste costs between $1.50–$3.79 for a 6.0 ounce tube, which, according to manufacturers, represents about a 60 to 90–day supply.

Toothpicks and Floss—Very little research into the efficacy of fluoridated toothpicks or floss has been published to date. Studies indicate that both modalities can deliver a quick release of fluoride into the oral cavity, but controlled studies designed to measure parameters such as the amount of time needed to affect salivary concentration have not been conducted. Both of these products are available in Europe, but only dental floss containing fluoride is available in the United States.

The retail cost of fluoride dental floss (.15 mg F/18 inches) is approximately $2.00 for a 90-day supply.

Chewing Gum—Fluoridated chewing gum has been prescribed for individuals at high risk for dental caries, particularly because of medical conditions or treatments that lead to low salivary secretions such as head and neck or oral cancers. Given that chewing gum would have great acceptability among children and youth in the United States, this particular delivery method of fluoride might be very appealing. Again, controlled studies that examine how long the gum must be chewed to have a positive effect or to identify possible risk factors have not been published.

Fluoride chewing gum is no longer available.

Varnishes—Fluoride varnishes involve the topical treatment of teeth, with the material being painted or syringed onto a dry tooth and resulting in a thin, transparent film. The cariostatic action is related to a slow release of fluoride, which bathes the mouth with a low concentration of fluoride (43). Varnishes have been reported to decrease the incidence of caries from 3.3% to 72% (44). But that makes them an unlikely candidate for caries prevention because of the typical six-month interval between recommended dental office visits. Fluoride varnish has not received FDA clearance as a caries preventive agent; rather, it is considered a dental material.

Reimbursement for the use of fluoride varnish is not typically available, and in one case in Washington state, when third-party reimbursement was available, most dentists had not adopted the technology even after two years (45). The dentists we surveyed do not use varnishes, and none of the offices we contacted could provide us with cost data.

Sealants—Some polymeric sealants (applied to the chewing surfaces of molar teeth) are designed to release fluoride slowly so could be considered another fluoride alternative.

The cost of sealants among a sample of dentists and clinics in Wichita/Sedgwick County, ranged from $5 to $37 per tooth.

Summary The risk of under-consumption or over-consumption of fluoride is a common factor when considering any alternative to standard water fluoridation. Because the efficacy of each of these systemic and topical alternatives largely is influenced by how an individual uses the product (except sealants) and by whether dentists recommend them, variation in both the positive and negative side effects of fluoride are more likely to be noted.

If the most important impact of fluoride is on the oral environment when present in a consistent, low dosage, no other alternative provides the benefit as well as fluoridated drinking water.

Given the wide variety of possible alternative delivery systems of fluoride, cost is an important factor. The supplemental product with the lowest cost is fluoridated toothpaste, followed by fluoride drops or tablets, vitamins, mouth rinses, and gels (see Table 7-1). It is ironic that some of these products (e.g., fluoridated toothpaste) are sweetened or flavored to encourage use by children. They also do not have safety caps, and can therefore be consumed inappropriately by young children.

In comparison, costs associated with the fluoridation of public water are approximately $0.50 per person per year. The cost of fluoridated water ranges from $0.12 to $5.41 per person per year, depending mostly on the size of the community (46, 47).

Table 7-1
Fluoride Cost Comparisons

Fluoridated Water	Sealants (per Tooth)	Fluoride Tooth-paste	Fluoride Treatment by Dentist	Fluoride Drops	Fluoride Tablets	Vitamin with Fluoride	Fluoride Mouth Rinse	Fluoride Gel
$0.50	$5.00–$37.00*	$10.00–$73.00[†]	$15.00–$25.00[§]	$73.00	$85.17	$85.17	$109.50	$146.00

Note. Figures show the estimated average cost per person per year of various fluoride-delivery options. Information on costs was provided by Wichita area pharmacies and drugstores and by dentists participating in the KHI dental health status project (see Chapters 10 and 11).

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*Expected duration or life of sealant varies among individuals; least expensive option includes costs underwritten at a number of health clinics in Sedgwick County.
[†]Least expensive generic to most expensive prescription (.15% to 1.1% fluoride).
[§]Assumes one fluoride treatment received in a dental office setting.

A variety of factors can affect the cost of the alternatives presented in this section of the report. For example, purchasing fluoride mouth rinse for home use as compared to the costs of purchasing the rinse for an entire school district would be substantially higher. Rather than provide a detailed cost-benefit analysis which is beyond the scope of the project, Table 7-2 presents a relative rank order of the alternatives for comparison. Actual costs could be developed once an alternative was chosen. With respect to the cost of standard community water fluoridation, we refer to the work done by Adrian and colleagues (1993) (48).

Table 7-2
Relative Ranking of Fluoride Alternatives

Alternatives	Cost	Safety vs. Risk	Effectiveness	Applicability as a Public Health Alternative
Public Fluoridated Water	♦	♦	♦♦♦	♦♦♦
Toothpaste	♦	♦♦	♦♦♦	♦♦
Rinses (School Administered)	♦	♦♦	♦♦	♦♦♦
Supplements	♦♦	♦♦♦	♦♦	♦♦
Sealants	♦♦	♦	♦♦	♦
Chewing Gum (Xylitol)	♦♦	♦♦	♦♦	♦♦
Gels	♦♦♦	♦♦♦	♦	♦
Floss	♦	♦	unknown	♦♦
Toothpicks	♦	♦	unknown	♦♦
Fluoridated Bottled Water	♦♦	♦	unknown	♦♦
Varnishes	unknown	♦	♦♦	♦
Salt	unknown	N/A	♦♦	♦
Milk	unknown	N/A	♦♦	♦
Sugar	N/A	N/A	N/A	♦

♦ = Low
♦♦ = Moderate
♦♦♦= High
N/A = Not applicable

Note. Some alternative methods of fluoride delivery have not been approved by appropriate United States regulatory agencies (i.e., Food and Drug Administration).

8 Methods to Remove Fluoride from Water

One final alternative to standard community water fluoridation we were requested to examine is the establishment of a system that would provide non-fluoridated drinking water to citizens in a community with a fluoridated water supply. An extensive search of the professional literature failed to find any published information on mechanisms that any community has used to provide non-fluoridated water to persons living in an area served by a fluoridated water system. Rather, information about providing non-fluoridated water was gathered from representatives in communities that had attempted to provide this service.

The Lawrence Experience

The city of Lawrence, Kansas, fluoridated its water supply in the mid-1950s. Because of the concerns of some residents regarding potential health risks associated with water fluoridation, the city installed two taps in the early 1960s at its water processing plant. The taps extracted water from the plant prior to the addition of fluoride. This non-fluoridated drinking water was free to those who wanted it and were willing to travel to the water processing plant for it. Although the Lawrence taps apparently were used to some degree after installation, their use declined to less than once a month by the mid-1980s. At that point, a review was undertaken to reevaluate the appropriateness of the taps. It was found that there was a considerable expense associated with maintaining the taps, but more importantly, there were serious water quality concerns. With the taps being used less than once a month, water remained in the pipe, leading to serious problems with water quality. Because of this health risk, the taps were removed in 1986.

(This chronology was obtained from an interview with Sherry Stamen, Lawrence Water Department, April 2000.)

Other Cities' Experiences

Lawrence is not the only community to use a non-fluoridated water tap at its water treatment plant. Kansas City, Missouri, also attempted to accommodate those who did not want fluoridated

water by placing a tap in the line prior to the water entering the fluoridation phase of treatment. Those wanting non-fluoridated water were allowed to draw as much water as they wanted into gallon jugs (or similar containers) for free. As with the Lawrence experience, over time the use declined to a point where a determination was made to dismantle the tap.

After a legal battle to force the city of Canton, Ohio, to comply with a state fluoridation mandate, a similar tap was put in to allow those opposed to water fluoridation access to non-fluoridated water. As in the other communities described earlier, the lack of usage of this service led to eventual removal of the tap.

(Information regarding Missouri and Ohio was obtained from communications with Michael Easley, Director, National Center for Fluoridation Policy and Research, April 2000.)

Non-Fluoridated Water

Option 1. Providing Water Prior to Fluoridation

This method was undertaken in the mid-1960s by the cities of Lawrence, Kansas City, and Canton. It is unlikely to be successful, however, because it requires individuals to travel to a water treatment plant to obtain their water. The ease and relatively low expense of obtaining fluoride-free, purified water from local retail outlets would likely make traveling to a centralized location for tap water an unattractive choice for most individuals. Furthermore, there appears to be considerable expense to a community to establish and maintain a fluoride-free water source. This option may be less attractive to communities seeking a cost-effective alternative to standard water fluoridation because of (1) the expense involved in developing such a system, and (2) the easy availability to the public of distilled or bottled water from retail sources.

Water Conditioners

Option 2. Point-of-Use Water Conditioning Systems

A number of commercially available water conditioning systems can successfully remove most of the fluoride from tap water. Research indicates that these systems remove between 81% and 99% of the fluoride in tap water. Specifically, activated carbon filters remove 81% of fluoride, reverse osmosis removes approximately 84% of fluoride, and distillation units remove 99% of fluoride (49). All these units would bring fluoride levels to a point below that naturally occurring in the water sources of Kansas. The largest barrier to point-of-use water conditioning

systems is cost. Activated carbon filters retail from $40 to $150, depending on style and brand. Reverse osmosis units retail at $200 or more, with units sufficient to remove fluoride being available for between $200 and $300, not including installation. Distillation units can be the most expensive and retail at approximately $300 each, and are typically countertop units not requiring installation. Added costs would include maintenance and repair, and replacement costs.

Retail Outlets

Option 3. Providing Non-Fluoridated Water Via Retail Outlets. Most, if not all, grocery stores have non-fluoridated drinking water available for consumers, both as prepackaged water and through reverse osmosis refill systems. The price for pre-filled containers of water varies considerably, from around $.80 to $1.50 per gallon. The price for water from filtration refill stations is more stable and averages about $.39 per gallon. If there is concern about requiring people to pay for non-fluoridated drinking water in addition to a monthly water bill, it is possible that some type of voucher system could be established to allow those individuals who do not want fluoridated drinking water to obtain a limited amount of purified water from participating vendors. Given health recommendations suggesting each person should drink eight glasses of water a day (about one half-gallon), each person should receive a voucher for about 15 gallons a month, at about $5.85 per person per month (retail value).

As these options indicate, the economic impact of providing non-fluoridated water to some individuals in a publicly fluoridated community depends on the number of people who participate in an "opt-out" program.

9 New Technologies

Research Advances Dental research continues to explore ways in which products, treatments, and preventive measures can decrease the likelihood of an individual suffering from dental disease. Included below is a sample of the kinds of promising research initiatives currently underway that could either enhance the effect of fluoride or promote an oral environment less likely to succumb to dental disease.

"Smart" Fillings—Since the mid-1980s, a wide variety of dental restorative materials that contain fluoride has been available to dentists. These materials include fluoride-releasing amalgam, glass-ionomer cements, composites, primers, sealants, liners, acrylic resins, and orthodontic bracket-bonding materials (50). Research into the efficacy of these materials continues in controlled clinical trials.

Vaccine—Current research into a vaccine is focused on impairing the ability of *mutans streptococci* to accumulate in dental plaque and other oral tissues. If salivary glands can be stimulated to produce immunoglobulin A antibodies toward the bacterium, then the resulting saliva would prevent them from taking hold (51). If an individual also used topical fluoride treatments (e.g., fluoridated water, toothpaste, rinses), an even greater cariostatic benefit might occur. This type of vaccine is currently undergoing phase II clinical trials and could be available commercially within 5–6 years (52). It should be noted, however, that compliance in vaccinating children is not always very high. Today, some parents are still reluctant to vaccinate their children and choose not to, even when the vaccine has been shown to prevent life-threatening illnesses.

Blocking Plaque—Approaches that attempt to decrease plaque build-up include developing both an antibacterial agent that will interfere with or inhibit plaque, and topical applications that have an anti-plaque

effect. Two anti-plaque agents (Crest Gum Care and Colgate Total) were recently approved by the FDA and are currently available without prescription. Longitudinal studies documenting the impact of these products among individuals who are or are not exposed to fluoridated drinking water and other fluoridated products will need to be done.

Chewing Gums— A number of other chewing gum products are available that demonstrate important benefits to improving oral health. It is important to note that none of these are actually fluoride alternatives, but rather they enhance remineralization or cariostasis by inhibiting the action or development of oral bacteria.

Chewing gum with calcium phosphate (CPC) helps to prevent further demineralization to an incipient enamel defect by promoting the level of enamel-forming minerals in plaque fluid (53). Gum with chlorhexidine has been tested and found to be very effective at reducing dental plaque formation, however it is not approved by the FDA as a caries-preventive agent. Another gum product uses xylitol, and has two benefits: decreased caries (but less effectively as compared to chlorhexidine containing gum); and decreased recurrent otitis media (ear infections) among children (54, 55).

Polymeric Coatings—Sealants placed on the occlusal surfaces of molar teeth have been shown to be a highly effective preventive method in reducing the most common type of dental caries (pit and fissure) in the permanent dentition (teeth) of children and youth. Some of these sealants are designed with fluoride-releasing properties (e.g., Helioseal F, Fissurit F). The addition of fluoride does not increase sealant loss rates or impair quality, and it may provide additional benefit over non-fluoride polymeric coatings (56).

Sealant use has increased, but still less than one fifth of United States children aged 5–17 years have sealants on their teeth (57) (see Section 10 “KHI Dental Health Status Project” for Wichita/ Sedgwick County, rate of sealant use). A major issue regarding sealants is the lack of consistent insurance coverage for the intervention in traditional, indemnity, fee-for-service commercial, and Medicaid plans. Sealant costs can range from $5 per tooth ($40 and $60 per person) to $37 per tooth ($296 and $444 per person), not including loss and replacement costs.

KHI Dental Health Status Project

10

Purpose

The debate over fluoride inevitably focuses on the primary dental benefit associated with fluoride and its potential harm resulting from either chronic or acute over-exposure. If one accepts that fluoride has a biological, cariostatic effect promoting dental health, then an assessment of both current fluoride exposure and current dental caries experience would be basic to developing an informed position on the use of supplemental fluoride at both a community and an individual level.

The purpose of the Kansas Health Institute dental health status project was to examine the current dental health status of schoolchildren 5–18 years of age in Wichita/Sedgwick County. We assumed that children receiving professional dental services would be more likely to be exposed to preventive services (including fluoride) than the general school population and that assessing dental health among those children actually visiting dentists for care would provide a "best case" estimate of the level of dental disease (and treatment) for Wichita/Sedgwick County, youth.

Primary Findings

The primary findings from the field study are as follows:

1. About one-fourth of the children studied were caries-free. The other 75% had an average of 4.55 decayed and filled teeth. The pooled rate of decayed and filled teeth for the entire Sedgwick County, sub-sample was 3.44 per child. This rate is a conservative estimate, because it does not include children using public health dental services or those who do not use dental services at all. It also under-enumerates the standard DMFT scores reported in the literature, because we were unable to quantify the "M" (number of missing teeth due to decay). Even with these two limitations, it represents a level higher than the United States national average.

2. Not all children are receiving fluoride treatments regularly from their dentists, even though dentists responded that they thought fluoride was important or very important in the prevention of dental disease.

3. Differences in the average number of decayed and filled teeth could not be attributed to receiving dental-visit fluoride treatment, the insurance status of the patient, or the application of at least one sealant. The results indicate that receiving less than optimal fluoride levels is the "equalizer" among these groupings of children.

4. Fluorosis status was not mentioned in any of the charts reviewed.

Materials and Methods

Information on dental practice, fluoride treatments, and sealant application was collected from dentists practicing in the Wichita area. The data collected on dental disease were obtained from two sources: (1) through state-mandated [Kansas Statute No. 72-5201, 72-5202 and 72-5203] and Unified School District (USD) 259 [Wichita public schools] free annual school-based dental screening exams, and (2) through the process of dental chart review that contained information on the current oral health status of patients seen by a select panel of dentists.

Sample Selection

To develop a sample of practicing dentists, researchers compiled a list of all dentists with mailing addresses in the Wichita area who were registered members of the ADA and/or the Kansas Dental Association (KDA) (n=165). This list included retired dentists but did not include student members with a Wichita mailing address. Random selection was obtained by assigning each dentist a computer-generated identification number that was then sorted in ascending order. The first 28 numbers or names were selected as the primary sample. In addition, the two Wichita area pediatric dentists were specifically included in the sample because of the project's primary interest in children. The total sample size of dentists was 30 (18% of those listed professionally).

Survey Instrument

KHI researchers developed a short survey instrument designed for a number of purposes. First, questions were focused on validating the kinds of approaches dentists are currently using with respect to fluoride supplementation for their patients. Second, questions were

designed to allow the dentists to speak to their concerns regarding fluoride as they experience the health care environment in Wichita/Sedgwick County. Finally, dentists were asked to estimate their patient populations with respect to age categories provided in the survey.

Distribution Procedure

Dentists were sent a survey packet containing a cover letter that described the purpose of the study, a copy of KHI's researcher confidentiality form, a self-addressed, stamped return envelope, and the two-page survey instrument (see Appendix I). Of the 30 dentists sent a packet, one was deceased and two could not be located because of invalid addresses. According to the survey protocol, these unfindables were to be replaced with the next sequential names on the prepared list.

Follow-Up

Approximately one week after mailing the survey packet, KHI researchers made a telephone call to each dentist (or their representative). The purpose of the call was to facilitate survey completion and to recruit dentists for the chart review phase of the study. Three of the 30 dentists were retired and were therefore deemed not eligible for participation in the chart review phase. Three dentists declined to participate in both the written survey and the chart review, which resulted in a total chart review sample of 24 dental practices.

At the time telephone contact was made with each dentist or office staff member, they were asked if they had completed and returned the survey. Those who had not yet returned the questionnaire were encouraged to do so. Those dentists who had not received or could not locate the questionnaire were mailed an additional survey packet, and received another follow-up call a few days later. In some cases, additional telephone inquiry was made to obtain information necessary to develop sample size estimates for the chart review phase of the study.

For those participating dentists who did not return the survey, arrangements were made by phone for the survey to be collected by the researcher(s) when they arrived at the dental office. This combination of methods resulted in the return of 21 completed survey forms, which represents a 70% response rate (21 of 30) for the dentists in the original sample.

Chart Review

Out of the 24 dental practices contacted by telephone, 16 agreed to allow KHI researchers to conduct an on-site, limited chart review. These chart audits were designed to determine the level of dental disease among patients between the ages of 5 and 18 years. Administration personnel from USD 259 indicated that for kindergarten enrollment a child must be five years old by August 31 and that high school graduations within the District usually occur by May 31. Using these criteria, we determined acceptable date-of-birth ranges for three age groups: birth dates within the 08/31/95–08/31/90 range comprise the 5- to 10-year-old group; birth dates within the 09/01/90–08/31/85 range comprise the 11- to 15-year-old group; and birth dates within the 09/01/85–05/31/82 range comprise the 16- to 18-year-old group.

The number of charts needed for review by age group was calculated using information obtained from the surveys. Dentists were asked to provide (or estimate) the total number of active school-aged patients (5 to 18 years) in their practice by the three age ranges we provided.

Because of time limitations, approximately 30 dental charts were reviewed from each of 16 dental practice (n=480). Using the age distribution data provided by the dentists, researchers calculated proportional sample sizes by age group for each dental practice. This was done to ensure that each dentist's sample represented his or her practice's age mix of patients.

Approximately a week prior to the scheduled on-site chart audit, staff from the 16 dental offices were telephoned and told the number of charts within each age range that the researcher(s) would like to review. Requests were made for dental office staffs to *randomly* select the specified number of charts for the review. The selection procedure differed in each office because of their varying manual and electronic record-keeping systems.

Chart reviews were scheduled in three to four hour blocks at each dental office during regular business hours (or at a time most convenient for the dentist). On arriving at each dental office, the researcher(s) identified himself or herself and provided an original signed copy of the KHI Confidentiality Form, along with the Participant Payment Request Form. In 75% of the dental offices, the charts had been selected by the office staff prior to the arrival of the researchers; in the remaining 25%, the researcher(s) pulled the charts for data collection and then re-filed them. During data collection, researchers tried to reject charts where the patient's age

did not fall within the appropriate range (too young or too old, according to the research parameters) or when the patient did not live in the Wichita/Sedgwick County, area. Dental support staff cooperated by providing replacement charts for review.

The chart review instrument (see Appendix II) was field tested in two dental offices by the principal investigator. The principal investigator then trained two KHI researchers to conduct chart audits and complete the data collection forms. As part of this training, data collection instruments were checked and validated by the principal investigator to ensure internal consistency and accuracy. Strict confidentiality of personal information relating to patients was maintained.

This phase of the project yielded 493 reviewed charts from the 16 dental practices. In cleaning these data, it was determined that 12 records were not eligible because they fell outside the established age ranges (1 patient was too young and 11 patients were too old). These 12 charts were dropped, resulting in a final sample of 481 audited charts.

Residential zip code information for each patient was collected and compared two ways: (1) zip codes that broadly compose the Sedgwick County, boundary that includes the Wichita public schools, and (2) zip codes that just compose the USD 259 [Wichita public schools] boundary. There were 28 charts with home zip codes that either were unknown or not completely within the Sedgwick County, boundary. Of these 28 charts, eight did not have home zip codes and two had zip codes that fell in both Sedgwick and Sumner counties. To facilitate a broad analysis of the data, these 10 charts were retained in the Sedgwick County, boundary data set, resulting in a county-based sub-sample of 463 charts.

In selecting the sub-sample of charts that fell within the USD 259 (Wichita public schools) boundary, we used a stricter standard (i.e., charts were not included if the zip code was unknown or if the home zip code did not fall completely within the boundary). Sub-setting the data this way eliminated 86 charts and resulted in a final USD 259 boundary sub-sample of 395 charts. Each sub-sample was analyzed separately, but only the Sedgwick County, sub-sample is described below, because the USD 259 sub-sample cannot currently be compared to the available data from the annual school-based dental inspection data.

Participation Incentive

The transmittal letter mailed with the survey packet offered a $100 incentive to the dental practice for participating in the research project. This remuneration was designed to compensate the participants for any inconvenience experienced during completion of the written survey or participation in the on-site chart review. A KHI check was prepared and mailed to the dental office within 10 business days of receiving the Participant Payment Request Form.

Chart Data Profile

The sample of children examined in the chart audit portion of the study was equally divided by sex (51.1% male; 48.9% female). Their residence zip codes span the entire county, with the largest number representing zip codes 67212, 67217, and 67226. Three quarters of the children in the sample had dental health insurance (74.5%; n=345).

The total number of visits among the 463 charts reviewed was 5,004. The average number of visits (approximately six visits for 5–10 year olds, 11 visits for 11–15 year olds, and 14 visits for 16–18 year olds) increased with patient age, which indicates that the dentist-patient relationship is probably stable over time.

Fluoride treatments were provided as a routine part of a prophylactic examination. More than 1,830 fluoride treatments were recorded in the study population. The average number of fluoride treatments for all children in the study was approximately five (with a low of 0 and a high of 60). This wide range can be attributed to at least four factors. First, some children were routinely seeing their dentists, while others were new patients who had not yet had preventive or prophylactic care. Second, fluoride treatment would not be appropriate on every visit. Third, in some offices, the protocol for how frequently children should receive fluoride treatments was twice a year, annually, or not at all. Fourth, even when fluoride treatment was recommended, not all parents or guardians gave their approval for it.

Sealant placement in one or more teeth for a child was recorded for 48% of the children in the study. This rate of sealant use is more than twice the 23% rate reported nationally (1), which substantiates the fact that almost all the dentists who responded to our survey reported using sealants routinely on their patients.

Dental Health Findings

Data collected from the dental charts included both active decay and fillings (restorations). Because we were collecting information

that is dynamically changing (decay identified at one visit was recorded as a restoration at a later visit), we summarized the data in terms of total decayed and filled teeth (DFT). Accurately quantifying missing teeth due to decay was not possible because of differences in how missing teeth were accounted for in the dental record (e.g., extracted for orthodontic treatment, lost from injury, or extracted because of disease). We assumed that restorations present in the mouth were primarily the result of dental caries, and where possible, observed restorations that were noted to be the result of accident or other causes were *not* included in the data. Therefore, we equate the DFT, or defect rate, to be a proxy measure of a dental caries rate.

The total number of DFT and the average DFT scores of the children we studied are presented in Table 10-3. It is important to note that this is a *minimum* defect profile, because we recorded data for each tooth (noting that the tooth was either with or without a defect) rather than quantifying the total number of fillings per tooth. Many children in the sample had more than one restored surface per tooth. In addition, as stated earlier, missing teeth were not included in the measure.

Table 10-3
Number of Defective Teeth by Age Group for All Children

	5–10 years (n=134 children)		11–15 years (n=175 children)		16–18 years (n=154 children)	
	Number of DFT	**Average**	**Number of DFT**	**Average**	**Number of DFT**	**Average**
Primary Teeth with Defects	325	2.43	199	1.14	115	0.75
Permanent Teeth with Defects	40	0.30	285	1.63	627	4.07
Total Teeth with Defects	365	2.72	484	2.77	742	4.82

Note. The largest average number of defective primary teeth by age group for three sub-samples of a Sedgwick County, sample of 463 children was 2.43 (for those children who were 5–10 years of age), and the largest average number of defective permanent teeth was 4.07 (for those children who were 16–18 years of age).

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DFT = Decayed and filled teeth

The distribution of defects across age cohorts reflects the process of permanent tooth replacement for primary (deciduous) teeth by permanent teeth, and the increasing decayed and filled tooth "burden" in permanent teeth as the child ages. Among those children who visited a dentist in our Sedgwick County, sub-sample, the average child had about 3.44 teeth with either an active cavity or a filling.

Table 10-4
Number of Defective Teeth by Age Group for Sub-sample of Children

	5–10 years (n=91 children)		11–15 years (n=126 children)		16–18 years (n=133 children)	
	Number of DFT	Average	Number of DFT	Average	Number of DFT	Average
Primary Teeth with Defects	325	3.57	199	1.58	115	0.87
Permanent Teeth with Defects	40	0.44	285	2.26	627	4.71
Total Teeth with Defects	365	4.01	484	3.84	742	5.58

Note. In a Sedgwick County, sub-sample of 350 children with at least one decayed or filled tooth, those 5–10 years old had the largest number of defective primary teeth (325), while those 16–18 years old had the largest number of defective permanent teeth (627).

DFT = Decayed and filled teeth

For children in the group with at least one decayed or filled tooth, Table 10-4 presents their DFT scores and averages by age category. The pooled average number of decayed and filled teeth was 4.55 per child.

DFT scores were examined with regard to the influence of four variables: (1) zip code of residence, (2) insurance status, (3) fluoride treatment, and (4) the presence of sealants.

Zip Code—We examined whether the number of decayed and filled teeth is associated with the location of the child's residence. The rationale for this approach is based on two factors. First, access might be a barrier for some children to receive care if the nearest dental office or clinic is too distant from their home. Second, zip code of

residence can be used as a proxy for estimating family income, and children from more affluent areas might display different decay rates than children from lower income areas.

Using 1990 United States Census data, we used median income and quartile distributions to rank the zip codes in Sedgwick County. The lowest and highest reported median incomes by zip code were groupings representing annual incomes ranging from $6,503–$26,147 (lowest quartile) to $47,536–$67,060 (highest quartile).

The results of this analysis are presented in Table 10-5. Note that there are no statistically significant differences between children living in the lowest and highest quartile income zip code areas. This finding suggests that the socioeconomic factor of average family income does not predict a child's dental decay status in this study.

Table 10-5
Dental Defect Differences by Income

	Lowest Income Quartile	Highest Income Quartile
Number of Children	20	84
Average Number of Defects	2.80	2.85
T Value (df)	-.0700 (33.9)	-.0618 (102)
Probability > |T|	0.9446 (NS)	0.9508 (NS)

Note. A comparison of the children in the Sedgwick County, sub-sample by income as determined by zip code area showed a higher ratio of dental defects for children in families with the lowest incomes, compared to children in families with the highest incomes.

NS = Not significant

It is important to note that most of the children in the Sedgwick County, sub-sample had insurance and were visiting dentists in private practice. Children from the lowest socioeconomic areas of Wichita/Sedgwick County, who are more likely to visit public health clinics might have significantly different (higher) DFT scores, but they were not included in this study. Another confounding variable to consider is that some children in the

sample were probably born and reared in other communities that could have fluoridated water.

Insurance—The Surgeon General's report reaffirms that insurance is a strong predictor of access to dental care. Uninsured children are 2.5 times less likely than insured children to receive dental care (1).

Because we suspected that children without insurance might have more severe dental health problems and may have waited longer from the onset of symptoms to seek care, we compared children with and without insurance who received care from a participating dentist. The data did not support this hypothesis. However, anecdotal information gained from talking to the participating dental professionals suggested that uninsured children more typically presented with multiple and untreated dental caries.

The results of testing for differences among children with and without dental insurance revealed no statistically significant differences between these two groups regarding the number of DFT (see Table 10-6). A major limitation of this analysis is that the data do not address the issue of whether either group of children more typically had more than one decayed or filled surface per tooth. However, data collected during the study included the number of defects per tooth, a factor that will be examined at a later time.

Table 10-6
Association of Insurance Coverage to Total Number of Dental Defects

	Number of Children	5–10 Years	11–15 Years	16–18 Years	TOTAL
Dental Defect with Insurance	345	2.886	2.877	4.916	3.583
Dental Defect without Insurance	118	2.413	2.351	4.486	3.008
T Value (df)		-0.8202 (132)	-1.2388 (94.6)	-0.5765 (152)	-1.5412 (461)
Probability >|T|		0.4136	0.2185	0.5651	0.1239 (NS)

Note. A comparison of insurance coverage to total number of dental defects by age group for the Sedgwick County, sub-sample revealed no statistically significant differences between these two groups.

NS = Not significant

Fluoride Treatments—The number of fluoride treatments applied in the dentist's office was examined as a variable that might distinguish children with different DFT experiences. Also, whether a child had a sealant placed in one or more teeth was a variable for analysis. The results of these tests were inconclusive at a broad level of analysis; the data need to be adjusted so that, for each child, the amount of time spent seeing a dentist and the number of visits can be used to make valid comparisons across participants.

What we do suggest is that preventive care (such as fluoride treatment and sealants) provided by a dentist may not result in an advantage for those children in comparison to their peers. It is more likely that the public health dental prevention aspect of fluoridated water would be more unanimously effective than the measures currently used for dental care of children.

Comparison to School Data

One goal of this project was to compare the data collected to the annual school-based dental inspection data. For the-1998–1999 school year, USD NO. 259 examined 17,667 children. Fifty-three percent of these children had no apparent dental defects, compared with 24.4% in the KHI study. Of the remaining school-based sample, 7,017 children were reported to have at least one defect and 784 were recommended to have sealants (unpublished data provided by the Wichita Public Schools Department of Health Services). Because the school-based data include categories such as "infectious condition (urgent)," which could represent decay or other conditions, and because the school project did not count filled teeth, the two data sets are not comparable.

National Comparisons

To put the level of dental disease identified in our chart review project into perspective, we searched the dental epidemiological literature for comparable communities or populations but found the data available difficult to interpret for a number of reasons. The national studies are often based on school-based populations, and they include children from both fluoridated and non-fluoridated communities. Also, capturing the effects of public water fluoridation on dental caries is difficult because few reports include decayed, missing, and filled teeth (DMFT) or surfaces (DMFS) both before and after fluoridation, the level of water fluoride, or the length of time the population has been exposed to fluoridated water. These discrepancies make it impossible to correctly compare summary dental disease estimates.

Dentist Fluoride Practices and Opinions 11

Dentist Profile

Of the 21 responding dentists, 13 received their degree from the University of Missouri, Kansas City. The balance comprised seven other institutions. Their practices were distributed across 13 different zip codes throughout Sedgwick County. Four respondents had practiced dentistry 1–5 years, three had practiced 6–10 years, and 14 had practiced for 11 years or more. Most have never practiced dentistry in a water-fluoridated community (81%; n=17).

Dentists' Practices

Dentists reported panel sizes of children between 0 and 3,000, with a mean panel size of 912 children 5–18 years of age. Fifteen respondents *estimated* that the decayed, missing, and filled teeth (DMFT) scores for their patients ranged from 0 to 16, with an average estimate of 5.47, (the average *observed* DFT score found in our chart review was 3.44).

The use or recommendations of fluoride supplements varied among the respondents (see Table 11-7).

Table 11-7
Dentists Who Use, Recommend, or Prescribe Fluoride Treatments or Supplements

Varnishes	Sealants	Fluoride Tablets/Drops	Fluoridated Toothpaste	Fluoride Mouth Rinse	Fluoride Gels
23.8% (5)	95.2% (20)	85.7% (18)	100% (21)	90.5% (19)	100% (21)

Note. Responses of 21 dentists participating in the KHI survey regarding fluoride practices and opinions revealed that all of them use, recommend, or prescribe fluoridated toothpaste and fluoride gel. The treatment intervention least popular among these dentists was fluoride varnish.

Of note is that respondents reported they do consider patient compliance when deciding to prescribe or apply a fluoride supplement (66.7%; n=14) but do not consider the cost of treatment when making a recommendation (66.7%; n=14). A few respondents noted that they considered supplements to be very cost effective, compared to dental restorative procedures.

Dentists' Opinions

Dentists who responded to the dental survey also provided their opinions on water fluoridation and fluoride supplementation (see Table 11-8).

Table 11-8
Dentists' Opinions about Fluoride

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The use of supplemental fluoride in Wichita children and adolescents is important today.	0	0	0	5 (23.8%)	16 (76.2%)
The lack of water fluoridation in Wichita has contributed substantially to dental disease in children and adolescents.	1 (4.8%)	0	0	8 (38.1%)	12 (57.1%)
The Wichita-Sedgwick County, Department of Community Health has adequately addressed dental disease and education in Wichita children and adolescents.	2 (9.5%)	6 (28.6%)	3 (14.3%)	9 (42.8%)	1 (4.8%)

Note. The majority of the 21 dentists participating in the KHI survey indicated strong agreement with the opinion statements that use of supplemental fluoride is important and that lack of water fluoridation has contributed to dental disease in children and adolescents.

The observation that approximately equal numbers of dentists responded at each "end" of the response scale regarding the Department of Community Health's activities may indicate that

there exists a variety of experiences, and/or different levels of personal or professional contact with the department.

Community Perception

The survey provided space and encouragement for the respondents to share additional comments. Although these data are qualitative in nature, when taken together, they provide a consistent perception of the community in which the dentists practice.

Descriptors such as "conservative," "passive community leadership," "vocal minority" (opposed to fluoride), and "uninformed"(about fluoride) were used to describe Wichita/ Sedgwick County. Respondents attributed equally a lack of information and education about fluoride and a vocal minority of community members who oppose public water fluoridation for the difficulties the county has experienced in arriving at a majority-driven consensus on the issue. Eight respondents (38.1%) attributed some degree of responsibility for the lack of adequate public health response (e.g., water fluoridation) to the Board of Health or the Department of Community Health. Thirteen respondents (61.9%) identified the community's conservative nature, lack of leadership, and education as the primary barriers to public water fluoridation.

The respondent sample included in the study was randomly selected and represents 12.7% of the dentists in the Wichita area. Results are therefore likely to represent relatively common views held by those in the professional dental community. To statistically validate these results, a larger survey effort could be conducted.

Educational Opportunities

Dentists attribute the lack of attention to dental health issues to a population poorly educated on the topic of fluoride in Wichita/ Sedgwick County. This observation, if true, would suggest that they and the rest of those in the dental health community might need to renew their approaches to sharing information about the importance of both systemic and topical fluoride, and its effect on dental health. School-based programs, education provided "in the dental chair," and broader dissemination of dental health promotion and/or disease prevention information may be warranted. Finally, the opportunity may exist for a greater collaborative relationship between the dentists in the county and the Department of Community Health.

12 Conclusion

1. Children's oral health has a substantial impact on their health and their lives. School performance is substantially impacted; for example, with more than 51,679,000 hours of school lost during one year nationally because of dental treatment and problems (58). Dental pain, poor speech, diminished growth, and psychosocial issues are recognized as outcomes of oral disease. A host of other hidden costs can be associated with poor dental health, such as time lost from work to address the dental health needs of a child, or the costs associated with delayed dental treatment (resulting in restricted activity days and bed days).

2. Most dental disease is preventable, and prevention is not just an individual child or parenting issue. Although good oral hygiene at home is critical, other factors are also important. Appropriate use of professional dental services, dental health education (both school-based and community-based), use of proven interventions such as sealants, and effective use of fluoride are considered the most important factors influencing dental health. Of these, educational outreach and water fluoridation are the only ones amenable to a public health effort that advantages all citizens equally.

3. Alternatives to community water fluoridation do exist. Each alternative offers different advantages and risks that should be considered. But no alternative is as cost effective, safe, or efficacious as public water fluoridation in providing safe levels of fluoride to a population irrespective of age, income, education, or other socioeconomic factors.

4. The level of dental disease (as measured by the number of teeth with dental decay and fillings) among school-aged children and youth in Wichita/Sedgwick County, is high. If fluoridated water were to have the same effect as has been observed internationally, a very conservative estimate would be that caries rates would decrease by approximately 20% (meta-analysis study of more than 113 studies conducted in the United States and in 22 other

countries indicates that modal caries reduction is 45%–55%) (48). In Wichita/Sedgwick County, that decrease would represent a cost savings of more than $2.9 million in the number of decayed teeth and fillings *avoided* in children, based on extrapolations from the KHI chart review project (see Appendix III). Savings from other sources, such as the decreased need for dental crowns or other treatments, are not included in this estimate, nor is the cost savings associated with decreased time and cost associated with going to the dentist to receive care. Additional financial savings also would accrue over time, due to improved dental health in adulthood and old age.

5. Dental practice varies among dentists in Wichita/Sedgwick County, with respect to their approach to and use of fluoride. Much like professionals in other medical fields, individual dentists practice differently, and the impact of such differences is likely to affect patient outcomes. This observation is particularly noteworthy because all the survey respondents supported the use of fluoride in preventive treatment.

6. From a statewide perspective, Wichita is the largest city in the state and one of approximately 526 communities throughout the state, serving 1.1 million people, with non-fluoridated public water. The estimated total cost (in 1998 dollars) for water fluoridation in a community the size of Wichita is approximately $800,000–$900,000. These costs produce cost/benefit ratios of 20:1 and 40:1 in effectively reducing dental disease. The majority of Kansans recently surveyed would support legislation requiring fluoride in all community water supplies, even if it meant that their water bills would increase $0.10 to $0.50 per month. The cost burden of water fluoridation decreases as community size increases (47).

   Kansas is one of only seven states without a dental health officer or a public health dental program (59). A growing focus on oral health at both the national and state levels makes it particularly meaningful to proactively address issues such as public water fluoridation, and the use of sealants and other preventive measures aimed at improving dental health.

13

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Water Fluoridation Alternatives: Use and Opinion Among Wichita Dentists

Instructions: Please read each question carefully and mark or fill in your best answers as requested.

1) In your practice, do you prescribe or apply any of the following fluoride preventatives/treatments?

	Yes	No
a. Fluoride varnishes	☐	☐
b. Fissure sealants	☐	☐
c. Fluoride tablets/drops	☐	☐
d. Fluoride toothpaste	☐	☐
e. Fluoride mouth rinse	☐	☐
f. Fluoride gels/topical applications	☐	☐
g. Other _____		

2) For what age groups do you typically prescribe or apply these fluoride preventatives/treatments?

	Less than 5 yrs.	5 to 10 yrs.	11 to 15 yrs.	Over 15 yrs.	N/A
a. Fluoride varnishes	☐	☐	☐	☐	☐
b. Fissure sealants	☐	☐	☐	☐	☐
c. Fluoride tablets/drops	☐	☐	☐	☐	☐
d. Fluoride toothpaste	☐	☐	☐	☐	☐
e. Fluoride mouth rinse	☐	☐	☐	☐	☐
f. Fluoride gels/topical applications	☐	☐	☐	☐	☐
g. Other _____	☐	☐	☐	☐	☐

3) Do you consider the cost of fluoride preventatives/treatments when making a recommendation?

- Yes ☐
- No ☐
- I do not recommend fluoride preventatives/treatments ☐

4) Does your assessment of patient compliance affect the types of fluoride preventatives/treatments you choose to prescribe or apply?

- Yes ☐
- No ☐
- I do not prescribe or apply fluoride preventatives/treatments ☐

5) Please mark the extent to which you disagree or agree with the following statements:

	Strongly Disagree	Disagree	Niether Disagree nor Agree	Agree	Strongly Agree
a. The use of supplemental fluoride in Wichita children and adolescents is important today.	☐	☐	☐	☐	☐
b. The lack of water fluoridation in Wichita has contributed substantially to dental disease in children and adolescents.	☐	☐	☐	☐	☐
c. The Wichita-Sedgwick County Department of Community Health has adequately addressed dental disease and education in Wichita children and adolescents.	☐	☐	☐	☐	☐

Please Continue to Other Side ➡

Now we would like to ask a few questions about you and your practice.

1) Please estimate the number of school aged children and adolescents (5 to 18 years) who are active patients in your practice. _____

2) What is the approximate age distribution of those children and adolescents? (should total 100%)

5 to 10 years	____ %
11 to 15 years	____ %
Over 15 years	____ %

3) For your school aged and adolescent active patients, what would you *estimate* their average decayed, missing, and filled tooth (DMFT) score to be? _____

4) At which institution did you receive your degree in dentistry? _____

5)

For how many years have you…	Practiced Dentistry?	Practiced in Wichita?
Less than 1 year	☐	☐
1 to 5 years	☐	☐
6 to 10 years	☐	☐
11 or more years	☐	☐

6) In what zip code is your practice located? _____

7) If you have previously practiced in a fluoridated community, how does the rate of dental caries in Wichita children compare to the rate of dental caries in the fluoridated community?

a. Wichita children have more dental caries ☐
b. Wichita children have about the same amount of dental caries ☐
c. Wichita children have less dental caries ☐
d. I have never practiced in a fluoridated community ☐

8) What do you believe is the Wichita community's attitude toward water fluoridation and why?

_____

_____

_____

_____

_____

Thank you for taking time to complete this survey. If you would like to share any additional comments about dental need, dental disease, and fluoride in Wichita and Sedgwick County, please feel free to attach them to this survey. Please enclose the survey in the provided self-addressed stamped envelope.

Thank You!

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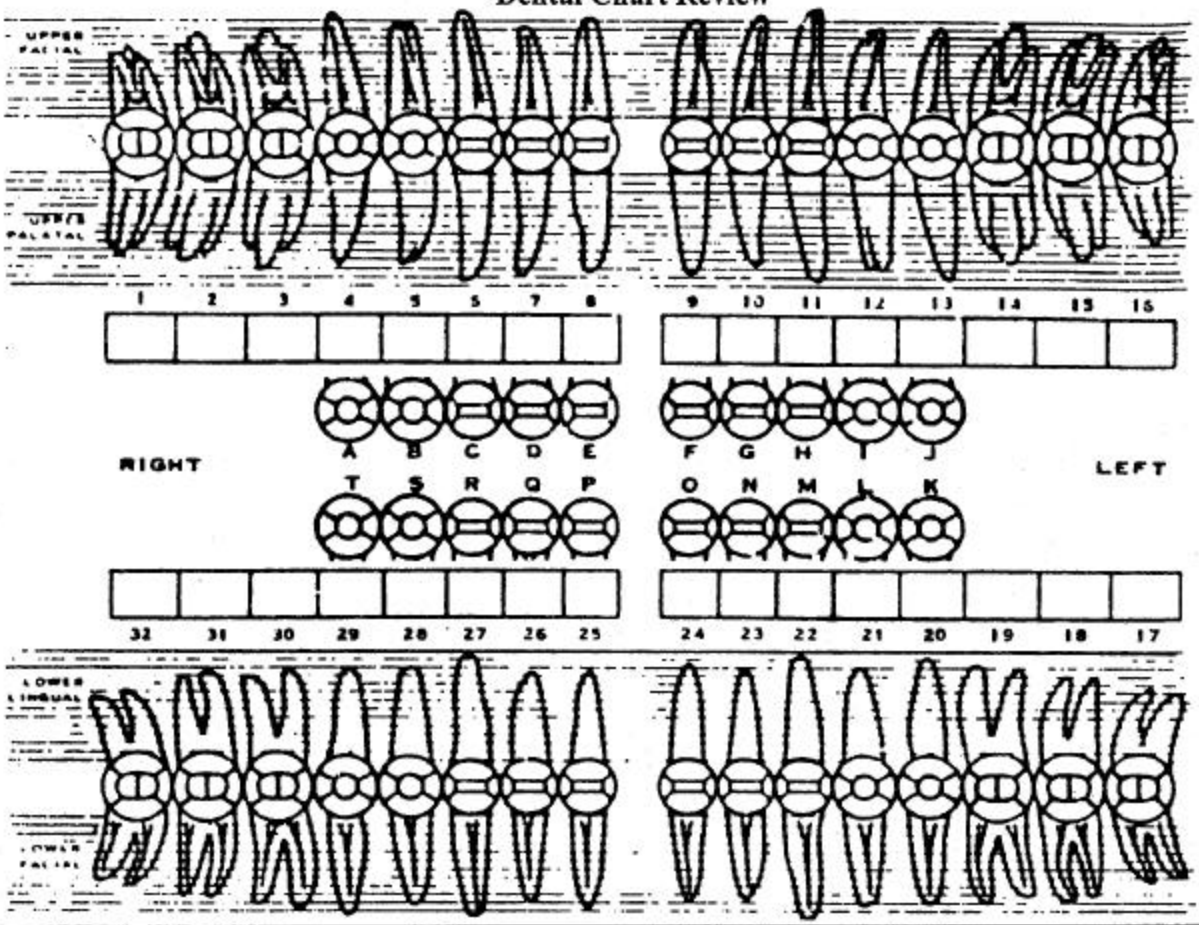
5/15/00

Kansas Health Institute
Dental Chart Review



Charting Codes	**H/F** = Flourosis	**S** = Sealant Applied	
D = Decay / Defect	**M** = Missing	**F** = Filled (# of surfaces)	**E** = Erupting
C = Capped	**R** = Extracted / Removed	**H** = Hypoplasias / Hypocalcifications	**O**= Malocclusion

Subject Information

Date of Birth _____/_____/_____

Date First Visit _____/_____/_____

Date Last Visit _____/_____/_____

Total Visits_____

Sex: M F

Zip Code (residence) _672____

Treatments

Fluoride Treatment Y N

Dates_____

Sealant Treatment Y N

Dates_____

Review Information

Reviewers Initials KK MS

Review Date_____

Dentist ID_____

Dentist Zip Code __672_____

Chart ID_____

Notes/ Comments

_____

_____

_____

_____

Calculations for Cost Savings Achieved by 20% Reduction in Defect Rates

Information from United States Census County Population -- Estimates for 7/1/98[1]

Sedgwick County, Kansas -- number of 5-17 year olds = **88,747**

Pricing Information from 16 Wichita, Kansas DDS offices:

1-4+ Surface(s) Cost Range for Amalgam = **$49-$130** (average cost for multi-surface amalgam filling = $89)

Chart Counts from Sedgwick County Sub-Sample:

Age Group	Sample Size	Number 'Primary' Defects	Number 'Permanent' Defects	Combined Number of Defects	Average Number of Defects
5-10 yrs	134	325	40	365	2.7239
11-15 yrs	175	199	285	484	2.7657
16-18 yrs	154	115	627	742	4.8182
Total	463	639	952	1591	**3.4363**

Sedgwick County Population Estimates:

Number of 5-18 year olds in Sedgwick County Sub-Sample (chart review) = 463
Number of 5-17 year olds in Sedgwick County Census Estimate = 88,747
Sedgwick County Sub-Sample / Census Estimate = .52%
Head count using the Sedgwick County Census Estimate (only covers 5-17 year olds): 88,747
Average Number of Teeth Defects for 5-18 year olds: 3.4363

County-wide Defect Estimates:

88,747 x 3.4363 = **304,961**

County-Wide Estimated Cost of Amalgam-Filled Defects:

Conservative Cost Estimate ($49 for 1 surface):	**304,961 x $49 =**	**$14,943,089**
Average Cost Estimate ($89 for between 1-4+ surfaces):	304,961 x $89 =	$27,141,529
Liberal Estimate ($130 for 4+ surfaces):	304,961 x $130 =	$39,644,930

20% Savings by Implementing Water Fluoridation:

Conservative Cost Estimate:	**$14,943,089 x 20% =**	**$2,988,618**
Average Cost Estimate:	$27,141,529 x 20% =	$5,428,306
Liberal Estimate:	$39,644,930 x 20% =	$7,928,986

[1]United States Department of Commerce, Census Bureau Homepage <http://www.census.gov/>