

Dental and Dental Hygiene Students' Knowledge and Perception on Fluoride Use in Dentistry

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ABSTRACT

Aim: The 75th anniversary of community water fluoridation in the United States was celebrated in 2020. However, there are studies that stimulate polarized discussion over the use of fluoride in dentistry. The purpose of this study was to evaluate dental and dental hygiene students' knowledge and perception of fluoride use in dentistry.

Materials and methods: A survey was conducted to gauge participant's knowledge and perception of fluoride and their opinion on the need for developing viable alternatives to fluoride. An Institutional Review Board (IRB# 5190496) application was filed and approved. A hard copy survey was distributed to all student classes at Loma Linda University School of Dentistry (U.S.) between January 13, 2020, and February 5, 2020. Descriptive data were compiled and analyzed. Knowledge-based questions were compared using Kruskal–Wallis procedure to evaluate correct percentage among different classes. Perception questions were analyzed using a Likert scale and also a Chi-squared test. All tests were two-sided with α at 0.05.

Results: Out of 482 students, 282 students responded (58.5%). The mean of correct responses for knowledge ranged from 49 to 69%. There was a statistically significant difference among the classes. Overall the perception of the use of fluoride in dentistry was positive, and it changed with exposure to lectures on fluoride over the years.

Conclusion: There was a correlation between knowledge and the perception of the use of fluoride in dentistry, indicating the importance of adequate delivery of didactic teaching on knowledge of fluoride to dental and dental hygiene students.

Clinical significance: The oral healthcare provider plays a pivotal role in communicating pertinent information on the benefits of fluoride in preventing dental caries to the general public, prompting adequate delivery of didactic teaching on this topic in dental education.

Keywords: Community fluoridation, Dental hygiene students, Dental students, Fluoride, Knowledge, Perception.

The Journal of Contemporary Dental Practice (2021): 10.5005/jp-journals-10024-3025

INTRODUCTION

Fluoride is a naturally occurring mineral that can reduce tooth demineralization and enhance remineralization to prevent tooth decay.¹ In the early 1900s, dentists wondered why the teeth of many residents of the American Southwest were stained yellow, brown, or black. The unique presentation of these teeth was called "Colorado brown stains."² In the 1930s, it was found that naturally occurring fluoride in drinking water reduced the incidence of tooth decay.³ These findings collectively led to a monumental step, as Grand Rapids in Michigan in 1945 became the world's first city to change the level of fluoride in its water supply to reduce dental caries of the public. Since then, many other states and countries have joined this effort of water fluoridation. The beneficial effects are supported with decreased dental caries incidences in community water fluoridated (CWF) areas compared to non-fluoridated communities.⁴ Nowadays, fluoride is not only available in water but also in various types of products, such as preventative or restorative dental materials, dentifrices, mouth rinses, and dietary supplements.

The American Dental Association (ADA) supports CWF as a safe, effective, cost-saving, and socially equitable way to prevent tooth decay.⁵ Furthermore, the Centers for Disease Control and Prevention (CDC) have proclaimed CWF as one of the 10 great public health achievements of the 20th century.⁶ However, the positive impacts of fluoride have been clouded by studies, claiming that fluoridation may cause lower intelligence (IQ) in

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How to cite this article: Shin Y, Lopez E, Bullock A, *et al.* Dental and Dental Hygiene Students' Knowledge and Perception on Fluoride Use in Dentistry. *J Contemp Dent Pract* 2021;22(1):4–8.

Source of support: The study was funded by Loma Linda University School of Dentistry Student Research Program Fund

Conflict of interest: None

children or have a significant neurological impact.⁷⁻¹⁰ Additionally, there are ongoing controversies on fluoride toxicity. It has been debated that with a variety of fluoride interventions commonly used, it is difficult to determine the level of fluoride exposure of

each person. Thus, potential excessive ingestion may lead to acute or chronic toxicity, depending on the type of fluoride solution, duration, and dosage.¹¹ It is this contention that fueled possible search for alternatives to fluoride interventions to prevent tooth decay.¹²

It is critically important to address controversies in an educational environment. There have been studies that examined various healthcare providers' knowledge and perception regarding fluoride and their prescription practices.¹³⁻¹⁶ An analysis of the 2001 report from the CDC failed to give specific guidelines on determining when a person has consumed a sufficient amount of fluoride for maximum protection.¹⁷ Several studies addressed concerns about knowledge on fluoride and prescription recommendations made by practicing dentists, pediatric dentists, dental public health personnel, and general dentists.^{13,14} About 90% of the dentists reported regular use of fluorides, even though only 5% of them knew the primary effect of fluoride.¹⁴ The consensus of these studies was that healthcare providers possessed inadequate knowledge about water fluoridation and lack of understanding about fluoride's predominant mode of action. Thus, the purpose of this study was to evaluate students' knowledge and perception of fluoride use in dentistry at Loma Linda University School of Dentistry (LLUSD). We aimed to achieve this by distributing a survey to all classes of dental (DDS) and dental hygiene (DH) students. The following null hypotheses were tested: there would be no difference in knowledge and perception among the different DDS and DH classes.

MATERIALS AND METHODS

An IRB application was approved by the Loma Linda University Health Institutional Review Board (IRB #5190496) for a cross-sectional study that included all classes of dental students (D1-D4: N = 404) and dental hygiene students (DHJ: dental hygiene junior; DHS: dental hygiene senior; N = 78) at LLUSD (Table 1).

The survey questions are listed in Table 2. There was a total of 10 questions, five on knowledge and five on perception. The knowledge questions were formulated by three students and six faculty to reflect the didactic content taught at institutions, including LLUSD (U.S.), Yonsei University College of Dentistry (South Korea), and Guizhou Medical University School of Stomatology (China). The final questions were selected to reflect knowledge that oral healthcare providers should be competent to answer correctly. Questions pertained to general properties of fluoride, mechanism of action, optimal concentration of CWF, recommended toothpaste

amount for children, and potential adverse effects of CWF. Questions on perception were formulated to evaluate students' responses to CWF, confidence in the knowledge of fluoride, and the need for fluoride alternatives. Knowledge responses were dichotomized as correct or wrong. Perception responses on a five-point Likert scale ranged from strongly disagree to strongly agree. Students were invited to fill-out the anonymous hard copy survey between January 13, 2020, and February 5, 2020. The collected hard copies were then entered into an excel spreadsheet and data entry checked for any potential errors.

Based on the sample size calculation, at least 44 students per DDS class needed to participate to detect a 30% knowledge difference among the classes at a power level of 80%. All descriptive data were compiled and analyzed with a statistical program (SPSS26, Chicago, MI, USA). The percentage of correct responses to knowledge questions were examined using Kruskal-Wallis procedure followed by pairwise comparisons with the Dwass-Steel-Critchlow-Fligner method. Perception questions were analyzed on a Likert scale and later a chi-squared test was conducted. All tests were two-sided with α at 0.05.

RESULTS

This study surveyed students of LLUSD's knowledge and perception of dental fluoride in a questionnaire format by the voluntary participation of DDS and DH students of all grades.

Table 1 summarizes the response rate to the survey. Out of 482 students, 282 students participated in the study (response rate = 58.5%). The response rate by class varied from 42.4 to 95.0%. Overall DH students showed more active participation. Table 2 summarizes the percentage of correct responses on the five knowledge questions by DDS and DH classes. Difference in

Table 1: Response rate to survey by class

	Class	Number of students	Respondents
DDS student	D1	101	49
	D2	99	42
	D3	100	53
	D4	104	64
DH student	DHJ	40	38
	DHS	38	36
Total		482	282

Table 2: Percentage of correct responses on knowledge questions by class

Questions	D1	D2	D3	D4	DHJ	DHS
Q1. What is not a mechanism of action of fluoride to prevent tooth decay?	42.9% ^a	52.4% ^a	39.6% ^a	43.8% ^a	39.5% ^A	33.3% ^A
Q2. Which of the following is a correct statement related to general properties of fluoride?	57.1% ^a	64.3% ^a	69.8% ^a	60.9% ^a	47.4% ^A	66.7% ^A
Q3. What is the target range of fluoride concentration in community water fluoridation to prevent tooth decay?	28.6% ^a	88.1% ^b	62.3% ^c	81.3% ^{bc}	57.9% ^A	100% ^B
Q4. How much fluoridated toothpaste is recommended for children at the age of 4 years?	61.2% ^a	57.1% ^a	62.3% ^a	62.5% ^a	47.4% ^A	47.2% ^A
Q5. A 14-year-old boy presents with symmetrical small opaque, chalk white areas covering less than 25% of the tooth surface of upper incisors. What is the most likely cause of this oral presentation?	53.1% ^a	83.3% ^b	54.7% ^a	75% ^{ab}	57.9% ^A	61.1% ^A
Total	48.6% ^a	69% ^b	57.7% ^{ab}	64.7% ^b	50% ^A	61.7% ^B

Different lower case letters indicate statistical difference among DDS classes in the same row at $p < 0.05$; Different upper case letters indicate statistical difference between DH classes in the same row at $p < 0.05$

knowledge was compared among the four DDS classes and between the two DH classes. The mean of correct responses for knowledge by class ranged from 48.6 to 69.0%. Statistically significant differences in assessment of knowledge were observed among the DDS classes [$\chi^2, 3, N = 208 = 16.6, p < 0.001$]. The distribution of percentage of correct responses by class is illustrated as boxplots in Figure 1. Overall, the D1 class had the lowest mean score for correct responses, which was statistically, significantly different from the D2 and D4 classes ($p < 0.05$). Analyzing the difference by question item, it was observed that the D2 class had statistically significant higher knowledge on optimal concentration of CWF and potential adverse effects of community water fluoridation than the D1 class ($p < 0.05$, in both instances).

Statistically significant higher knowledge scores were observed for the DHS than the DHJ class [$\chi^2, 1, N = 74 = 5.81, p < 0.016$]. Analyzing the difference by question item, it was observed that the DHS class had statistically significant higher knowledge on optimal concentration of CWF than the DHJ class ($p < 0.05$).

Perception responses on a five-point Likert scale ranged from strongly disagree to strongly agree. For the analysis, we dichotomized the responses into positive and negative, with the "neutral" response categorized into the negative response.¹⁸ Table 3 summarizes the perception response by question and class. Overall the perception of the use of fluoride in dentistry was positive for all classes. However, there was a statistically significant difference

between the D1 and all other DDS classes, on the statement that CWF is the most cost-effective way to prevent tooth decay ($p < 0.05$). While 73.8–79.7% of the other DDS classes agreed or strongly agreed, almost half of the D1 class (45.8%) disagreed or were neutral about the cost-effectiveness of CWF. The same trend was observed for the DH classes. The majority of DHS students (94.4%) perceived CWF as cost-effective while only 63.2% of DHJ students had a positive perception. This difference was statistically significant ($p < 0.05$). Almost two-thirds of the D1 class felt that they did not have adequate knowledge of fluoride's mechanism of action to prevent tooth decay and potential adverse effects of fluoride. With regard to whether there is a need to develop other alternatives to fluoride in preventing tooth decay, there was no statistically significant difference among the DDS classes and between the DH classes ($p > 0.05$, in both instances). The majority of students felt that there was no need for other alternatives.

When further analyzing the relationship of knowledge and perception, it was observed that higher perception scores (positive perception) were observed among students with higher knowledge in Q1 ($p = 0.024$), Q2 ($p = 0.002$), Q3 ($p < 0.001$), and Q4 ($p = 0.04$), but not for Q5 ($p = 0.516$)

DISCUSSION

Fluoride occupies a unique position in dentistry as a chemotherapeutic agent to prevent and manage dental caries. It is relatively inexpensive and can be delivered through several cost-effective ways, i.e., through water fluoridation, dentifrices, and other oral care products.¹² Fluoride's mode of action in combating dental caries is well-established and is attributed to three main actions. The first mechanism of fluoride is its ability to prevent demineralization of tooth structure, i.e., it delays or prevents the loss of minerals.¹⁹ Fluoride's second mechanism of action is through remineralization, which reverts the demineralization process by being available at the right place and at the right time.²⁰ Lastly, fluoride hinders the ability of bacteria to metabolize carbohydrates and attach to the tooth surface readily.^{21,22} The widespread use of fluoride, by acting collectively through various modes, has caused a decline in dental caries in most industrialized countries.¹² While fluoride is unequivocally an effective anti-caries agent, dental caries still remains a major issue to be addressed in high-risk populations, and so far, there seems to be no complete cure. Additionally, although fluoride is highly effective in smooth surface caries, its effect is limited on pit and fissure areas. Thus, it is inevitable and most desirable that the search for alternative preventive anti-caries therapies continues.

ADA is celebrating the 75th anniversary of CWF in the United States in 2020. Over the years, CWF has been endorsed by over

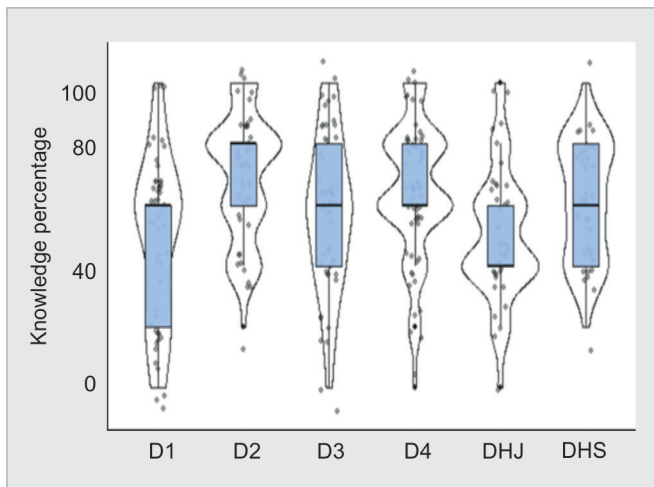


Fig. 1: Boxplots illustrating the distribution of percentage of response to knowledge on fluoride by class

Table 3: Percentage of respondents who agreed or strongly agreed on perception with survey items

Questions	D1	D2	D3	D4	DHJ	DHS
Q1. Community water fluoridation is the most cost-effective way to prevent tooth decay.	54.2% ^a	73.8% ^b	77.4% ^b	79.7% ^b	63.2% ^A	94.4% ^B
Q2. The use of fluoride in dentistry is controversial and the risks may outweigh its benefits.	14.6% ^a	7.1% ^a	7.5% ^a	12.5% ^a	26.3% ^A	8.3% ^A
Q3. As a future oral healthcare professional, I have adequate knowledge of fluoride's mechanism of action to prevent tooth decay.	39.6% ^a	64.3% ^b	49.1% ^a	67.2% ^b	71.1% ^A	91.7% ^B
Q4. As a future oral healthcare professional, I have adequate knowledge about fluoride's potential adverse effects.	37.5% ^a	71.4% ^b	56.6% ^b	67.2% ^b	68.4% ^A	86.1% ^A
Q5. There is a need to develop other alternatives to fluoride in preventing tooth decay.	33.3% ^a	28.6% ^a	43.4% ^a	45.3% ^a	52.6% ^A	36.1% ^A

Different lower case letters indicate statistical difference among DDS classes in the same row at $p < 0.05$; Different upper case letters indicate statistical difference between DH classes in the same row at $p < 0.05$



90 national and international governments and health organizations around the world.²³ Despite the endorsement of governments and health organizations, and a large body of empirical evidence on its preventive effect on dental caries, CWF remains a controversial and keenly debated issue. The issue is periodically surfaced by literature on its potential harmful side effects to human health, including dental fluorosis,^{24–26} skeletal fluorosis,^{26,27} osteosarcoma,^{28,29} thyroid function,^{30,31} and children's intelligence quotient.^{7–10,32–37} Based on a recent publication by the ADA, it has been emphasized that according to the best scientific evidence, drinking water that has been fluoridated at the recommended level does not have an adverse effect on the raised concerns.⁵ Furthermore, several methodological limitations were identified in some studies including the lack of control for important confounding variables, such as exposure to known neurotoxicants (e.g., lead, arsenic, or iodine), socioeconomic status, nutritional status, and parental education that could be related to fluoride exposure and also potentially affect children's IQ.²³

The oral healthcare provider plays a pivotal role in communicating pertinent information on the benefits of fluoride in preventing dental caries to the general public. While there have been many studies on the perception of the public and oral healthcare providers' attitude and knowledge about fluoride,^{13–16,38–42} there have been only limited information on the perception and knowledge of future oral healthcare providers, the DDS and DH students.^{43–45} The overall survey response rate of 58.5% indicated that the results were reflective of LLUSD's DDS and DH students' knowledge and perception of the use of fluoride in dentistry. Based on the results we rejected our null hypothesis. There was a difference among the DDS classes in knowledge and perception that was also observed for the DH classes. A major deficit in knowledge was observed on the mechanism of fluoride in preventing dental caries. This is in accordance with studies by Bansal et al., Akbar et al., and Moon et al. that reported that many oral healthcare professionals do not fully understand the mechanism underlying the use of fluoride in dental caries prevention and management.^{14,16,42} It is noteworthy to highlight that a clear understanding of how fluoride works to prevent dental caries would not only drive to advocate for CWF but also potentially optimize clinical procedures, such as topical fluoride applications. The degree of knowledge differed among the classes, which was not surprising. At LLUSD, most of the didactic information on fluoride is delivered by the Division of General Dentistry (2-hour lecture) and the Pediatric Department (1-hour lecture) to the D2 students during the spring quarter and to the DHS students during their summer quarter. Therefore, except for the D1 and DHJ students, all remaining classes received the didactic courses on fluoride before taking the survey. It was interesting to note that there was a significant correlation; that is, positive perception toward the use of fluoride in dentistry was observed among students with higher knowledge. This is an important aspect, emphasizing the need for adequate education as students will be the oral healthcare professionals responsible for delivering information on preventive measures, including the use of fluoride to the general public. A study by Levy examined curricula content on selected fluoride topics at 42 dental schools and 141 dental hygiene programs in the U.S. reported that on average most dental schools taught approximately 1.6 hours on water fluoridation and topical fluorides, while dental hygiene programs allotted twice as much on these topics.⁴⁶ Levy noted that opportunities to put into practice students' knowledge was minimal and that simulated opportunities on dietary fluoride supplements

were recommended for student experience and education.⁴⁶ It was unexpected that many students did not find the need for additional research or search for an alternative to fluoride. In the view of the authors, despite the large body of evidence of fluoride's preventive effect on dental caries, oral healthcare professionals should always strive for improved ways that may even complement current procedures and preventative strategies.

The generalizability of this study is limited due to the distribution of the survey to students of one educational institution. We plan to collaborate with other dental institutions nationally and internationally to investigate this topic on a wider scope. Along with the survey, an analysis of the curriculum content on fluoride may be done to establish the relationship between didactic teaching content and perception. The information gained could improve the quality of care provided by oral healthcare professionals worldwide that in turn will also affect public health.

CONCLUSION

Within the limitations of this study, we conclude that there is a correlation between knowledge and the perception of the use of fluoride in dentistry. Thus, there is room for improvement in delivering adequate knowledge on fluoride to DDS and DH students.

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