GRADUATION PROJECT:

Degree in Dentistry

THE HISTORY OF FLUORIDES AND ITS USE NOWADAYS IN PREVENTIVE DENTISTRY.

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1. ABSTRACT

Introduction: Fluoride is one of the most prevalent chemicals used in preventive dentistry. The initial discovery of its association with preventive dentistry began in 1909, when it was discovered that 'brown stained teeth' were resistant to decay. Fluorides main association in dentistry is with its benefit in the reduction of dental caries. This project aims to explore how fluoride was discovered and how it is currently used in preventive dentistry.

Objectives: To evaluate whether fluoride has been integrated into society by analysing whether individuals use it on a daily basis. To analyse the frequency of use of fluoride in comparison to how often someone smokes. To evaluate whether individuals are more likely to use fluoride if they are concerned with aesthetics.

Methodology:

- A survey will be carried out and sent out electronically to conduct research into whether individuals use fluoride.
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Results: 57.8% of respondents brush their teeth twice a day, 95.2% use a fluoridated toothpaste, 64.6% don't use a dental prescribed toothpaste. 50.6% don't use a mouthwash, 76.8% don't smoke but of those that do smoke, the majority (40.9%) smoke between 1-5 per day. 34.9% of respondents floss once per day, 69.9% are concerned over their smile aesthetics. 44.6% visit their dentist twice per year.

Conclusions: The use of fluoride in preventive dentistry was discovered from its presence in water. Fluoride definitively reduces the risk of decay. Those concerned about smile aesthetics are more likely to brush their teeth more and use a fluoridated mouthwash. Smokers have similar hygiene levels to non-smokers.

Keywords: Dentistry, fluoride, prevention, remineralisation, caries.

1. RESUMEN

Introducción: El flúor es uno de los productos más utilizados en la odontología. Es un mineral que está presente en la naturaleza y se libera de las rocas al suelo, el aire y el agua. El descubrimiento de su asociación con la odontología preventiva comenzó en 1909. La principal asociación del flúor en odontología es con su beneficio en la reducción de la caries dental. Este proyecto tiene como objetivo estudiar cómo se descubrió el flúor y cómo se usa actualmente en odontología preventiva.

Objetivos: Evaluar si el flúor se ha integrado en la sociedad analizando si los individuos lo utilizan a diario. Analizar la frecuencia de uso de flúor en comparación con la frecuencia con la que alguien fuma. Evaluar si es más probable que las personas usen flúor si les preocupa la estética.

Metodología:

- Se llevará a cabo una encuesta y se enviará electrónicamente para conocer su utilización en la actualidad.

Resultados: el 57,8% de los encuestados se cepilla los dientes dos veces al día. 95,2% usa una pasta dental con flúor. 64,6% no usa una pasta dental prescrita. 50,6% no usa enjuague bucal. 76,8% no fuma pero de los que fuman, la mayoría (40,9%) fuma entre 1-5 cigarros al día. 34,9% usa hilo dental una vez al día. 69,9% está preocupado por la estética de su sonrisa. 44,6% visita a su dentista dos veces al año.

Conclusiones: El uso del flúor en odontología preventiva se descubrió a partir de su presencia en el agua. El flúor reduce significativamente el riesgo de caries. Aquellas personas a las que les preocupa la estética de la sonrisa se cepillan más los dientes. Los fumadores tienen niveles de higiene similares a los no fumadores.

Palabras clave: Odontología, flúor, prevención, remineralización, caries.

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1. INTRODUCTION

1.1 DEFINITION

Fluoride is a naturally occurring monatomic anion of fluorine. It is represented by the symbol F−. Its salts are known to appear white in colour or in some cases colourless. Its role in reducing decay has been demonstrated. [1,2]

1.2 BACKGROUND

Fluoride is used on an individual basis by patients and professionally by dentists with its main use being in preventive dentistry. The incorporation and use of fluoride has proven to be one of the most successful developments in preventive mechanisms in dentistry. It's widely available in supermarkets, pharmacies and dental clinics. Its specific mechanism of action is still being studied in further detail. As of today, it is currently understood that fluoride mainly acts topically. The accumulation of dental plaque demineralises enamel over time as the plaque produces acids that interact with the enamel. These acids are neutralised by other proteins and ions present in the oral cavity. Normally these incidents are quick however when the process of demineralisation occurs frequently in the oral cavity, mineral from the tooth is lost and the development of decay begins. Studies have shown that fluoride delays the development of decay by disrupting the demineralisation-remineralisation balance. It has been proven to decrease the rate of demineralisation and increase the rate of remineralisation of enamel. [3]

During the process of remineralisation, if fluoride ions are available, the process that occurs is the combination of the apatite structure with fluoride. This forms fluor-hydroxyapatite which research suggests is more resistant to attacks from acids. Following the placement of topical fluoride, it is retained as calcium fluoride. Studies show that these globules of calcium fluoride are sheltered against rapid dissolution due to a phosphate protein coating of salivary origin. [4]

Fluoride is not only able to prevent the occurrence of caries, but research suggests it can even reverse or arrest the progression of incipient lesions through remineralisation, for example by using a fluoride varnish. [5]

The conclusion concerning fluoride in its use in dentistry came following a long history of many scientists studying fluoride and its potential use in reducing levels of decay.

1.3 HISTORY OF FLUORIDE

The history of fluoridation began in 1901-1902 when two independent dentists, Dr. F Mckay and Dr J.M Eager, were situated in two separate locations yet both observed a unique type of staining to the teeth. [6]

They discovered that these stains were brown, permanent, varied in size and were able to occupy a large part of the teeth. At first, they were unable to attribute these stains to a specific origin. It was perceived that it could be due to dietary habits such as pork, milk, or drinking water containing calcium. [1]

Dr. McKay noticed that where staining was prevalent, it was accompanied with lower levels of decay. This correlation was confirmed when another dentist, Mr. Ainsworth conducted a study in Essex, UK containing over 4,000 children. He statistically compared the level of decay in areas that had a lot of stained teeth and areas that didn't. Following this comparison, Dr. Ainsworth concluded that areas with prevalent staining had less decay. [6]

Dr. Black agreed to collaborate with Dr. McKay to further investigate. He continued investigating fluorosis for six years, until he passed in 1915. The two of them concluded that the staining of enamel was due to developmental alterations in temporary dentition. This discovery meant that adults with permanent teeth that had already calcified were not at risk if they had not yet experienced it. Due to children having primary dentition that had not yet calcified, they were considered to be high risk for the potential development of this staining. [1]

Dr. Black and Dr. McKay discovered that teeth that were affected by the infamous 'Colorado Brown Stain' were more resistant to caries and couldn't find

an explanation as to why. There was a theory that the water source could be the cause however nothing had yet been conclusive. In 1923, McKay reunited with his parents who he found had also observed a specific type of brown staining on their children's teeth in Oakley, Idaho. McKay's parents noted that these stains only started appearing following the placement of a new water pipeline in Oakley. With now both the theory and his parents, McKay investigated this claim and analysed the water. Unfortunately, he was unable to find anything of significance that could be the cause. Despite this, he still took initiative and told the town's population to avoid the water coming from the pipeline and use the nearest different pipeline as their water source. Following this advice, it had appeared that the children in Oakley were developing permanent dentition that had no staining and remained healthy. This confirmed to McKay that the water was the issue, but he was still unable to specify exactly which element in the water was the culprit. McKay and Dr. Grover Kempf collaborated and travelled to Bauxite, Arkansas – a town owned by the Aluminium company in America. They discovered that the type of enamel staining they had consistently been seeing was prevalent in this town yet not in another one nearby. The history of fluoride continued and in 1931, the findings reached a chemist called HV Churchill. He was refuting the theory and the possibility that the staining was due to the aluminium in the drinking water. This caused him to analyse water samples from different regions and investigate different elements and their concentrations to find the origin. He conducted more thorough research using photospectographic analysis, which was a more advanced technology. [1]

He was finally able to find an underlying theme with all of the areas that presented staining - they all had elevated levels of fluoride. Dr. Ainsworth, after being made aware of this research, followed up to see if he would produce similar results. He compared the endemic staining area to Witham, which had no cases of staining, and found that Witham had significantly lower levels of fluoride in their water (0.5 ppm fluoride, compared to 4.5-5 ppm in the endemic

staining area). From this, it became evident that there was a correlation between the fluoride levels in water, the stained teeth, and the resistance to decay. Dr. H.T Dean was selected by the department of health in the US to further research the links between fluoride and decreased risk of decay since a theme had been observed. He established two things: 1) that the risk of teeth mottling was considered rare at levels below 1 ppm and 2) that the higher effect of caries prevention was observed at 1 ppm. These results were eventually published by Dean in 1942. In a separate region, children from a town called South Shields were moved to the Lake District during the Second World War. There was a senior dentist that noticed with the arrival of these children that they had healthier teeth than children who were local to the area. Being aware of the research developments in America, Robert Weaver, a dentist, analysed the fluorine content in the water from South Shields. The fluorine content was 1.4 ppm, which was higher than present water supplies. The water from North Shields, the other side of the Tyne, was also analysed and had a fluorine content of 0.25 ppm. Following the analysis of dentition in 1000 children from both sides of the Tyne, Weaver concluded that levels of decay were much lower in both primary and permanent dentition of children from South Shields. [6]

1.4 WATER FLUORIDATION

Through this research it was evident that fluoridated water at 1 ppm improved dental health. In an attempt to somewhat replicate these results, the US health authorities decided to artificially add fluoride to areas that had lower levels. Areas that already had naturally fluoridated water didn’t have any significant cases of adverse health effects and so there were no perceived disadvantages to this plan.

To launch this project, the first area to receive artificially fluoridated water was Grand Rapids, Michigan. In a domino effect, in July 1951, Muskegon health

officials also decided to fluoridate their water artificially after seeing the success Grand Rapids had with reduced levels of decay.

This trend allowed for further studies to be carried out outside of the USA. Studies were conducted in Canada, the Netherlands and New Zealand. All of the studies came to the same conclusion: areas with water that was artificially fluoridated had significantly lower levels of decay. These results prompted other countries to artificially add fluoride to their water including the United Kingdom and the Republic of Ireland. Currently, over 40 countries have artificially added fluoride to their water. [6]

It has been over 30 years since we've witnessed the successful results of using artificially fluoridated water in Grand Rapids, and fluoride remains the main method of prevention against tooth decay in dentistry. The conclusions of the research projects have had a major impact in dental science. The majority of toothpastes currently available now include fluoride as the active ingredient.

Artificially fluoridated water programs are now actively in use, with over 200 million Americans receiving the benefits. Other fluoride programs such as fluoride mouth rinse programs have also been integrated into school systems. As the results clearly show, McKay, Dean, and other researchers have aided in the transformation of dentistry into a profession that now uses a more preventive approach. They have provided a preventive approach for a disease that was previously thought to have no prevention. [6]

1.5 RISK OF FLUOROSIS

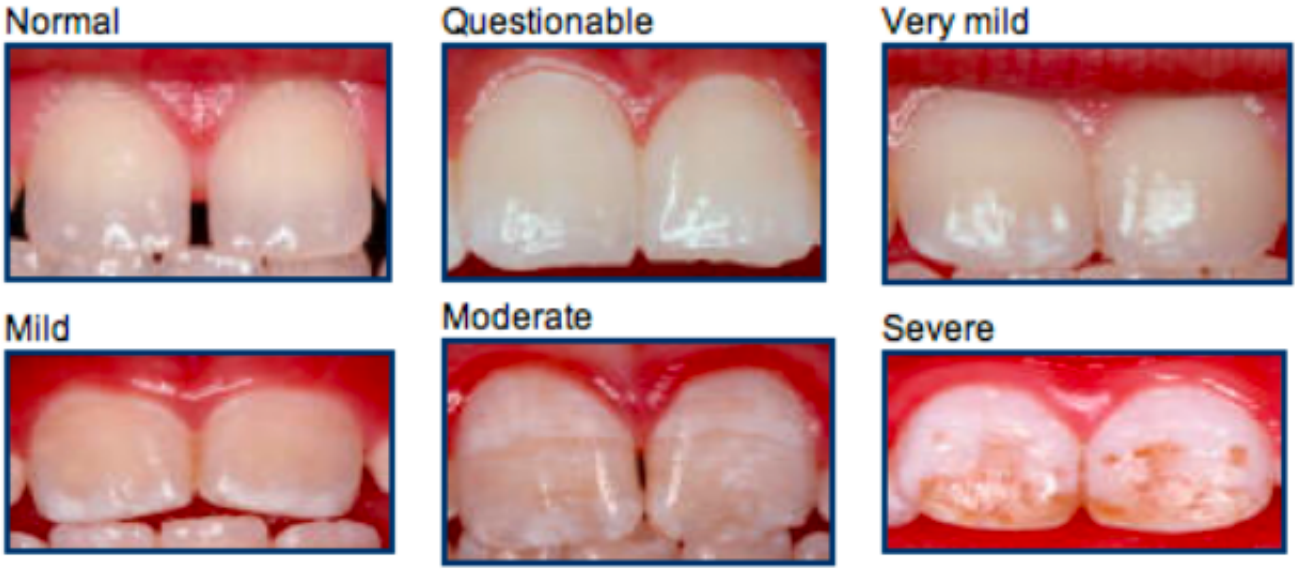
The main adverse effect proven to be associated with high fluoride intake is fluorosis. It occurs as a result of excessive fluoride being ingested during the development of teeth and bones. Fluorosis of permanent dentition happens

when fluoride is ingested in high quantities for a prolonged period. This amount of fluoride must be consumed during the mineralisation of tooth enamel. Fluorosis occurs because of hypomineralisation at a subsurface level and porosity between enamel rods that are developing. Although it can happen up to 8 years of age, the highest susceptibility period for it happening in permanent maxillary incisors is from 15 months until 2 and a half years of age. Factors that influence the risk and severity of fluorosis include the dosage ingested and the time period it was ingested for. More recently, evidence has suggested there could also be a genetic component that influences fluorosis susceptibility. Using toothpaste in children could potentially be hazardous if care is not taken as it could increase their risk of fluorosis if they swallow the toothpaste. Research suggests that toothpaste alone can account for up to 80% of the recommended daily dose for fluoride. It is therefore recommended that parents apply an age-appropriate amount of toothpaste to their children's toothbrush and supervise them brushing their teeth until 7 years of age. Children should be advised to spit, not to swallow toothpaste once finished with toothbrushing and parents should monitor their children's swallow reflex. Dental fluorosis can happen when fluoride levels reach over 1.5 mg/l (1.5 ppm) in drinking water. [7]

In children who may ingest fluoride from various sources and therefore be considered a higher risk, 1000 ppm fluoridated toothpastes can be used however it should be noted that evidence for the prevention of caries with fluoridated toothpaste less than 1000 ppm is limited. [8]

There is no further risk of fluorosis after a child has exceeded 8 years of age due to the permanent tooth enamel being completely mineralised - this excludes third molars as they erupt at a later age. Mostly enamel fluorosis presents as mild or very mild cases. Mild cases of enamel fluorosis have striations that appear white in colour or opaque areas that would not be immediately noticeable at a first glance. This type of enamel fluorosis has no clinical consequences and is usually only of aesthetic concern to the patient.

Over the last 20 years, the frequency of enamel fluorosis has increased over 40%. This is due to various factors, including the fact that fluoride sources are currently much more accessible and available. Moderate or severe cases of enamel fluorosis are considered rare as most cases are usually mild. The main concern with moderate to severe forms of enamel fluorosis is usually aesthetics, with staining being noticeable. They can also have a structural concern due to incisal edges being more fragile, anatomical grooves becoming weakened and pitting occurring in the permanent 6-year molars. [9]



[10]

1.6 FLUORIDE TOOTHPASTE

Fluoride toothpaste has more benefits in preventing caries than non-fluoride toothpastes. Evidence proving the effects between varying concentrations of fluoride is more limited however a clear association with fluoride toothpastes and the prevention of dental caries has been established. The evidence for this is present in the Cochrane library and has also been displayed in various multiple randomised clinical trials. The development of new caries with the use of 1000 to 1250 ppm F- toothpaste or 1450 to 1500 ppm F- toothpaste was lower in comparison to non-fluoridated toothpastes. Furthermore, the use of 1450 to 1500 ppm fluoride toothpaste was proven to reduce new levels of decay compared to 1000 to 1250 ppm. Although 1450 to 1500 ppm reduced levels of decay more than 1000 to 1250, it was still proven that the use of 1000 to 1100 ppm was effective in reducing decay compared to a non-fluoridated toothpaste. In the primary dentition of children, the use of a 1500 ppm toothpaste had lower levels of decay than non-fluoridated toothpastes and 550 ppm fluoridated toothpastes. The measure used to make these comparisons was the DMFT/S (D = decayed, M = missing due to caries, F = filled, T = tooth, S = surfaces) index. [11]

Comparison	Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Certainty of the evidence (GRADE)	Comments
		Risk with lower fluoride concentration toothpaste	Risk with higher concentration toothpaste				
1000 or 1100 ppm F compared with 0 ppm F	Caries increment (surface index D_3MFS) Follow-up: 12 to 24 months	The mean caries increment with 0 ppm F ranged from 0.69 to 4.99 D_3MFS[a]	The mean caries increment in the higher fluoride group was on average MD 0.53 lower (95% CI 1.02 lower to 0.04 lower)	-	2162 (3 RCTs)	⊕⊕⊕⊖ moderate[b]	Mean caries increment in the higher fluoride group was on average SMD 0.17 lower (95% CI 0.29 lower to 0.06 lower)
1000 or 1100 ppm F compared with 0 ppm F	Caries increment (tooth index D_3MFT) Follow-up: 24 months	The mean value with 0 ppm F was 1.52 D_3MFT[c]	The mean caries increment in the higher fluoride group was on average MD 0.46 lower (95% CI 0.93 lower to 0.01 higher)	-	247 (1 RCT)	⊕⊕⊖⊖ low[d]	Mean caries increment in the higher fluoride group was on average SMD 0.24 lower (95% CI 0.49 lower to 0.01 higher)
1000 or 1100 ppm F compared with 0 ppm F	Proportion of adults developing new caries	No studies reported this outcome					
1000 or 1100 ppm F compared with 0 ppm F	Adverse effects of toothpaste	No studies reported this outcome					

[12]

The EAPD recommends that fluoridated toothpaste should be used from the eruption of the first tooth. In order to avoid adverse effects of fluoride such as the previously mentioned fluorosis, the recommended amount of fluoride is as follows: 1000 ppm from the first tooth up to 24 months (using the size of a grain of rice), 1000 ppm from ages 2-6 (a higher amount can be used if the patient is higher risk, otherwise a pea sized amount is recommended) and 1450 ppm for ages 6+ (up to full length of the brush). [8]

The concentration of fluoride is not the sole factor in toothpastes that contributes to achieving maximum efficacy, the formulation is also important. The concentrations for fluoridated toothpastes available over the counter vary

depending on the region you live in. Currently in Europe the maximum level of fluoride permissible in toothpaste without prescription is 1500 ppm, which is significantly higher than the 1,100ppm allowed in the USA. Higher concentrations of fluoridated toothpastes such as 2,500 ppm and 5000 ppm are available however usually only on prescription. The varying concentrations serve different purposes - higher concentrations can be used as a preventive approach in individuals who are more susceptible to the development of caries. This can include individuals who are inconsistent with brushing their teeth, have a cariogenic diet, or are undergoing treatment with a fixed orthodontic appliance. Fluoride toothpastes at 5000 ppm for example, reduced caries at the surface of the root, and reduced caries more than a 1450 ppm fluoridated toothpaste. This was more effective in patients who had irregular brushing habits or poor oral hygiene. The general consensus is that fluoridated toothpaste should be used twice daily in combination with instructions for oral hygiene. It is now estimated that over 95% of the population in developed countries use a fluoride dentifrice. [12]

1.7 FLUORIDE MOUTHWASH

Fluoride mouth rinses are an available product that require no prescription. The use of fluoride mouth rinses is easy and is said to retain fluoride in the oral cavity more than fluoride toothpastes. Fluoride mouth rinses are recommended following the completion of toothbrushing. Patients with a high risk of caries are often recommended to use it in combination with a fluoridated toothpaste. [13]

Fluoridated mouth rinses are associated with a reduction of caries in permanent teeth. Studies show that the DMFS index had a 27% average reduction with the use of fluoridated mouth rinses in comparison to the control groups (placebo, or

rinses without fluoride). The mouth rinse used in this study contained 0.05% sodium fluoride, NaF. Over the duration of the 2-3 year study, a 230 ppm mouth rinse was given daily or a 900 ppm mouth rinse was given either weekly or fortnightly. Currently there are various concentrations available, including 100 ppm F which is recommended to be used twice a day and is available without prescription. The recommended frequency of fluoride mouth rinses depends on the concentration. In studies where rinsing was only performed once a week, a higher concentration of 900 ppm F was used to compensate for the lower usage. When it was performed daily, a lower concentration of 230 ppm F was used. In most studies, 5-10mL of mouth rinse was used for approximately one minute. There is a discrepancy on whether mouth rinses are more effective in the prevention of dental caries than simply just spitting after toothbrushing and keeping the remaining toothpaste in the mouth. Fluoride mouth rinses can only be used in those older than 6 years of age. Children younger than this are less likely to be in control of their swallow reflex and therefore are more at risk of swallowing it and experiencing acute toxicity. [14]

Another study showed that the use of a 0.05% NaF fluoridated mouthwash twice per day post toothbrushing with a fluoridated toothpaste had the highest remineralisation of caries. This suggests that using a fluoridated mouthwash more frequently reduces decay more than using it less frequently, even if used at a higher concentration. The use of a fluoride toothpaste and fluoride mouth rinse in combination reduced decay more than a fluoride toothpaste alone. Using a fluoride mouth rinse twice per day remineralised lesions more than using it once per day. From this data we can conclude that the frequency of use is also important. [15]

Fluoride is incorporated into mouthwash in different forms, such as sodium fluoride, NaF, and amine fluoride, AmF. In regard to root caries, the results of a systematic review showed that using a fluoride mouthwash containing between 225 and 900 ppm F reduced levels of decay in comparison to the use of a

placebo. This was concluded following a reduction in the DMFRS (decayed, missing or filled root surfaces). 38% silver diamine fluoride (SDF) however, had a higher inhibition effect than a fluoride mouth rinse. There is a general controversy across articles on whether fluoride mouthwash prevents caries. The controversy stems from the inability to differentiate between whether the reduction in caries shown is from the dentifrice used in toothbrushing or from the mouthwash itself. Articles conclude that the quality of evidence that supports the usage of fluoride mouthwash to prevent dental caries is low. [16]

This is demonstrated in an article that compared the effects of fluoride mouth rinses to herbal mouth rinses (containing 5mg of the active ingredient Salvadora Persica) and sesame oil pulling. The use of a herbal mouth rinse reduced bacteria and was also proven to be as equally effective as the fluoride mouth rinse in reducing caries. It should be noted that there are various chemical compounds found in the Salvadora persica plant. This includes sodium chloride, calcium oxalate, silica, fluoride, sulphated compounds, Flavonoid, an alkaloid Salvadorin, TrimEthylamine, Benzyl Isothiocyanate, vitamin C and tannic acid. This therefore creates an uncertainty as to which chemical specifically it is contributing to the reduction in caries since fluoride is also a compound found in the plant. However, a herbal mouth rinse providing a reduction in caries even though the main component isn't fluoride raises doubts as to whether we are certain that fluoride is the main component that we can suggest reduces caries. [17]

1.8 FLUORIDE GEL

Fluoride gels are a relatively new treatment with only being in use over the last 30 years. There are various fluoride gels available, with the most frequently used being acidulated phosphate fluoride (APF) with 1.23% (12,300 ppm)

fluoride ion and 2% sodium fluoride (NaF) with 0.90% (9050 ppm) fluoride ion. The procedure of applying a fluoride gel includes placing the gel in a tray and keeping it in the mouth for 4 minutes. Patients can't eat, drink or rinse for 30 minutes post treatment. This allows time for the fluoride to absorb into the teeth and aid in the process of repairing lesions. There is evidence to support that the use of fluoride gel reduces caries incidence in both primary and permanent dentition. Evidence to support the prevention of caries in permanent dentition is regarded stronger than in primary dentition. The use of a fluoride gel is contraindicated in children under the age of 6 due to its high fluoride concentration and the risk of children swallowing it and experiencing side effects. A 2015 updated Cochrane review showed a higher reduction in the DMFS of permanent teeth (28%), than in primary teeth (20%) with the use of fluoride gels. This review shows the correlation between the application of fluoride gels and the decrease in caries in permanent dentition in children. Evidence for the reduction of caries in permanent dentition is considered moderate and considered low for primary dentition due to less available studies. There isn't sufficient evidence to make any conclusions on the risk of negative side effects with the use of fluoride gels. [18]

However, the most frequently noted side effect of fluoride gel application is nausea and vomiting caused by ingesting too much. In order to prevent this occurring, the patient must be seated upright, and the trays shouldn't be filled more than required. The current recommendation is to not fill the trays with more than 40% of their volume. Well-fitted or custom trays should also be used, alongside aspirating with a suction device to prevent ingestion. Younger children may gag or experience discomfort throughout the procedure. The formulation of fluoride gels has a pH level around 3.0 due to studies showing that acidity aids in increasing the fluoride intake by enamel. Evidence shows that the application of fluoride gel is more likely to be of benefit towards people who are at a high risk of caries, including those who aren't exposed to other sources of fluoride such as fluoridated water or aren't consistent with brushing

their teeth daily with a fluoridated toothpaste. The application of fluoride gel is considered low risk for dental fluorosis since it isn't applied frequently by a professional. The frequency of application ranges from 1-4 times a year depending on the individual necessity. [19]

A study compared the efficacy of silver diamine fluoride as a topical fluoride in children aged 6-9 years old to APF gel and fluoride varnish. After the application of all 3 topical fluorides, a 6 month follow up period was conducted and demonstrated that a significant increase in fluoride content was found in the case of SDF compared with Fluoride Varnish and APF Gel. No significant increase in fluoride content was found between Fluoride Varnish and APF Gel. The study concluded that after the application of SDF, the fluoride content in enamel was much higher and maintained at 6 months in comparison to fluoride varnish and APF Gel. The application of SDF was also proven to be more effective in reducing new decay in comparison to fluoride varnish and APF gel however these results were not significant. [20]

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	No treatment/placebo	Fluoride gel				
Changes in caries on the surfaces of permanent teeth, measured by D(M)FS increment - nearest to 3 years	The mean increment ranged across control groups from 0.2 to 11.5, median 1.7	The mean increment in the intervention groups was **0.27** (95% CI 0.18 to 0.37) **lower**	**PF**[1] 28% (95% CI 19% to 36%)	8479 (25 studies)	**moderate** ⊕⊕⊕⊖[2]	
Changes in caries on the surfaces of primary teeth, measured by d(m)fs increment - nearest to 3 years	The mean increment ranged across control groups from 1.8 to 5.1, median 1.8	The mean increment in the intervention groups was **0.52** (95% CI 0.17 to 0.88) **lower**	**PF**[1] 20% (95% CI 1% to 38%)	1254 (3 studies)	**low** ⊕⊕⊖⊖[3]	
Signs of acute toxicity - nausea, vomiting	0 per 1000	**10 per 1000** (10 fewer to 20 more)	**RD**	490 (2 studies)	⊕⊖⊖⊖ **very low**[4,5,]	Risks were calculated from pooled risk differences (RD: 0.01 (95% -0.01, 0.02)

[18]

1.9 FLUORIDE VARNISH

Fluoride varnishes are treatments that are normally applied by a dentist between 2-4 times a year depending on the individual necessity. The advantage of varnishes is that they have the ability to stick to the tooth's surface for prolonged periods of time, releasing fluoride efficiently. The main active ingredient in fluoride varnishes is 5% NaF by weight, or 22,600 ppm fluoride ions. The current composition of most fluoride varnishes are similar and consist of a resin, an alcohol and sodium fluoride. The alcohol is used as a solvent to maintain the varnish as a fluid. Once the varnish is exposed to air, the alcohol evaporates, and the varnish adheres to the surfaces of the teeth. More recently, some varnishes have adapted to add calcium-phosphate compounds to enhance remineralisation. When applying the varnish, it is not obligatory to dry the teeth prior. Wiping the teeth using cotton is considered sufficient. 0.3- 0.75 mL of varnish is applied to the surfaces of the

teeth and patients are advised to avoid eating for 2-4 hours. They are also advised to avoid brushing their teeth the same night of application. An advantage of fluoride varnishes is that it can remain attached to the surface ranging from hours to a few days. They also have the advantage of being an alternative option to fluoride gels for use in patients that gag. Fluoride varnishes work by inhibiting bacteria, fluorapatite formation, increasing remineralisation and decreasing demineralisation. A 2013 Cochrane Library review was conducted to compare how effective fluoride varnishes are in preventing caries in children in comparison to no treatment or a placebo. A review of 13 clinical trials showed a 43% reduction in DMFS was found with the use of fluoride varnish in permanent dentition. 10 clinical trials that evaluated the use of fluoride varnish on primary teeth showed a 37% decrease in the DMFS. It was also found that this benefit seemed to be applicable regardless of several factors including the existing caries they already had, how often they were exposed to fluoride, how frequent the varnish was applied and at what concentration. [21]

Mishra et al conducted a systematic review in 2017 which looked at the relationship between fluoride varnish and the prevention of early childhood caries. It showed that 1% fluoride varnish had a caries preventive fraction of 6.4-30% whereas a 5% fluoride varnish had a caries preventive fraction of 5-63%. [22]

Resin based fissure sealants were compared with fluoride varnishes in a clinical trial to assess which of the two prevents decay more on the occlusal surfaces of first permanent molars in children aged 6-7. The sealants and fluoride varnish were reassessed bi-annually. Every 6 months the fluoride varnish was reapplied whereas the fissure sealants were only reapplied in the cases that it had been lost or was incomplete. The results in the development of new caries were very similar between the two. These results conclude that a fluoride varnish being applied every 6 months prevents occlusal decay to a comparable level produced by resin sealants. [23]

1.10 JUSTIFICATION

Fluoride is the most integral element in preventive dentistry. This literature is being carried out in order to have a more current understanding on how prevalent its use is in today's society to see if the decades of research has come to fruition.

2. OBJECTIVES

2.1 GENERAL OBJECTIVE

- To explore if fluoride is used by individuals in adult age.

2.2 SPECIFIC OBJECTIVES

- To evaluate if people are more likely to be consistent with oral hygiene if they are concerned over the aesthetics of their smile.
- To evaluate if individuals are more or less likely to have good oral hygiene if they smoke cigarettes.

Hypotheses: Individuals will be more consistent with fluoride use and oral hygiene if they are concerned about their smile aesthetic.

3. MATERIALS AND METHODS

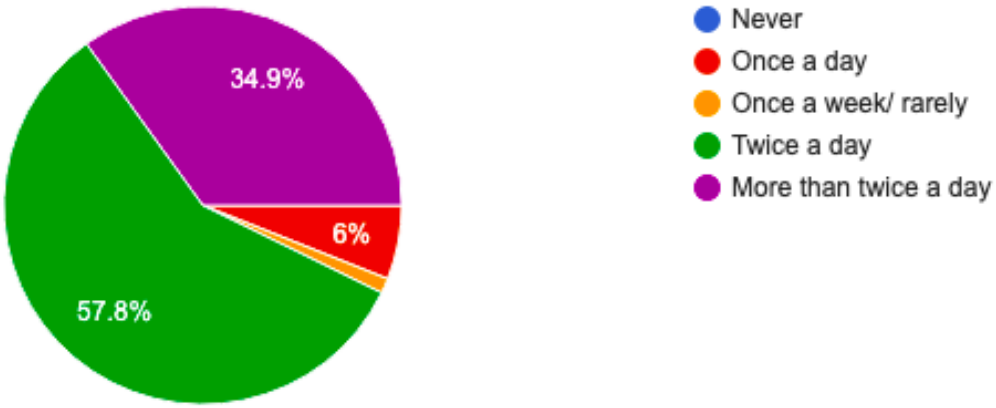
- To conduct the research, I created a survey using the electronic platform google forms. The survey was sent to all genders of varying diverse backgrounds. The age range used was from 18-60 years old. The survey was sent electronically through various online and social media platforms. The respondents gave consent to ensure that the results could be used in the TFG. Respondents remained anonymous and the results were converted into statistics for use in the discussion.
- Questions relating to whether the subject uses fluoride or not, at what concentration, how frequently, if they were concerned about the aesthetics of their smile and other questions pertaining to lifestyle habits such as smoking were included.
- To create the survey 2 questions from another survey were used as inspiration. [24]
- Code required: CIPI/ 23.145
- Code required: OD.047/2223

4. RESULTS

A survey was carried out and had a total of 83 respondents.

The results of each question are as follows:

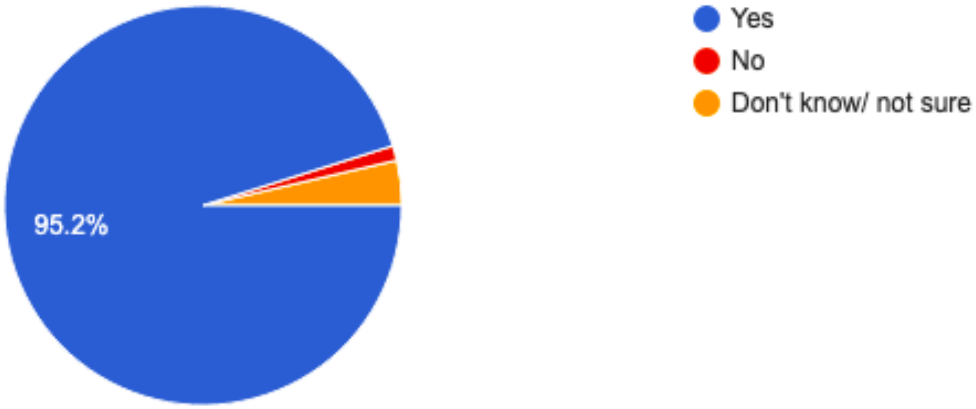
Question 1 was titled ‘How often do you brush your teeth?’



Graphic representation of the responses to question 1.

57.8% of respondents answered twice a day, 34.9% more than twice a day, 6% once a day, and 1.2% responded with once a week/ rarely.

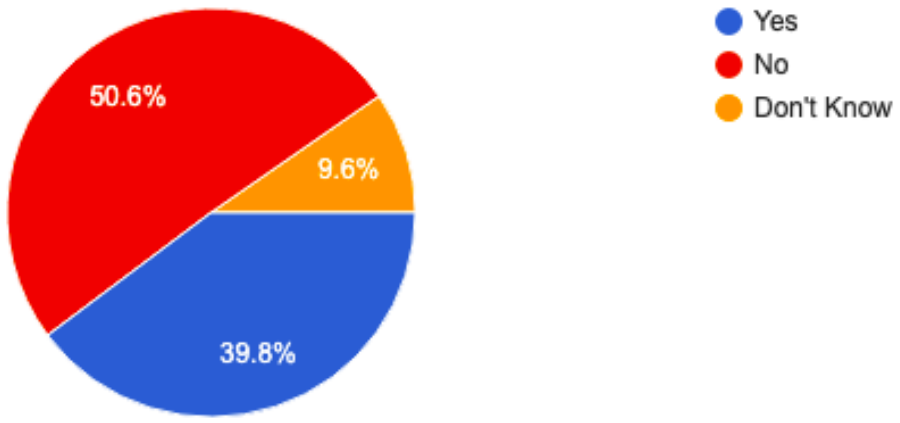
Question 2 was titled ‘Do you use toothpaste containing fluoride?’



Graphic representation of the responses to question 2.

95.2% of respondents answered yes, 3.6% answered they don’t know or are unsure, and 1.2% answered no.

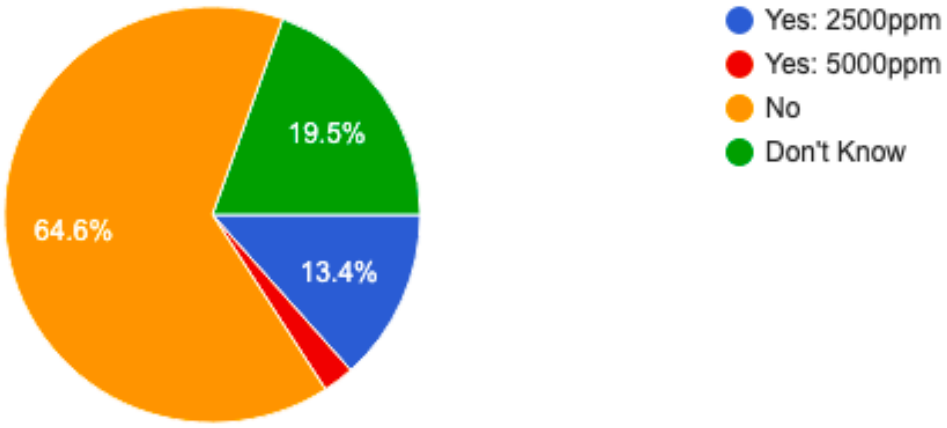
Question 3 was titled ‘Do you use mouthwash containing fluoride?’



Graphic representation of the responses to question 3.

50.6% responded no, 39.8% responded yes, 9.6% responded ‘don’t know’.

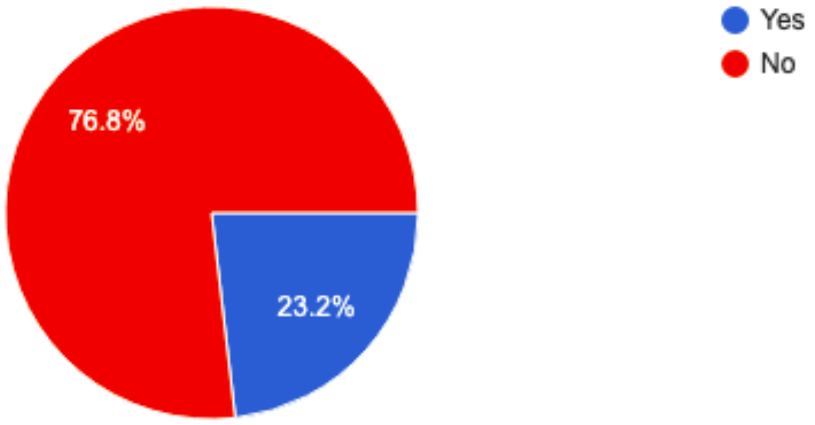
Question 4 was titled ‘Do you use a dental prescribed toothpaste with a higher concentration of fluoride?’



Graphic representation of the responses to question 4.

64.6% of respondents answered no, 19.5% answered they didn't know, 13.4% answered yes to 2500 ppm, 2.4% answered yes to 5000 ppm.

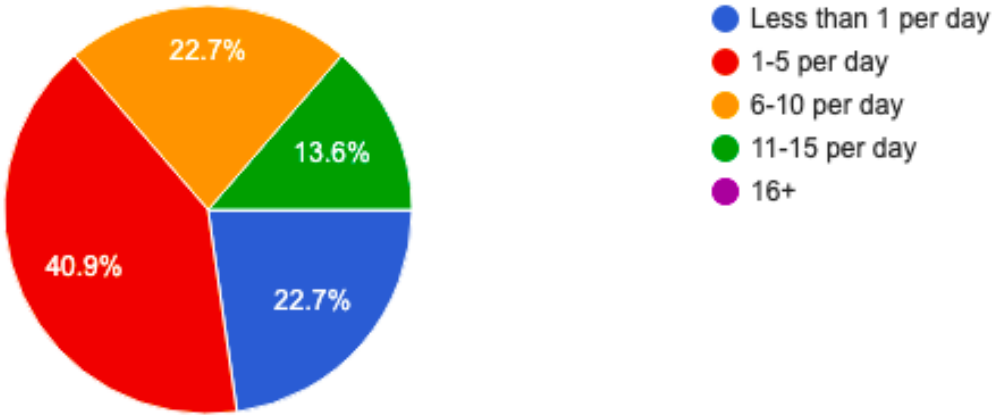
Question 5 was titled ‘Do you smoke cigarettes?



Graphic representation of responses to question 5.

76.8% responded no, 23.2% responded yes.

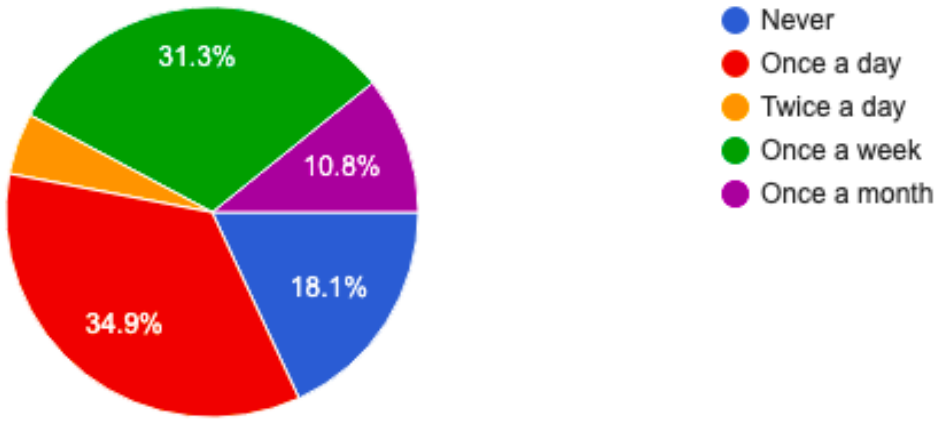
Question 6 was titled ‘If yes, how many cigarettes do you smoke a day?’



Graphic representation of responses to question 6.

40.9% smoke between 1-5 per day, 22.7% smoke less than 1 per day, 22.7% smoke 6-10 per day and 13.6% smoke 11-15 per day.

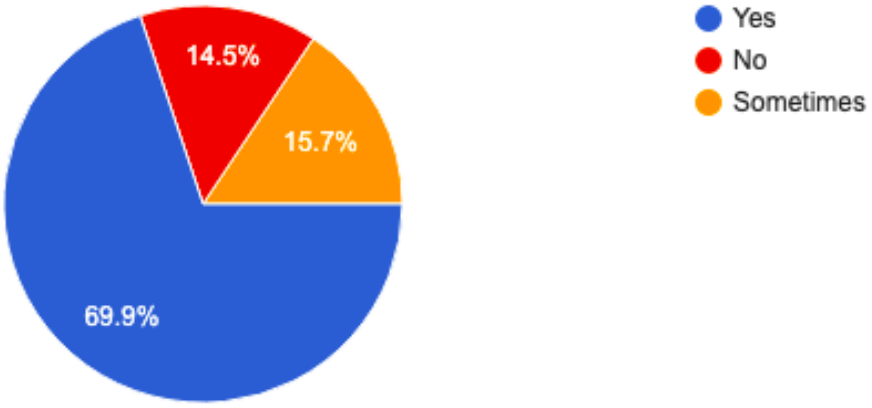
Question 7 was titled ‘How often do you floss?’



Graphic representation of responses to question 7.

34.9% answered once a day, 31.3% answered once a week, 18.1% answered never, 10.8% answered once per month, 4.8% answered twice a day.

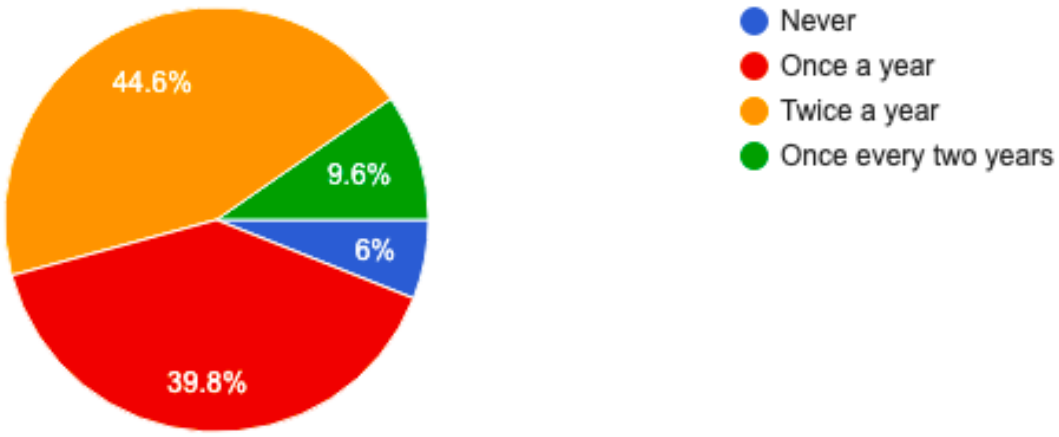
Question 8 was titled ‘Are you concerned over the aesthetics of your smile?’



Graphic representation of responses to question 8.

69.9% answered yes, 15.7% answered sometimes, 14.5% answered no.

Question 9 was titled ‘How often do you visit your dentist?’



Graphic representation of responses to question 9.

44.6% responded with twice a year, 39.8% responded with once a year, 9.6% responded with once every 2 years, 6% responded with never.

5. DISCUSSION

Of the 83 respondents, 92.7% of them brush their teeth at least twice a day. This is in alignment with the current agreed recommendations found by the majority of sources on the frequency of toothbrushing for a healthy mouth. [25]

These results are likely to be higher than those across the average population due to a large proportion of respondents being current dental students. The American Dental Association (ADA) and the NHS, among many other

healthcare systems, recommend brushing teeth twice a day with a fluoridated toothpaste, for 2 minutes.

95.2% of those who brush their teeth use a fluoridated toothpaste, compared to only 1.2% who don't, with the remaining 3.6% unsure if their toothpaste is fluoridated. This shows that most individuals who responded use fluoride at least twice per day and therefore opt for a fluoridated toothpaste as their main choice of toothpaste, with only a minimal percentage actively choosing non-fluoridated. This is a clear display of how integrated fluoride is today into the average individual's daily routine. It can therefore be concluded that amongst those who responded to the survey, fluoride is used as the principal ingredient that acts as prevention against decay. Studies have confirmed that a frequent exposure to fluoride, e.g. tooth brushing twice a day, is more effective in caries prevention than semi-annual topical fluoride treatments. The consensus today is that fluorides mechanism of action in prevention is by enhancing the remineralisation of initial caries defects and by inhibiting the demineralisation that could lead to the progression of caries. [12]

Over 35% of respondents follow up their toothbrushing with a fluoridated mouthwash, showing how widespread the use and combination of different fluoridated products are today. Research suggests that the combination of using a fluoridated toothpaste and fluoride mouth rinse has the highest success rate in reducing decay, compared to using a fluoride toothpaste alone. [15]

15.8% of respondents use a higher prescribed concentration of fluoride in their toothpaste, with the majority using 2500ppm, and a minority using 5000 ppm. Higher concentrations of fluoride usage in toothpaste have proven to be beneficial in the prevention of caries in high-risk individuals in comparison to lower concentrations. An individual is identified as 'high risk' by their clinician. Factors contributing to this could be poor oral hygiene, if an individual is more susceptible to caries due to underlying diseases, smokers etc. A systematic

review of studies showed that the use of a 5000 ppm fluoride toothpaste significantly improves the remineralisation, salivary concentration of fluoride and fluoride retention in plaque. It also modifies caries risk, reduces root caries susceptibility and prevents mineral loss compared to 1450 ppm. [26]

An estimated intake of fluoride from all sources (water, gels, varnishes) must be estimated prior to prescribing a higher concentration. Studies also show that fluoridated toothpaste with over 2500 ppm had a higher preventive effect in coronal caries (37%) compared to toothpaste containing 1100 - 1250 ppm (23%). It also showed that, under net-remineralising conditions, the highest mineral gain was observed for over 2500 ppm F−, and that for highly demineralised lesions, 2500 ppm demonstrated a higher gain in mineral content compared to 1100 ppm. [27]

Respondents who smoke between 1-5 cigarettes a day brush their teeth at least twice per day, with 66.6% brushing more than twice and using a fluoridated mouthwash. This statistic drops lower with individuals who smoke 6-10 per day. 60% of respondents who smoke 6-10 per day brush their teeth twice a day, with 40% brushing only once a day, with one respondent using a 2500 ppm prescribed fluoridated toothpaste. A majority of 80% don’t use a fluoridated mouthwash in this category. Initially these results suggest that oral hygiene care reduces with a higher consumption of cigarettes however this trend is interrupted in the respondents who smoke 11-15 per day. All of the respondents who smoke 11-15 brush their teeth at least twice per day, with 33.3% brushing more than twice per day. 30% of all individuals who use a fluoridated mouthwash were smokers and 40% of all smokers use a fluoridated mouthwash. These results suggest that smokers who smoke between 1-5 today are more likely to maintain better oral hygiene with a combined use of toothpaste and mouthwash compared to those who smoke between 6-10 per day who brush their teeth less on average and have a majority that don’t use mouthwash. Reasoning for this could include that those who smoke less may

have an overall higher concern for their physical and general health compared to those who smoke more and therefore translate that into taking care of their oral hygiene more. Toothbrushing being better on average for those who smoke 11-15 could be explained by the need to compensate for the increased usage of tobacco by taking care of their oral health more. No particular trend could be identified with the frequency of flossing and smokers, this seemed to vary on an individual basis significantly. 100% of smokers who smoke 6-10 responded that they are concerned with the aesthetics of their mouth even though this category had the lowest oral hygiene. Smokers in this survey had comparable levels of oral hygiene to non-smokers, as previously mentioned, this could also be because a majority of respondents are active dental students.

89.6% of those who responded that they brush their teeth more than twice a day answered ‘yes’ or ‘sometimes’ to ‘are you concerned over the aesthetics of your smile?’. This shows a direct correlation that individuals are more likely to brush their teeth more than the recommended amount if they are concerned over the aesthetics of their smile. Respondents may believe that through brushing their teeth more than twice a day they have more potential of achieving or maintaining a more aesthetic smile, however, there has been no evidence to suggest that brushing more than twice a day provides any additional benefit to twice a day. Furthermore, over brushing teeth can lead to abrasion, sensitivity and receding gums, although three times a day is still considered safe. [28]

A total of 44.8% of those who answered ‘yes’ or ‘sometimes’ to ‘are you concerned over the aesthetics of your smile?’ brush their teeth more than twice a day, with the overall majority brushing twice a day. 93.3% of those who use mouthwash in combination with tooth brushing also answered ‘yes’ or ‘sometimes’ to being concerned about the aesthetics of their smile. It can therefore be witnessed that those who are concerned about their smile aesthetics seem to maintain their level of oral hygiene to a higher standard.

6. CONCLUSION

The history of fluoride and its use in preventive dentistry initially derived from the observation that areas with fluoridated water caused children to develop stained teeth that were more resistant to decay. This knowledge allowed fluoride to be integrated into preventive dentistry and used worldwide as the main active ingredient for prevention, whilst using it at concentrations that minimise the potential adverse effects. The main side effect to consider with the use of fluoride is fluorosis. Fluorosis can vary from mild which isn't noticeable to moderate or severe with pitting, staining and brittle incisal edges.

We can definitively conclude that the use of fluoride effectively reduces the risk of decay. 1450 - 1500 ppm fluoride toothpaste reduces decay more compared to toothpaste containing 1000 - 1250 ppm fluoride and non-fluoride toothpastes.

Fluoride can be used in many different forms including dentifrices, gels and varnishes. Gels and varnishes are used at a higher concentration bi-annually to reduce the risk of caries. These conclusions are made based on research that shows the clear reduction in the DMFS/ DMFT index.

There is controversy surrounding the effectiveness of fluoride mouthwashes and whether the effect is from the mouthwash itself or the dentifrices used prior. Further research needs to be conducted in order to differentiate this.

Following the analysis of the survey carried out throughout this TFG, it can be concluded that the use of fluoride has successfully been integrated into preventive dentistry with almost all individuals (over 95%) using a fluoridated toothpaste daily.
Those concerned about the aesthetics of their smile are more likely to brush their teeth more often and use a fluoridated mouthwash post toothbrushing. Those who smoke cigarettes maintain a similar level of oral hygiene to

non-smokers, with the poorest oral hygiene being displayed in those who smoke 6-10 cigarettes per day.

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