THE EFFECT OF AUTOMATED MESSAGING ON THE LEVEL OF ORAL HYGIENE IN ADOLESCENT ORTHODONTIC PATIENTS: A RANDOMIZED CONTROL TRIAL

A Thesis

By

MICHAEL CADEN ROSS

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Phillip M. Campbell
Committee Members,	Larry P. Tadlock
	Peter H. Buschang
	Reginald Taylor
	Terry Rees
Head of Department,	Larry Bellinger

May 2017

Major Subject: Oral Biology

ABSTRACT

Text message reminders have been shown to be effective at increasing oral hygiene compliance, and it has also been shown that increasing the frequency of reminders improves compliance. The purpose of the present study was to determine if automated text messages sent daily to adolescent orthodontic patients were more effective at improving oral hygiene than those receiving weekly reminders.

A double blind, prospective, randomized clinical trial was performed to evaluate the effects of automated messages on oral hygiene. Subjects were recruited from patients undergoing orthodontic treatment at the Texas A&M University College of Dentistry Department of Orthodontics. They were being treated with a variety of fixed full appliances in both arches. Subjects were randomly assigned to either a once a week text message group or a daily text message group. There were 52 females and 27 males who participated in the study. The daily group had significantly greater increases in oral hygiene compliance.

The daily score increases were 52%, 19%, and 21% for the BI, PI, and GI. The weekly score increases were 30%,13% and 14% for the BI, PI, and GI. Adolescents who completed our survey preferred more frequent messages and found that decreasing treatment time was the most effective type of text message received. Daily text messages were more effective at improving oral hygiene than weekly text messages.

ACKNOWLEDGEMENTS

I would like to thank my committee members Dr. Tadlock, Dr. Taylor, Dr. Rees, Dr. Campbell, and Dr. Buschang for their support and guidance throughout the project.

We are all fortunate at the department of orthodontics and thankful for the Gaylord Endowed Chair for providing financial support to this project and other projects.

My co-residents have been an amazing support system throughout the project and I am very grateful for all of their help recruiting patients and support throughout the entire project.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supported by a thesis committee consisting of Drs. Campbell, Buschang, Taylor, and Tadlock of the Department of Orthodontics and Dr. Rees of the Department of Periodontics.

The data analyzed for entire thesis was provided by Dr. Buschang. All other work conducted for the thesis was completed by the student independently.

Funding Sources

Graduate study was supported by a fellowship from Texas A&M University and a dissertation research fellowship for the Robert E. Gaylord Endowed Chair Foundation.

TABLE OF CONTENTS

Page

CHAPTER I

INTRODUCTION AND

LITERATURE REVIEW

An ideal treatment outcome depends on the orthodontists' ability to maintain an optimum level of compliance.[7-9] It is particularly important for patients to be compliant with respect to oral hygiene. Oral hygiene almost always declines in patients with full fixed appliances due to difficulty with brushing and flossing.[10] Adhesively bonded, fixed orthodontic appliances often makes brushing and maintaining good oral hygiene difficult.[11] This leads to increased gingivitis, poor oral hygiene and increases the risk of developing white spot lesions.[11] Studies have shown that there is a rapid decline in oral hygiene after fixed appliances are placed, with some showing improvement in the 5th month and others showing oral hygiene at its lowest point after orthodontic treatment.[10,12] Compliance is particularly important for the teenagers, who are the patients most commonly treated in orthodontics.[10] Teenagers have hobbies, extracurricular activities, busy social schedules, and various family and interpersonal stresses that can make compliance with treatment difficult. Younger patients have been shown to have higher non- attendance rate at clinical services and thus the use of text message reminders maybe more beneficial in this group.[13] Studies on automated messaging systems have shown that these services increase patient compliance.[14] Triggering patients is an

important aspect of the human behavior model used to produce a desired response. To our knowledge, the dental literature has not investigated automated messages as it relates to frequency.

The medical literature has many systematic reviews and meta-analyses on the effectiveness of automated messaging.[1-3]It has also shown that increasing the frequency of automated message increases compliance.[1,4-6] Sending multiple text messages has been shown to improve attendance and reduce no shows across a healthcare setting.[5] A recent systematic review and meta-analysis showed that patients receiving multiple text messages over a given period of time had a 25% improvement in appointment attendance, while those who were sent just one reminder over the same time period improved only 6%.[5] A recent randomized control trial found that sending multiple text reminders can improve adherence in pediatric cataract treatment.[6] Weight loss is another aspect of health care for which increasing the frequency of reminders has been shown to be effective. A randomized control trial by Dinger et al sent automated prompts to patients to increase daily walking for one-week and three-week intervals. Participants who were prompted weekly walked significantly more often than the patients receiving reminders every three weeks.[4]
Another study examined patients receiving reminders during a weight loss program and were prompted in weekly and monthly intervals and found no statistically significant differences between groups.[15]

Text messaging has been shown to be an effective way to influence orthodontic patients.[16] Bowen et al who followed patients for 8 weeks showed that automated weekly text reminders were effective in improving oral hygiene.[16]

Another randomized controlled trial showed that the bleeding index, gingival index, and plaque index all improved in the group that received weekly text messages for 5.44 months.[17] There have been no studies evaluating how the frequency of the automated messages affects patient compliance in orthodontics. Will there be a difference in compliance between patients who receive automated messages once per week versus daily? The medical literature has shown that increasing frequency can have a positive effect on influencing patient behavior.[5,6,18]

The goal of the present study is to analyze how the frequency of reminders affects patient behavior. The primary outcome measure of compliance will be oral hygiene. The potential results of this study are important for clinical orthodontists wanting to maintain excellent treatment outcomes related to oral hygiene in their practice.

Overview

The purpose of this study is to evaluate how text messaging affects compliance by acting as triggers. First, a review of compliance in the orthodontic setting summarizes what important factors have been documented to affect

patient response to treatment. Next, methods for measuring compliance in orthodontics will be evaluated. Oral hygiene has been shown to be an accurate measure of compliance in the orthodontic literature and the rationale for the periodontal tests used in the study are discussed. Accordingly, a review of behavior modification literature gives insight as to how medical professionals have used different methods to initiate behavior change and how text messages are effective modifiers. Finally, studies on automated messages are analyzed and shown how they are effective for measuring compliance and changing patient behavior.

Compliance in Orthodontics

One of the most important factors in reaching an ideal treatment outcome is the orthodontists' ability to maintain an optimum level of compliance.[19] Compliance is a vital aspect of success. Although some appliances and treatment modalities are thought by many to be "non-compliant ", such as the Herbst appliance or utilizing miniscrews for additional anchorage, they are in fact not compliance free. The patient must always maintain good oral hygiene, keep the appliances clean and functioning properly, as well as show up for scheduled appointments. Thus, it is impossible for any procedure related to orthodontics to be deemed totally non-compliant.

Studies have shown that there are two key environments that influence patient compliance.[20] The 'macro environment' that is shaped by the norms that

exist in the patients' social environment, can influence behavior. Behavior changes that are outside the macro environment will not be successful. However, it is possible to change oral health behaviors over a certain period of time. Accordingly, the "micro environment" is inside the orthodontic office and behavior must be managed with patient education. Far too often communication in practices is haphazard, unplanned, and sub-par to garnish a high level of compliance.[20]

Korabik et al (1977) found that one of the main reasons that patients actively seek orthodontic treatment is the expected increase in social and occupational opportunities. Based on these studies, it is apparent that the greater the patient's desire or perception of need for orthodontic treatment, the higher the level of compliance will be. Accordingly, patients who have low self esteem and think poorly of themselves generally show a poor level of compliance.[21] Adherent patients are generally high academic achievers, sociable, involved in social activities, think highly of themselves, take pride in their accomplishments, and are optimistic about their future. Also, cooperative patients are enthusiastic, outgoing, energetic, wholesome, self-controlled, responsible, trusting, determined to do well, hardworking, forthright, and obliging.[22]

How does the term compliance relate to orthodontics? The orthodontist generally treats patients during their adolescent years. During these formative years the clinician is able to utilize growth to his or her advantage. The

limitations of orthodontics tend to increase as patients increase in age due to an eventual slowing down of growth. Long treatment times and the need for compliance can be demanding for an adolescent patient. There are many stresses during the adolescent stage that make compliance with orthodontics more difficult.[23] Many teenagers have hobbies, extracurricular activities, busy social schedules and various family and social stresses that can potentially make compliance with treatment difficult. Patient compliance is needed to correct malocclusions since orthodontic appliances are limited in what they can accomplish on their own. Patient cooperation includes caring for orthodontic appliances, maintaining excellent oral hygiene, and keeping scheduled appointments. Not meeting treatment expectations may result in compromised treatment and increased treatment time.[24]

Nanda et al conducted a perspective study on patient cooperation using 100 adolescent patients.[9] They used patient, parent, and orthodontist questionnaires to assess behavior at three stages of orthodontic treatment. The first was administered at the initiation of treatment and the other two were administered at 6-month intervals. Psychosocial measures from investigators reported in orthodontic patient cooperation included attitudes toward treatment, social desirability, need for approval, and need for achievement. They concluded that the orthodontist's perception of the orthodontist-patient relationship had the strongest association with patient compliance, however none of the variables adequately predicted cooperation during orthodontic treatment.[9]

Compliance rates in orthodontic treatment have been shown to be as low as 50%.[10] There have been many studies showing demographic, psychological, and behavioral factors can be used to predict compliance. Demographic factors include gender, age, and socioeconomic status. Psychosocial and psychological factors include the personality traits; relationships with parents, peers, and doctor; performance in school; and locus of control. The initial orthodontic visit has also been shown to be a positive predictor of compliance.[10]

The difficulty of encouraging patients occurs on a day-to-day basis. Most orthodontists have only limited knowledge concerning the behavioral considerations of compliance. Simple ways of assessing cooperation range from measuring the amount of tooth movement that has occurred, to questioning the parents/child about appliance wear, or even using a timing device inserted onto the appliance. There have been many techniques developed for improving compliance, such as educating the patient, verbal praising of good behavior, establishing a good rapport, using signed contracts, and using immediate rewards.[24] A clinician needs to be adept at predicting compliance at the initial appointment, so that the proper behavior modification strategies can be applied and treatment can progress efficiently and effectively.

The major predictors of patient compliance are patient demographics, interpersonal relationships, perceptions and interests of the patients and the parent, patient's education, maintenance of oral health and appliances, and appointment punctuality.[25] Previous studies have shown that parents have the

biggest influence on children at the initial visit. The child mostly determines compliance and motivation for treatment thereafter. If the child has very high dependency needs, the parental pressure will strongly influence the child. However, if the child has a low dependence on the parent, compliance levels are minimally affected by parental influences.[24] Kreit et al found that children that predominately had orthodontic treatment due to parents wishes were generally adherent, although their own personal perceptions were also found to be important.[23] They also found that most non-adherent patients had poor relationships with their parents. Characteristics of the patient and their family background, such as parental support and supervision are reliable indicators of compliance.[26]

Dorsey and Korabik assessed oral hygiene and attitude toward orthodontic treatment as possible predictors of patient compliance.[27] The positive correlation between hygiene and attitude that was found may have direct bearing on how patients comply with orthodontic treatment. Based on these studies, it is apparent that the greater the patient desire or perception of need for orthodontic treatment, the higher the level of compliance will be.[27]

Gershater et al found that orthodontists can obtain significant cues about conflicts and the family's attitudes toward the child and whether the parents are willing to help the orthodontist motivate the child.[28] Treatment is likely to be compromised if the parents appear to be helpless, frustrated, nagged, tense, hysterical, demanding, or insecure in coping with the child. Maternal influences

have a strong bearing on orthodontic treatment. Albino et al found that increased levels of compliance were related to parental support and belief in the value and effectiveness of orthodontists.[29,30] As with other studies, parental influence decreases as treatment time progresses. Patients' cognitive development has a greater influence in altering compliance later in treatment. Parental beliefs can be important in orthodontic compliance. Hence, assessing the relationships between patient and parent allows the orthodontist to predict future compliance.[31] The initial visit is critical for establishing rapport with the patient and understanding the social dynamic between the child and parent.

Studies show that the interaction between orthodontist and patient is an important factor in establishing compliance. Treating the patient with respect can facilitate an increase in patient compliance.[31]

Appointment punctuality is another major predictor of compliance. Since the parents or guardians usually bring adolescent patients, this aspect of compliance often falls with the parents and not the patient. Delinquency of appointments and punctuality are both parental factors directly influencing compliance. Accordingly, if parental interest is low, the child will be less motivated for appointments and less likely to maintain a high level of compliance throughout treatment.

Mehra et al ranked personality traits that predict behavior highest to lowest: High-self esteem, obedient, accommodating, self-confident, thankful, secure, polite, high academic achiever, self-conscious, and cheerful.[24]

Accordingly, patients who had a low self esteem and thought poorly of themselves generally showed a poor level of compliance.[21] Adherent patients were generally high academic achievers, sociable, involved in social activities, thought highly of themselves, took pride in their accomplishments, and were optimistic about their future. Also, cooperative patients were enthusiastic, outgoing, energetic, wholesome, self-controlled, responsible, trusting, determined to do well, hardworking, forthright, and obliging.[32] Once the clinician understands how to analyze compliance, it is equally important to use successful behavioral methods to improve adherence to orthodontic treatment.

Common methods used by orthodontists to improve patient compliance include verbally praising the patient, educating the patient about the consequence of poor compliance, discussing treatment goals with the patient, educating the patient about proper use of elastics, discussing the results of poor cooperation with the patient, and educating the patient about proper use of headgear. Communication about the need for good compliance during orthodontic treatment is the most important variable.[24] Mehra reported that educating the patient might have a greater impact on compliance than educating the parent. Fields reported that patient compliance could be improved by involving the patients in their own treatment. Educating the patient increases their autonomy, which decreases anxiety and increases compliant behavior.[33] Accordingly, allowing the patient to be a more active participant in treatment

gives the youth a feeling of teamwork, where the doctor and patient are working together to create a great result.[34]

There have been several methods to measure compliance in adolescent patients. However, oral hygiene has been shown in numerous studies to be an accurate and reliable indicator of compliance in orthodontics.[35-37] The bleeding point index, gingival index, and plaque index are reliable tests for compliance.[16]

Oral Hygiene/Periodontal Tests

The plaque-retentive nature of orthodontic appliances increases plaque accumulation at the gingival margin and contributes to the incidence and severity of gingival inflammation.[38-40] Today more attention is directed to the marginal periodontal damage from neglected or improper oral hygiene that not only manifests itself during orthodontic treatment but also continues after appliance removal.[41,42] The appliances usually contribute to periodontal disease in that they collect microorganisms.[35-37]

Patient education in oral hygiene is vital for an orthodontist to be successful.[43] Caries Risk Assessment forms are used to identify patient characteristics that might predispose them to a higher risk of developing white spot lesions (WSL) during treatment. Being in active orthodontic appliances increases the risk for caries for that particular patient.[44] Providing education in oral hygiene should be one of the primary goals of a clinician. Patients often fail to meet the expectations of the clinician, due to lack of motivation provided by

doctor and staff. It is important to discuss tooth brushing and optimal oral health in order for patients to maintain dental health.[45] In Clark's study on oral hygiene programs, he summarizes the benefits of motivation and the impact that it can create. The orthodontist has a responsibility to be concerned about oral health and ensure the patient is educated.[35] The orthodontist must have an internal locus of concern for the patient and Clark goes on to describe the importance of motivation and communication. Dental professionals need to communicate well with their patients and document this at each visit. Specific measures should be created to ensure patients are maintaining a set standard. Orthodontists should offer feedback and show concern for the patient's overall oral health.[35] Having a positive oral health program is an excellent way to enhance compliance in an orthodontic practice.

The behavioral and social sciences have played a role in current methods of increasing compliance in medicine. In Gluch-Scrantons studies, they noted how the technological advances in dentistry and the Internet allow patients to attain higher levels of oral hygiene. Disease prevention and oral health remain the most important considerations in dentistry.[32] Using behavioral and social sciences, have allowed clinicians to provide a positive preventive health method.[45] These health methods include nutritional counseling and oral hygiene instructions.

Ramfjord originally (1959) reported the use of selected teeth (maxillary right first molar, maxillary left central incisor, maxillary left first premolar,

mandibular left first molar, mandibular right central incisor, and mandibular right first premolar) for the evaluation of GI, probing depth, and attachment loss. The use of Ramjford teeth has controversial validity regarding its current use in the periodontal literature. Several studies have indicated that the use of Ramjford teeth underestimates periodontal disease presence and severity and thus the Center for Disease Control (CDC) has recently determined that it will use full mouth periodontal examinations in current and future NHANES studies.[46] Accordingly, Peres et al 2012 found the use of Ramjford teeth caused worse inaccuracy of BOP compared to full mouth evaluation.[47] Conversely, there have been many studies that have supported the use of Ramjford teeth as a reliable indicator to evaluate periodontal health.[18,48-51] For the purpose of this study, like other studies on automated messages[17], oral hygiene is being used as an outcome measure and should be an efficient and reliable way to compare OH among orthodontic patients.[52,53]

Oral hygiene almost always declines when patients are in full fixed appliances due to difficulty with brushing and flossing.[10] Adhesively bonded, fixed orthodontic treatment logically makes brushing and maintaining good oral hygiene difficult.[11] Because this leads to increased gingivitis, patients need to be closely monitored for oral care. Various oral hygiene indices have been used to evaluate the oral health status during orthodontic treatment.[11]

The plaque index has been used in many studies to measure compliance in orthodontic patients. The plaque index, bleeding point index, and gingival

index are good indicators for gingivitis levels for patients in general, and measurements for compliance in oral hygiene.[17] The plaque index is performed by scoring the amount of plaque accumulation on the teeth.[54] Factors like age, gender, socio-economic status, brushing practices, meal habits, type of brackets, types of ligations, and use of mouthwash have all been associated with different levels of plaque accumulation. Patients who brushed their teeth twice or more per day showed significantly less plaque accumulation. Also, subjects with shorter intervals between appointments had less plaque accumulation.[55]

The absence of bleeding on probing is another important periodontal test that has been used to measure compliance. Gingival bleeding tendency has been shown to be an important part of a comprehensive oral examination.[56] The BOP was found to be accurate in assessing periodontal health and a strong indicator of oral hygiene compliance.[57] Gingival bleeding is an objective, easily assessed sign of inflammation.[56] The positive predictive value was only 6 %; however the negative predictive value was 98% showing that the continuous absence of BOP is a reliable predictor of oral health status.[58]

The orthodontist has an important responsibility to help patients become concerned about oral health.[35,59,60] Hypertrophied gingiva is a very common oral health concern found in orthodontic patients during treatment. Zanatta et al concluded that anterior gingival bleeding and excess resin around brackets are associated with higher levels of anterior gingival enlargement for patients in

orthodontic treatment.[61] The gingival index is a common tool used by dentists to measure the inflammation of the gums and assess oral hygiene status.[54,61] Studies have shown that gingival index and bleeding on probing work in tandem when assessing periodontal health and produce similar results when used together in clinical trials.[62]

The literature has shown that compliance is vital to obtain a great orthodontic outcome and oral hygiene is a common tool to measure cooperation during treatment. Accordingly, it is important to understand what has been shown to modify adolescent behavior in order to understand how sending patient reminders can create behavior change and improve oral hygiene.

Behavior Modification

In order to create a successful dental practice, it is important for the dental professional to incorporate the behavioral sciences.[63,64] The outcome of the treatment depends on the dental professional's knowledge and skills and the patient's skills, objectives and expectations.[63,64] Schou et al argues that dentists need knowledge and skills in behavioral management and modification in order to change patient behavior and obtain the best treatment outcomes.[63]

Studies on compliance have not typically utilized behavior models in order to understand how desired outcomes can be reached more reliably. The social psychology literature indicates that it takes 66 days to turn a behavior into an automatic habit.[65] Before that, reminders are needed for short-term behavior

change.[66] As such, a background in social psychology and understanding behavior modification are important for an orthodontist who wants compliant patients. BJ Fogg, a professor at Stanford, developed a behavioral model for persuasive design that is simple and can be applied to orthodontics.[66]

Three things are necessary for a patient to perform a certain behavior, they have to be sufficiently motivated, they have to have the ability to perform the behavior, and they have to be triggered to perform the behavior. Without all three of these basic elements, the desired behavior will not occur.

Ability and motivation are often a trade off. Ability is having the mental power and physical aptitude to perform a task. In orthodontics, to increase ability, we must make tasks simpler. Only focusing on motivating patients will not obtain the desired result, excellent compliance. Ability can be broken down into time, money, physical effort, brain cycles (if you have to think “hard”, it’s not simple), social deviance (if behavior goes against the norm, it is no longer simple), and non-routine (if it’s not routine, it may not be considered simple).

The three main motivators are pleasure/pain, hope/fear, and social acceptance/rejection. Studies have shown that social acceptance is usually the dominating factor for patients seeking orthodontic treatment.[67,68] When motivation and ability are present, often a trigger is all that is required to initiate a response. The use of triggers is often forgotten when trying to induce change; they are a very simple, yet important part of the behavior model.

Today, most of the common daily functions are performed on mobile devices, as such; text message triggers provide excellent ways to induce short-term behavior. Facilitating triggers lets people know that a desired action is easy to do without the use of additional resources. Moreover, a signal as a trigger is simply a reminder.[66]

Culbert et al analyzed biofeedback and how health care providers can provide greater care for their patients by manipulating behavior.[69] Biofeedback techniques are behavioral methods to induce physiological, emotional, and behavioral changes. Manipulating body language is a common biofeedback technique. Pediatric specialists especially will be aided by biofeedback techniques. These techniques can change patient behavior and thoughts, leading to better treatment outcomes and patient satisfaction.

O'Neil et al examined behavior therapy and the techniques that are used to change behavior.[70] They analyzed behavior therapy in psychiatric disorders, depression, and other problems. They showed that recent developments in behavior therapy related to medicine could have a significant effect on treatment outcomes. Modifying body language and varying speech patterns are the commonality amongst behavior therapies. Through various techniques, health professionals can use behavior therapy to increase compliance and patient satisfaction.

Ramsay et al discuss current behavior methods to achieve optimal oral health.[45] Encouraging patients to practice appropriate oral hygiene is a major

goal in the preventive-oriented dental practice. Patients are given a goal when asked to comply with an oral self-care regimen and their task is to regulate their behavior to achieve the objective, excellent oral hygiene. Different principles of self-regulating behavior are analyzed with patients having poor compliance. Tooth brushing behavior is reviewed, methods for providing patient feedback about their oral hygiene is discussed, and components of behavioral regulation of oral hygiene.

Gluch et al analyzed different components of motivation, and motivational concepts.[32] They showed that behavior modification must be initiated in order to increase compliance. Through the learning ladder, patients can progress from unawareness of a behavior to a habit. The learning ladder is a theoretical progression. The learning ladder is a natural progress of becoming aware of current habits and cues in order to progressively change a certain behavior. The habits used in their study were brushing and flossing. At first patients had poor compliance, but through the learning process the patients become more invested and eventually the behavior of brushing and flossing daily becomes a normal daily activity.[32]

With a desire to learn a new habit, goals are set to maintain motivation toward obtaining a desired outcome. Franken contended that goals arise from three components: biological processes, learned processes, and cognitive processes.[71] Goal theory discusses how goals create tension and that people

work towards these goals to alleviate the tension. Depending on the goal, some or all of the components will be needed to elicit behavior change.

Numerous methods have been found to induce behavior change. As technology continually improves, we look to new methods to increase compliance by changing patient behavior. Text messages have been shown to be effective tools to modify behavior.[72]

Automated Messages

Fjeldsoe et al synthesized the current literature pertaining to the effectiveness of text messages for delivering behavior change in a health care setting.[72] The Meta analysis searched for studies published between January 1990 and March 2008. Studies were included in the review if they (1) evaluated an intervention delivered primarily via text messages, (2) assessed change in health behavior using pre-post assessment, and (3) were published in English in a peer-reviewed scientific journal. Fourteen studies were used in the study to compare results. Positive behavior changes were noted in 13 of the 14 studies reviewed. The review concluded that mobile telephone short message service had positive outcomes for short-term behavior change.

Schedlbauer et al systematically reviewed the literature evaluating the efficacy of computerized drug alerts and prompts using EMBASE, CINHAL, MEDLINE, and PsychINFO.[73] Studies on electronic alerts and prompts in clinicians' behavior were selected and categorized by type. Most alerts and

prompts produced improved behaviors and reduced error rates in 23 out of the 27 articles selected. In five papers, the alerts reported a positive impact on clinical and health service management outcomes. They concluded that the studies reviewed showed positive and substantial affects using prompts and alerts.

In another systematic review entitled, “Overview of systematic reviews of the effectiveness of reminders in improving healthcare professional behavior”, Cheung et al combined existing systematic reviews to evaluate the effectiveness of text messages for changing behavior in a clinical setting.[2] Relevant systematic reviews of reminder interventions were identified through searches in MEDLINE, EMBASE, DARE and the Cochrane Library in conjunction with a larger project examining professional behavioral change interventions. They found 35 systematic reviews that met their inclusion criteria and concluded that reminders were effective in improving behavior change in a broad range of settings.

In 2010, Cole-Lewis et al performed a meta-analysis of 17 studies.[3] Only studies using text messages as the primary mode of communication were used. Intervention length ranged from 3-12 months, message frequency was varied, and there were no follow-ups. They reviewed studies utilizing text messaging as the only tool for behavior change and found that eight studies had shown that text messages were effective for changing behavior. They concluded that text

messaging could be an important tool to reduce the global burden on health care by providing effective disease prevention and management support.

Holt et al performed a meta-analysis to investigate the current evidence on how electronically generated reminders effected patient behavior and then selected 42 papers to synthesize.[74] They showed that individually tailored, computer generated reminders generally produce positive but modest effects on clinicians' behavior.[74] Such interventions are inexpensive, widely available, and offer the potential both to improve clinical care and to impact health outcomes.

A systematic review by Fry et al was carried out to investigate how periodic prompts would effect behavior change with diet, weight loss, and physical activity.[1] They found 19 articles with a combined sample size of 15,655 subjects meeting their inclusion criteria. Eleven studies showed that the use of periodic prompts could be effective changing behavior.[1] Also, several articles showed that if prompts were frequent and personal contact with a counselor was added, the result was enhanced. Effectiveness is enhanced if prompts are frequent and personal contact with a counselor is included. These findings can be used to improve interventions that use periodic prompts and will hopefully result in increased effectiveness, positive behavior change, and improved health. They noted that further investigation into the effectiveness of different time intervals between prompts would be highly valuable.

Missed appointments are one of the greatest problems in healthcare, incurring substantial costs to the healthcare system.[75] Short message service

systems are an inexpensive and effective way for investigators to increase attendance at healthcare appointments.[75] Car et al assessed the effects of phone messaging reminders on the attendance of patients at healthcare appointments. A systematic review of four RCTs that included 3,547 participants was conducted. The authors concluded that there was moderate evidence that text messages are an effective way to increase healthcare attendance and that further studies are needed to draw more conclusions.[75]

Guy et al also investigated the use of text messages on increasing appointment attendance.[13] Studies that compared patients receiving and not receiving text messages were reviewed. A meta-analysis was performed to calculate the overall effect on attendance rates. They reviewed 18 articles, including eight RCTs and 10 observational studies, concluding that text message reminders substantially increase compliance and are simple and efficient option for the patient who receives the reminders.[13]

Similarly, Almog et al investigated the use of text messages to help reduce the number of broken healthcare appointments.[76] They compared an automated confirmation system over a 12-month period with centralized and decentralized manual confirmation strategies. The overall no-show rate dropped from 23.42% to 19.17%. Investigators concluded that an automated confirmation system is a cost effective and efficient method for handling no-shows. These messaging systems improve patient relations and compliance and increase overall efficiency.[76]

The medical literature has shown that increasing the frequency of automated message increases compliance.[1,4-6] Sending multiple text messages has been shown to improve attendance and reduce no shows across a healthcare setting.[5] A recent systematic review and meta-analysis showed that patients receiving multiple text messages over a given period of time had a 25% improvement in appointment attendance, while those who were sent just one reminder over the same time period improved only 6%.[5] A recent randomized control trial found that sending multiple text reminders improve adherence in pediatric cataract treatment.[6] Weight loss is another aspect of health care for which increasing the frequency of reminders has been shown to be effective. A randomized control trial by Dinger et al sent automated prompts to patients to increase daily walking for one-week and three-week intervals. Participants who were prompted weekly walked significantly more often than the patients receiving reminders every three weeks.[4]

Zotti et al evaluated the influence of an app-based approach on oral hygiene in orthodontic patients.[77] Eighty patients were randomly divided into either a control group or an experimental group using a mobile phone application. The plaque index, gingival index, white spots, and the presence of caries were recorded in all patients every 3 months during the first year of treatment. Study group patients were enrolled in a chat room-based competition and instructed to share two self-photographs showing their oral hygiene status. The study group had significantly lower scores in all tests compared to the

control group. They found that social technologies were effective at motivating patients and improving compliance in oral hygiene with adolescent patients in orthodontic treatment.[77]

Numerous studies have found that text messaging is an effective way to increase the likelihood that patients will brush their teeth.[16] Bowen et al investigated whether text message reminders had an effect on the oral hygiene of orthodontic patients. The RCT used 50 orthodontic patients assigned to a text message group or control group. Patients were followed through a baseline appointment (T0), received 12 texts up to their 4-week check up (T1), and one text message 8 weeks (T2) thereafter and pictures of the oral cavity were taken at each visit. Plaque was measured by planimetry and the groups were compared. There was a statistically significant difference between T1 and T2 in the text message group. The investigators concluded that automated text message reminders were effective in increasing oral hygiene compliance.[16]

Eppright et al evaluated the use of text message reminders in an orthodontic office.[17] In this prospective RCT, 42 orthodontic patients were assigned to either a text message group or a control group. The text message group received text messages weekly. Oral hygiene compliance was measured using bleeding index, modified gingival index, plaque index. Visual examinations for white spot lesions were also conducted. They were evaluated at baseline (T0), two appointments after baseline (T1), and four appointments after baseline (T2). All the periodontal test scores showed that the text message group had

significantly better hygiene than the control group at T2. In conclusion, a text message reminder system was found to be effective for improving oral hygiene compliance in orthodontics.[17]

CHAPTER II

BACKGROUND

Text messaging has become the primary mode of communication for adolescents and the rates have been increasing substantially.[78] There have been recent studies in the orthodontic literature validating the effectiveness of text messaging.[16,17,77]

Compliance is an important factor in orthodontics that determines the success of treatment. Orthodontists need to improve patient compliance in order to have the best treatment outcomes. Without a certain level of compliance, effective orthodontic treatment is not feasible. There have been numerous studies showing how important, and yet difficult it is for orthodontic patients to maintain good hygiene.

Studies on automated messaging systems have shown that these services increase patient compliance. However, there have been no studies discussing how frequency plays a role in the effectiveness of the automated messages in regards to patient compliance during orthodontic treatment. The medical literature has found that increasing frequency will increase patient compliance in a health care setting. Triggering patients is an important aspect of using the human behavior model to produce a desired response. The application of the results of this study goes beyond hygiene and will show the most effective way to trigger individuals to increase compliance in orthodontics

CHAPTER III

MATERIALS AND METHODS

Subjects

A double blind, prospective, randomized clinical trial was performed to evaluate the effects of automated messages on oral hygiene. Patients were recruited from patients undergoing orthodontic treatment at the Texas A&M University Dental School orthodontic department. They were being treated with a variety of fixed full appliances in both arches. The study was approved by TAMU IRB (approval # 2105-0532-COD-Ext). Parents/patients signed informed consent forms to enroll their child in the study and approved the use of direct messages sent to the child.

Power analyses were performed to determine sample size requirements based on reported estimates of variation.[16,77] Based on an alpha error of 5%, a beta error of 5%, and an effect size of 0.5, it was estimated that 27 patients were needed per group (Figure 1). Due to potential non-participation and dropouts, a total of 80 patients were recruited. To be eligible for the study, patients had to be between the ages of 12 and 17, must have had no significant medical history, had to have been in upper and lower braces for at least 4 weeks, and they must have been able to operate a cellular device with text messaging services. Patients were excluded if they could not speak/read English fluently, had to

spend more than an hour driving to TAMUDS, and were going to complete their treatment within 6 months.

Protocol

One examiner randomized the patients using the simple allocation method provided by Microsoft Excel©. Subjects were randomly assigned to either a once a week text message group or a daily text message group. One subject dropped out. There were 52 females and 27 males who participated in the study. Automated messages were sent using Orthodontext© automated messaging software. The actual texts varied by message content and consisted of three different message types: texts about oral hygiene, shorter treatment time, and motivational texts. Texts reminding about oral hygiene: 1." Don't forget to brush your teeth twice a day!" 2. "Make sure to brush your teeth for at least two minutes!" 3. "Floss your teeth before you go to sleep and remember to hug the teeth with the floss!" 4. "Remember to use mouth rinses when you brush and floss to help the teeth stay extra clean!" Texts about reducing treatment time with good compliance: 5. "If you want your braces off faster…be sure to keep your mouth super clean!" 6. "Your time in braces will be shorter if you keep your mouth very clean!" Texts sent to motivate: 7. "Research shows that a better smile leads to better paying jobs." 8. "Keep taking good care of your teeth and you're going to have a great smile!" Text messages were always sent at the same time, depending on when they best fit into the parents/patients

schedules. That same time was used throughout treatment. At the start of treatment, all subjects received oral hygiene instructions from a standardized video (Bracesquestions.com) on brushing and flossing, and also received an oral hygiene kit.

Follow-Up

Patients were followed for 8.6 weeks on average. Three periodontal indices (Table 1) of oral hygiene were evaluated on two occasions, T1 (baseline) and T2 (final). Ramfjord teeth (maxillary right first molar, maxillary left central incisor, maxillary left first premolar, mandibular left first molar, mandibular right central incisor, and mandibular right first premolar) were used for the periodontal tests.[17] One blinded examiner performed all standardized oral hygiene instructions and periodontal measurements at (T1) baseline and 8-12 weeks later (T2). These time periods were chosen because previous studies consistently used weekly time intervals.[16,17,77] Only the examiner sending the automated messages knew which group subjects had been allocated to. The examiners working with the patients, collecting data and evaluating the data were blinded until the completion of the study. A survey was conducted at the end of the study for qualitative analysis of compliance.

Statistical Analyses

The skewness and kurtosis statistics were used to evaluate the distributions. Since the data were normally distributed, means and standard deviations were used to describe the samples. Due to a initial group difference, analyses of covariance were used to compare between group differences. The Cohen's D effect size used to standardize the difference between two means in order to determine clinical significance.

CHAPTER IV

RESULTS

Initial and Final Values

At T1, there were statistical significant differences in the measures of oral hygiene (Table 2). The plaque index had a statistically significant difference, and no differences for the bleeding index and gingival index. The weekly group had higher scores in all three periodontal tests at the beginning of treatment. The bleeding index, gingival index, and plaque index had a possible total score of 108, 24, and 36 sites. The daily group had 16%, 40%, and 50% of possible sites scored for the BI, GI, and PI. The weekly group had 18%, 43%, and 54% of possible sites scored for the BI, GI, and PI. Overall, the two groups had a statistical significance for the PI, but were generally similar in their percentage scores. There were no statistically significant differences between the maxillary and mandibular teeth on all periodontal tests for both groups. Accordingly, there was no difference in duration between the weekly and daily group.

Daily and Weekly Changes

There were significant differences in the changes between the daily and weekly text message groups (Table 3). The daily group had a significantly greater decrease compared to the weekly group. For both groups, the bleeding index had the greatest decreases from baseline to final. The PI and GI had

similar decreases in both groups. The daily score decreases were 52%, 19%, and 21% for the BI, PI, and GI. The weekly score decreases were 30%,13% and 14% for the BI, PI, and GI. The Cohen's D statistic for the changes of the BI, PI, and GI were .59, .36, and .42.

Preference for Reminders

56 patients chose nightly reminders and 24 chose morning reminders. 75% of the subjects that chose morning reminders wanted a text reminder between 7:00-8:00 AM. 70% of the patients who chose to be reminded at night elected to receive a text message between 7:00PM – 9:00PM.

Sex Differences

There were no significant sex differences for the decreases in the scores of the BI, PI, and GI in both the weekly and daily group (Table 4). The bleeding index had the greatest decrease in both males and females and the GI and PI had similar decreases. The males had a 37%, 16%, and 16% decrease in the BI, PI, and GI. The females had a 38%, 15%, and 18% decrease in the BI, PI, and GI. Similar to group differences for both genders, the bleeding index had the most substantial change among genders.

Periodontal Correlations

All periodontal tests had a moderate correlation between 41-50% between initial and final measurements (Table 5). The correlation was significantly less between the three different periodontal tests ranging from 11-29%. All correlations were significant at the $p<.001$ level.

Absence of BOP

Only 11% of the sites that had no BOP were statistically significant between the daily and weekly group (Table 6). The maxillary anterior teeth had the greatest absence of BOP and the mandibular anterior teeth had the least absence of bleeding on probing.

Survey Results

A survey was conducted using Surveymonkey.com© at the completion of the study. The survey had a 42% response rate from the seventy-nine participants that participated in the randomized control trial. All of the respondents said they read the text messages that were sent. 44% said they always read the messages, the remaining participants said they sometimes or often read the messages. 75% of the respondents said that they would like to change the number of times they were texted. 37% of the participants wanted text reminders twice a day, 20% once a day, 20% 3-4 times a week, and 17% said they preferred weekly text messages. Only one third of the respondents

thought that some text messages were better than others. 97% of patients thought that the text messages had a positive effect on reminding them to brush their teeth. 75% of respondents said there was a time they forgot to brush until the text reminders were received. The most effective text category was the decrease in treatment time; 70% of respondents thought this was the most effective type of text message sent. The motivational text messages were the second most effective and the messages purely about oral hygiene were the least effective. The text messages about decreases in treatment time made the participants want to brush their teeth 75% of the time. The vast majority (97%) of patients found that text reminders helped them understand the importance of brushing. The majority (86%) of participants thought that a prize for good compliance could be motivating for future participants.

CHAPTER V

DISCUSSION

Text Usage

Text messaging has become the primary mode of communication for adolescents and the rates have been increasing substantially.[78] Teens are connected with media at any location and at all times with their mobile devices.[78] 88% of teens have access to cell phones and of those 91% use text messages on a daily basis.[79] The average adolescent sends 100 texts per day, which has grown substantially from the 2009 average of 60 texts per day.[79,80] The usage of cell phones by adolescents is astounding and has become an integral component of basic communication.[79] Kormendi et al studied 263 youths in primary and secondary education and found an average smart phone usage of 4.65 hours per day.[81,82] Communication between adolescents is growing increasingly immediate and brief.[83,84] Adolescents are heavily influenced through smart phones and the immediacy of communication.[83,84] The impact of cell phone usage and changing communication trends in adolescents make text message reminders an effective way to influence behavior. There have been recent studies in the orthodontic literature validating the effectiveness of text messaging.[16,17,77]

Text Messages Improving Hygiene

Text message reminders improve oral hygiene during orthodontic treatment. Patients' oral hygiene in the present study had statistically significant decrease in all oral hygiene tests. The BI, PI, GI decreased 30%, 13%, and 14% in the weekly text message group. Other studies have also shown statistically significant differences in the same indices between patients using text message reminders.[16,17] Eppright et al. showed score decreases of 34%, 56%, and 31% for BI, PI, and GI, respectively Bowen et al showed a 31% reduction in the PI using planimetry. Differences between these studies and the present study may be due to longer durations of the previous studies. Having longer study duration allows for additional motivation of study participants and can potentially increase compliance utilizing the Hawthorne effect.[7] These studies also differ from the present study by sending the text reminders to the parent rather than the patient. This could play a role because parents are often more motivated than their children to have orthodontic treatment, especially when they were already in treatment.[85] Almost all (97%) of patients in the present study thought that text messages had a positive effect on reminding them to brush their teeth.

Oral Hygiene in Orthodontics

The improvements in oral hygiene with text message is important because once orthodontic appliances are placed, it is difficult for patients to maintain optimal oral hygiene.[40,55,86] This is why oral hygiene almost always declines when patients are in full fixed appliances, due to difficulty with brushing and flossing.[10,11,23,40] One study shows a rapid decline in oral hygiene after fixed appliances were placed, with some showing improvement after the 5th month[10]; other studies show that decreases throughout treatment.[12,23,38] Because poor oral hygiene increases gingivitis, patients need to be closely monitored for oral care. Text messages offer an efficient way to make patients more aware of caring for their teeth.

Frequency of Texts

The more frequent that the patients received text messages, the greater the improvement in oral hygiene. Patients receiving automated messages daily had greater improvement in oral hygiene. In the present study, the daily group had significantly greater decreases than the weekly group. The decreases in BI, PI, and GI were 22%, 6%, and 7% greater than the weekly group. No other current orthodontic studies have compared weekly and daily text messages. The increased perceived communication of the daily group with more frequent texts might have increased their compliance. Daily text message reminders have been found to increase compliance in the health care setting.[87] In the medical

literature, daily messages make up 36% of all automated messaging frequencies based on systematic review.[87] Communication between adolescents is growing increasingly immediate and brief, showing a preferential trend for more frequent communication.[83,84] Texting has been shown to be a good form of maintaining communication with adolescents, by showing them that the doctor is still involved and care about their treatment during long intervals.[88] Daily text messaging is a constant reminder that the doctor is involved in the treatment. Increases in communication help strengthen the doctor-patient relationship, which is shown to increase compliance.[24] Increasing the frequency of text messages, improves doctor-patient relationships and compliance with oral hygiene by increasing communication.[9,88,89]

Adolescent Communication Preferences

The present study and current literature found that adolescents prefer more frequent communication. The patients in the present study were motivated by shorter treatment times and preferred more frequent text messages. The overall trend in this study is that patients would rather be reminded more often than less. Adolescents need additional motivation in order to be complaint with treatment and constant text message reminders are one method to improve compliance.[16] In the present study, adolescents thought that increasing frequency would have a positive effect on their oral hygiene.

Medical Literature on Text Messages

The medical literature has many systematic reviews and meta-analyses on the effectiveness of automated messaging.[1-3]It has also shown that increasing the frequency of automated message increases compliance.[1,4-6] Sending multiple text messages has been shown to improve attendance and reduce no shows across a healthcare setting.[5] A recent systematic review and meta-analysis showed that patients receiving multiple text messages over a given period of time had a 25% improvement in appointment attendance, while those who were sent just one reminder over the same time period improved only 6%.[5] A recent randomized control trial found that sending multiple text reminders can improve adherence in pediatric cataract treatment.[6] Weight loss is another aspect of health care for which increasing the frequency of reminders has been shown to be effective. A randomized control trial by Dinger et al sent automated prompts to patients to increase daily walking for one-week and three-week intervals. Participants who were prompted weekly walked significantly more often than the patients receiving reminders every three weeks.[4]
Another study examined patients receiving reminders during a weight loss program and were prompted in weekly and monthly intervals and found no statistically significant differences between groups.[15]

Sex Differences

There were no significant sex differences in oral hygiene. While males had higher scores initially, differences in the present study were inconsistent and less than 2%. Other studies using oral hygiene indices with patients in fixed orthodontic appliances, like the present study, found no differences between genders at baseline.[16,17,77] Fixed orthodontic appliances seem to normalize oral hygiene between gender. Female adolescents not in orthodontic appliances have been shown to have better oral hygiene habits than males, show more interest in oral health, and perceive their own oral health to be good to a higher degree than males.[90-93] Hoshang et al showed that female patients brushed twice and sometimes thrice as often as their male counterparts and had more oral hygiene awareness. The current literature concludes that female adolescents are more compliant than males with regard to oral hygiene.[90-93] In the present study, there were almost twice as many females than males. A larger female population could potentially have made the study more effective because female adolescents are more active on their cell phones and send more text messages daily than males.[79,81,82]

Periodontal Indices

Patients receiving automated reminders had a decrease in bleeding index, gingival index, and plaque index during orthodontic treatment. The plaque index scores for the daily group and weekly group were significantly

different at the beginning of the study; the gingival index and bleeding index were not statistically significant. The bleeding index had a greater decrease in both groups compared to the gingival index and plaque index. The bleeding index having the greatest decrease in this particular study is more than likely by chance alone. Direct comparisons to other studies are difficult because methods in the present study were considerably different. Establishing clinical significance based on periodontal indices is subjective. However, the Cohen's D statistic has been shown to correlate effect size and clinical significance. The Cohen's D statistic for BOP and GI showed a moderate effect, and the PI showed a small effect. There have been systematic reviews evaluating multiple RCTs using the indices used in this study in the Cochrane library and they conclude that clinical significance is unknown and unclear.[94,95]

Ramfjord Teeth

Ramfjord originally (1959) reported the use of selected teeth (maxillary right first molar, maxillary left central incisor, maxillary left first premolar, mandibular left first molar, mandibular right central incisor, and mandibular right first premolar) for the evaluation of GI, probing depth, and attachment loss. The use of Ramjford teeth has controversial validity regarding its current use in the periodontal literature. Several studies have indicated that the use of Ramjford teeth underestimates periodontal disease presence and severity and thus the Center for Disease Control (CDC) has recently determined that it will use full

mouth periodontal examinations in current and future NHANES studies.[46] Accordingly, Peres et al 2012 found the use of Ramjford teeth caused worse inaccuracy of BOP compared to full mouth evaluation.[47] Conversely, there have been many studies that have supported the use of Ramjford teeth as a reliable indicator to evaluate periodontal health.[18,48-51] For the purpose of this study, like other studies on automated messages[17], oral hygiene is being used as an outcome measure and should be an efficient and reliable way to compare OH among orthodontic patients.[52,53]

Decreased Treatment Time

Adolescents who completed our survey found that decreasing treatment time was the most effect type of text message received. The most effective text category was the decrease in treatment time; 70% of respondents thought this was the most effective type of text message sent. Our present study is in agreement with current literature that a shorter treatment time is one of the most important motivators for patients in braces (Richter, Kreit, Albino).[23,29-31] This is important because it verifies that a patient's chief concern during orthodontic treatment is treatment time and not necessarily maintaining excellent hygiene. Future studies need to analyze how the content of text messages affect patient behavior.

CHAPTER VI

CONCLUSIONS

1. Text messaging is an effective and simple way to improve oral hygiene in the adolescent patient while in fixed orthodontic appliances.
2. Daily text messages were more effective at improving oral hygiene than weekly text messages.
3. In our survey, adolescent patients preferred higher frequency text messages and are motivated by a decrease in treatment time in fixed appliances.
4. Future studies analyzing the content of text messages and different frequencies of messages would be beneficial to the clinical orthodontist to learn the best way to influence behavior.

REFERENCES

1. Fry JP, Neff RA. Periodic Prompts and Reminders in Health Promotion and Health Behavior Interventions: Systematic Review. *Journal of Medical Internet Research.* 2009;11(2).

2. Cheung A, Weir M, Mayhew A, Kozloff N, Brown K, Grimshaw J. Overview of systematic reviews of the effectiveness of reminders in improving healthcare professional behavior. *Systematic reviews.* 2012;1:36.

3. Cole-Lewis H, Kershaw T. Text messaging as a tool for behavior change in disease prevention and management. *Epidemiologic Reviews.* 2010;32:56-69.

4. Dinger MK, Heesch KC, McClary KR. Feasibility of a minimal contact intervention to promote walking among insufficiently active women. *American Journal of Health Promotion : AJHP.* 2005;20(1):2-6.

5. Robotham D, Satkunanathan S, Reynolds J, Stahl D, Wykes T. Using digital notifications to improve attendance in clinic: systematic review and meta-analysis. *BMJ open.* 2016;6(10):e012116.

6. Lin H, Chen W, Luo L, et al. Effectiveness of a short message reminder in increasing compliance with pediatric cataract treatment: a randomized trial. *Ophthalmology.* 2012;119(12):2463-2470.

7. Feil PH, Grauer JS, Gadbury-Amyot CC, Kula K, McCunniff MD. Intentional use of the Hawthorne effect to improve oral hygiene compliance in orthodontic patients. *Journal of Dental Education.* 2002;66(10):1129-1135.

8. Maj G, Grilli AT, Belletti MF. Psychologic appraisal of children facing orthodontic treatment. *American Journal of Orthodontics.* 1967;53(11):849-857.

9. Nanda RS, Kierl MJ. Prediction of cooperation in orthodontic treatment. *American Journal of Orthodontics and Dentofacial Orthopedics.* 1992;102(1):15-21.

10. Al-Jewair TS, Suri S, Tompson BD. Predictors of adolescent compliance with oral hygiene instructions during two-arch multibracket fixed orthodontic treatment. *The Angle Orthodontist.* 2011;81(3):525-531.

11. Beberhold K, Sachse-Kulp A, Schwestka-Polly R, Hornecker E, Ziebolz D. The Orthodontic Plaque Index: an oral hygiene index for patients with multibracket appliances. *Orthodontics :Tthe Art and Practice of Dentofacial Enhancement.* 2012;13(1):94-99.

12. Cantekin K, Celikoglu M, Karadas M, Yildirim H, Erdem A. Effects of orthodontic treatment with fixed appliances on oral health status: A comprehensive study. *Journal of Dental Sciences.*6(4):235-238.

13. Guy R, Hocking J, Wand H, Stott S, Ali H, Kaldor J. How effective are short message service reminders at increasing clinic attendance? A meta-analysis and systematic review. *Health Services Research.* 2012;47(2):614-632.

14. Austin SM, Balas EA, Mitchell JA, Ewigman BG. Effect of physician reminders on preventive care: meta-analysis of randomized clinical trials. *Proceedings / the ... Annual Symposium on Computer Application [sic] in Medical Care. Symposium on Computer Applications in Medical Care.* 1994:121-124.

15. Svetkey LP, Stevens VJ, Brantley PJ, et al. Comparison of strategies for sustaining weight loss: the weight loss maintenance randomized controlled trial. *Jama.* 2008;299(10):1139-1148.

16. Bowen TB, Rinchuse DJ, Zullo T, DeMaria ME. The influence of text messaging on oral hygiene effectiveness. *The Angle Orthodontist.* 2014.

17. Eppright M, Shroff B, Best AM, Barcoma E, Lindauer SJ. Influence of active reminders on oral hygiene compliance in orthodontic patients. *The Angle Orthodontist.* 2014;84(2):208-213.

18. Ding F, Lyu Y, Han X, et al. Detection of periodontal pathogens in the patients with aortic aneurysm. *Chinese Medical Journal.* 2014;127(23):4114-4118.

20. Blinkhorn AS. Factors affecting the compliance of patients with preventive dental regimens. *International Dental Journal.* 1993;43(3 Suppl 1):294-298.

21. Cucalon A, 3rd, Smith RJ. Relationship between compliance by adolescent orthodontic patients and performance on psychological tests. *The Angle Orthodontist.* 1990;60(2):107-114.

22. Allan TK, Hodgson EW. The use of personality measurements as a determinant of patient cooperation in an orthodontic practice. *American Journal of Orthodontics.* 1968;54(6):433-440.

23. Kreit LH, Burstone C, Delman L. Patient cooperation in orthodontic treatment. *The Journal of the American College of Dentists.* 1968;35(4):327-332.

24. Mehra T, Nanda RS, Sinha PK. Orthodontists' assessment and management of patient compliance. *The Angle Orthodontist.* 1998;68(2):115-122.

25. Rubin RM. Recognition and empowerment: an effective approach to enlisting patient cooperation. *Journal of Clinical Orthodontics : JCO.* 1995;29(1):24-26.

26. Bartsch A, Witt E, Sahm G, Schneider S. Correlates of objective patient compliance with removable appliance wear. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 1993;104(4):378-386.

27. Dorsey J, Korabik K. Social and psychological motivations for orthodontic treatment. *American Journal of Orthodontics.*72(4):460.

28. M. G. The psychological dimension in orthodontic diagnosis and treatment. *American Journal of Orthodontics.* 1968(54):327-338.

29. Albino JE, Cunat JJ, Fox RN, Lewis EA, Slakter MJ, Tedesco LA. Variables discriminating individuals who seek orthodontic treatment. *Journal of Dental Research.* 1981;60(9):1661-1667.

30. Albino JE, Lawrence SD, Lopes CE, Nash LB, Tedesco LA. Cooperation of adolescents in orthodontic treatment. *Journal of Behavioral Medicine.* 1991;14(1):53-70.

31. Richter DD, Nanda RS, Sinha PK, Smith DW, Currier GF. Effect of behavior modification on patient compliance in orthodontics. *The Angle Orthodontist.* 1998;68(2):123-132.

32. Gluch-Scranton J. Motivational strategies in dental hygiene care. *Seminars in Dental Hygiene.* 1991;3(1):1-4, 6-8.

33. Fields RS. Influencing patient cooperation. *Journal of Clinical Orthodontics : JCO.* 1980;14(6):417-421.

34. Veeroo HJ, Cunningham SJ, Newton JT, Travess HC. Motivation and compliance with intraoral elastics. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 2014;146(1):33-39.

35. Clark JR. Oral hygiene in the orthodontic practice: Motivation, responsibilities, and concepts. *American Journal of Orthodontics.* 1976;69(1):72-82.

36. Chapman JA, Roberts WE, Eckert GJ, Kula KS, Gonzalez-Cabezas C. Risk factors for incidence and severity of white spot lesions during treatment with fixed orthodontic appliances. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 2010;138(2):188-194.

37. Sadowsky C, BeGole EA. Long-term effects of orthodontic treatment on periodontal health. *American Journal of Orthodontics.* 1981;80(2):156-172.

38. Yeung SC, Howell S, Fahey P. Oral hygiene program for orthodontic patients. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 1989;96(3):208-213.

39. Baka ZM, Basciftci FA, Arslan U. Effects of 2 bracket and ligation types on plaque retention: a quantitative microbiologic analysis with real-time polymerase chain reaction. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 2013;144(2):260-267.

40. Martignon S, Ekstrand KR, Lemos MI, Lozano MP, Higuera C. Plaque, caries level and oral hygiene habits in young patients receiving orthodontic treatment. *Community Dental Health.* 2010;27(3):133-138.

41. Schwaninger B, Vickers-Schwaninger N. Developing an effective oral hygiene program for the orthodontic patient: review, rationale, and recommendations. *American Journal of Orthodontics.* 1979;75(4):447-452.

42. Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *Journal of the American Dental Association (1939).* 1962;65:26-29.

43. Tufekci E, Dixon JS, Gunsolley JC, Lindauer SJ. Prevalence of white spot lesions during orthodontic treatment with fixed appliances. *The Angle Orthodontist.* 2011;81(2):206-210.

44. Saxton CA, van der Ouderaa FJ. The effect of a dentifrice containing zinc citrate and Triclosan on developing gingivitis. *Journal of Periodontal Research.* 1989;24(1):75-80.

45. Ramsay DS. Patient compliance with oral hygiene regimens: a behavioural self-regulation analysis with implications for technology. *International Dental Journal.* 2000;Suppl Creating A Successful:304-311.

46. Eke PI, Wei L, Thornton-Evans GO, et al. Risk Indicators for Periodontitis in US Adults: NHANES 2009 to 2012. *Journal of Periodontology.* 2016;87(10):1174-1185.

47. Peres MA, Peres KG, Cascaes AM, et al. Validity of partial protocols to assess the prevalence of periodontal outcomes and associated sociodemographic and behavior factors in adolescents and young adults. *Journal of Periodontology.* 2012;83(3):369-378.

48. Amran AG, Alhajj MN, Al-Rafik NA. Evaluation of Gingival Health Status among 6- and 12-years-old Children in Dhamar City, Yemen: A Cross-sectional Study. *The Journal of Contemporary Dental Practice.* 2016;17(6):440-444.

49. Levin L, Margvelashvili V, Bilder L, Kalandadze M, Tsintsadze N, Machtei EE. Periodontal status among adolescents in Georgia. A pathfinder study. *PeerJ.* 2013;1:e137.

50. Al-Haddad KA, Ibrahim YT, Al-Haddad AM, Al-Hebshi NN. Assessment of Gingival Health Status among 5- and 12-Year-Old Children in Yemen: A Cross-Sectional Study. *ISRN dentistry.* 2013;2013:352621.

51. Relvas M, Diz P, Seoane J, Tomas I. Oral Health Scales: design of an oral health scale of infectious potential. *Medicina Oral, Patologia Oral y Cirugia Bucal.* 2013;18(4):e664-670.

52. Najah A. The usefulness of Ramfjord teeth to represent the full-mouth pocket depth in epidemiological study
MDJ. 2010;7(2):272-275.

53. Mumghamba EG, Pitiphat W, Matee MI, Simon E, Merchant AT. The usefulness of using Ramfjord teeth in predicting periodontal status of a Tanzanian adult population. *Journal of Clinical Periodontology.* 2004;31(1):16-18.

54. Loe H. The Gingival Index, the Plaque Index and the Retention Index Systems. *Journal of Periodontology.* 1967;38(6):Suppl:610-616.

55. Islam ZU, Shaikh A, Fida M. Plaque index in multi-bracket fixed appliances. *Journal of the College of Physicians and Surgeons--Pakistan : JCPSP.* 2014;24(11):791-795.

56. Newbrun E. Indices to measure gingival bleeding. *Journal of Periodontology.* 1996;67(6):555-561.

57. de Souza PH, de Toledo BE, Rapp GE, Zuza EP, Neto CB, Mendes AJ. Reliability of bleeding and non-bleeding on probing to gingival histological features. *Journal of the International Academy of Periodontology.* 2003;5(3):71-76.

58. Lang NP, Adler R, Joss A, Nyman S. Absence of bleeding on probing. An indicator of periodontal stability. *Journal of Clinical Periodontology.* 1990;17(10):714-721.

59. Zachrisson BU. Oral hygiene for orthodontic patients: current concepts and practical advice. *American Journal of Orthodontics.* 1974;66(5):487-497.

60. Zachrisson BU, Zachrisson S. Caries incidence and oral hygiene during orthodontic treatment. *Scandinavian Journal of Dental Research.* 1971;79(6):394-401.

61. Zanatta FB, Ardenghi TM, Antoniazzi RP, Pinto TM, Rosing CK. Association between gingivitis and anterior gingival enlargement in subjects undergoing fixed orthodontic treatment. *Dental Press Journal of Orthodontics.* 2014;19(3):59-66.

62. Barnett ML. Suitability of gingival indices for use in therapeutic trials. Is bleeding a sine qua non? *Journal of Clinical Periodontology.* 1996;23(6):582-586.

63. Schou L. The relevance of behavioural sciences in dental practice. *International dental journal.* 2000;Suppl Creating A Successful:324-332.

64. Milgrom P, Vignehsa H, Weinstein P. Adolescent dental fear and control: prevalence and theoretical implications. *Behaviour Research and Therapy.* 1992;30(4):367-373.

65. Gardner B, Lally P, Wardle J. Making health habitual: the psychology of 'habit-formation' and general practice. *The British Journal of General Practice.* 2012;62(605):664-666.

66. B.J. F. A Behavor model for Persuasive Design. 2009; bjfogg.com/fbm_files/page4_1.pdf.

67. Feu D, Oliveira BH, Celeste RK, Miguel JA. Influence of orthodontic treatment on adolescents' self-perceptions of esthetics. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 2012;141(6):743-750.

68. Lewit D VK. Conformity and inpendence in adolescents motivation for orthodontic treatment. *Child Dev.* 1968;38:1189-1200.

69. Culbert TP, Kajander RL, Reaney JB. Biofeedback with children and adolescents: clinical observations and patient perspectives. *Journal of Developmental and Behavioral Pediatrics : JDBP.* 1996;17(5):342-350.

70. O'Neill GW, Gardner R, Jr. Behavior therapy: an overview. *Hospital & Community Psychiatry.* 1983;34(8):709-715.

71. Franken RE. *Human Motivation.2002. 5th edition. Belmont, CA: Brooks/Cole.*

72. Fjeldsoe BS, Marshall AL, Miller YD. Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventive Medicine.* 2009;36(2):165-173.

73. Schedlbauer A, Prasad V, Mulvaney C, et al. What evidence supports the use of computerized alerts and prompts to improve clinicians' prescribing behavior? *Journal of the American Medical Informatics Association : JAMIA.* 2009;16(4):531-538.

74. Holt TA, Thorogood M, Griffiths F. Changing clinical practice through patient specific reminders available at the time of the clinical encounter: systematic review and meta-analysis. *Journal of General Internal Medicine.* 2012;27(8):974-984.

75. Car J, Gurol-Urganci I, de Jongh T, Vodopivec-Jamsek V, Atun R. Mobile phone messaging reminders for attendance at healthcare appointments. *The Cochrane Database of Systematic Reviews.* 2012;7:Cd007458.

76. Almog DM, Devries JA, Borrelli JA, Kopycka-Kedzierawski DT. The reduction of broken appointment rates through an automated appointment confirmation system. *Journal of Dental Education.* 2003;67(9):1016-1022.

77. Zotti F, Dalessandri D, Salgarello S, et al. Usefulness of an app in improving oral hygiene compliance in adolescent orthodontic patients. *The Angle Orthodontist.* 2015.

78. Adams SK, Daly JF, Williford DN. Adolescent Sleep and Cellular Phone Use: Recent Trends and Implications for Research. *Health Services Insights.* 2013;6:99-103.

79. Lenhrt A. *Teens, Social Media and Technology Overview 2015.* april 9 2015 2015.

80. Adams SK, Daly JF, Williford DN. Adolescent sleep and cellular phone use: recent trends and implications for research. *Health Serv Insights.* 2013;6:99-103.

81. Kormendi A. [Smartphone usage among adolescents]. *Psychiatria Hungarica : A Magyar Pszichiatriai Tarsasag tudomanyos folyoirata.* 2015;30(3):297-302.

82. Kormendi A, Brutoczki Z, Vegh BP, Szekely R. Smartphone use can be addictive? A case report. *Journal of Behavioral Addictions.* 2016;5(3):548-552.

83. Mas FG, Plass J, Kane WM, Papenfuss RL. Health education and multimedia learning: connecting theory and practice (Part 2). *Health Promotion Practice.* 2003;4(4):464-469.

84. Mas FG, Plass J, Kane WM, Papenfuss RL. Health education and multimedia learning: educational psychology and health behavior theory (Part 1). *Health Promotion Practice.* 2003;4(3):288-292.

85. Daniels AS, Seacat JD, Inglehart MR. Orthodontic treatment motivation and cooperation: A cross-sectional analysis of adolescent patients' and parents' responses. *American Journal of Orthodontics and Dentofacial Orthopedics.* 2009;136(6):780-787.

86. Boke F, Gazioglu C, Akkaya S, Akkaya M. Relationship between orthodontic treatment and gingival health: A retrospective study. *European Journal of Dentistry.* 2014;8(3):373-380.

87. Wang K, Wang C, Xi L, et al. A randomized controlled trial to assess adherence to allergic rhinitis treatment following a daily short message service (SMS) via the mobile phone. *International Archives of Allergy and Immunology.* 2014;163(1):51-58.

88. Sinha PK, Nanda RS, McNeil DW. Perceived orthodontist behaviors that predict patient satisfaction, orthodontist-patient relationship, and patient adherence in orthodontic treatment. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics.* 1996;110(4):370-377.

89. Keles F, Bos A. Satisfaction with orthodontic treatment. *The Angle Orthodontist.* 2013;83(3):507-511.

90. Calderon SJ, Mallory C. A systematic review of oral health behavior research in american adolescents. *The Journal of school nursing : the official publication of the National Association of School Nurses.* 2014;30(6):396-403.

91. Östberg A-L, Halling A, Lindblad U. Gender differences in knowledge, attitude, behavior and perceived oral health among adolescents. *Acta Odontologica Scandinavica.* 1999;57(4):231-236.

92. Kawamura M, Takase N, Sasahara H, Okada M. Teenagers' oral health attitudes and behavior in Japan: comparison by sex and age group. *Journal of Oral Science.* 2008;50(2):167-174.

93. Addy M, Dummer PM, Hunter ML, Kingdon A, Shaw WC. The effect of toothbrushing frequency, toothbrushing hand, sex and social class on the

incidence of plaque, gingivitis and pocketing in adolescents: a longitudinal cohort study. *Community Dental Health.* 1990;7(3):237-247.

94. Deery C, Heanue M, Deacon S, et al. The effectiveness of manual versus powered toothbrushes for dental health: a systematic review. *Journal of Dentistry.* 2004;32(3):197-211.

95. Yaacob M, Worthington HV, Deacon SA, et al. Powered versus manual toothbrushing for oral health. *The Cochrane Database of Systematic Reviews.* 2014(6):Cd002281.

APPENDIX A

FIGURES

Figure 1: Diagram of patient flow through the study

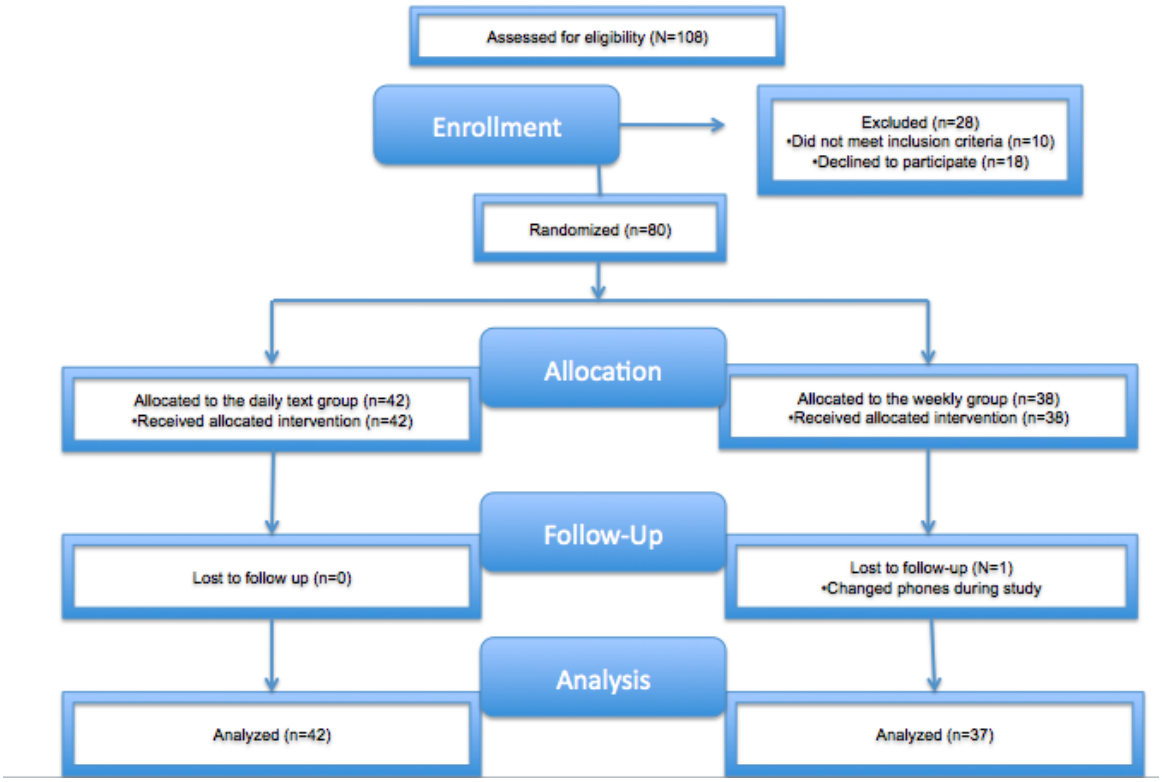


Figure 2A.

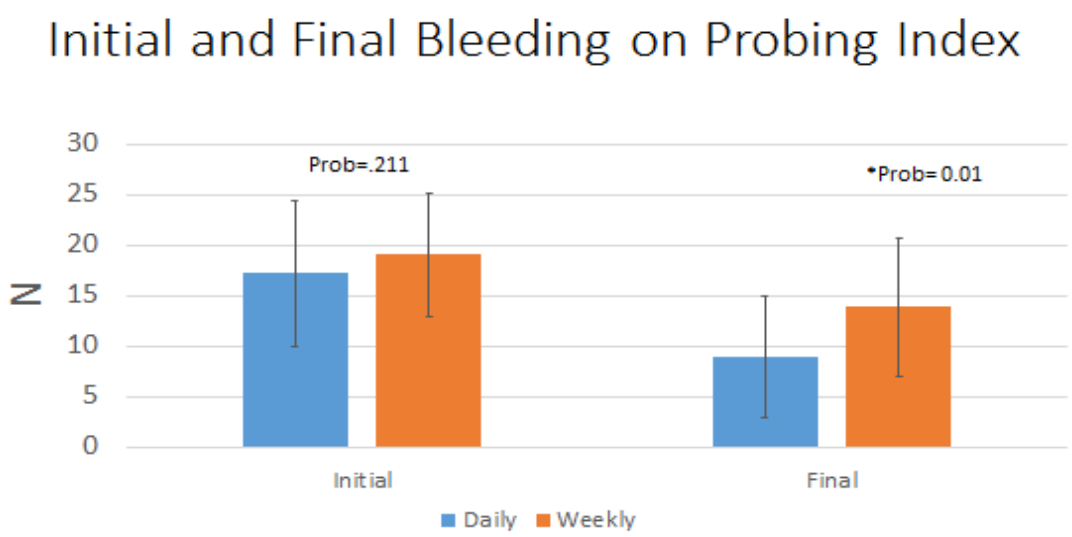


Figure 2B.

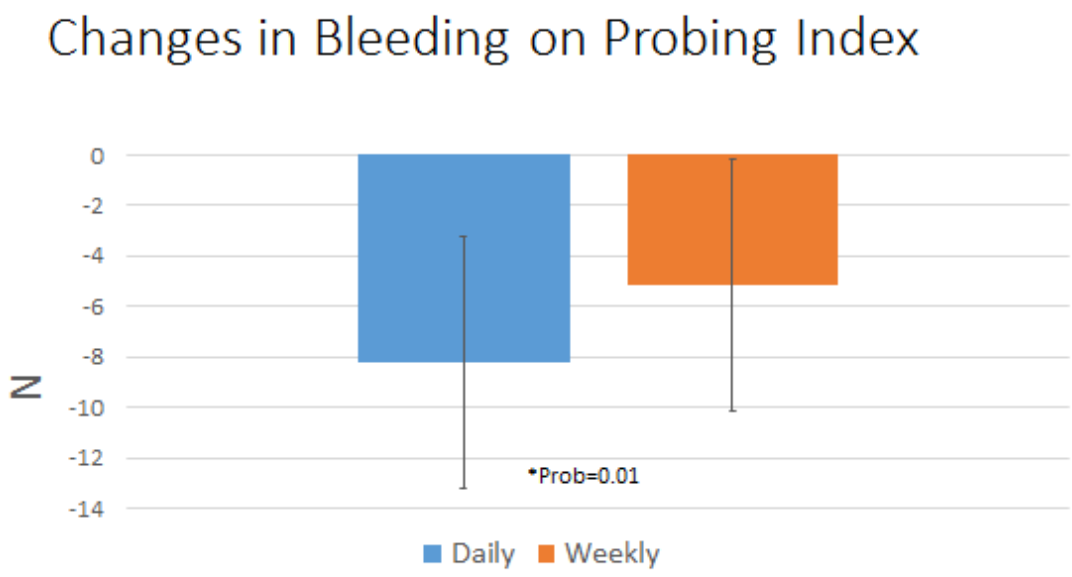


Figure 3A.

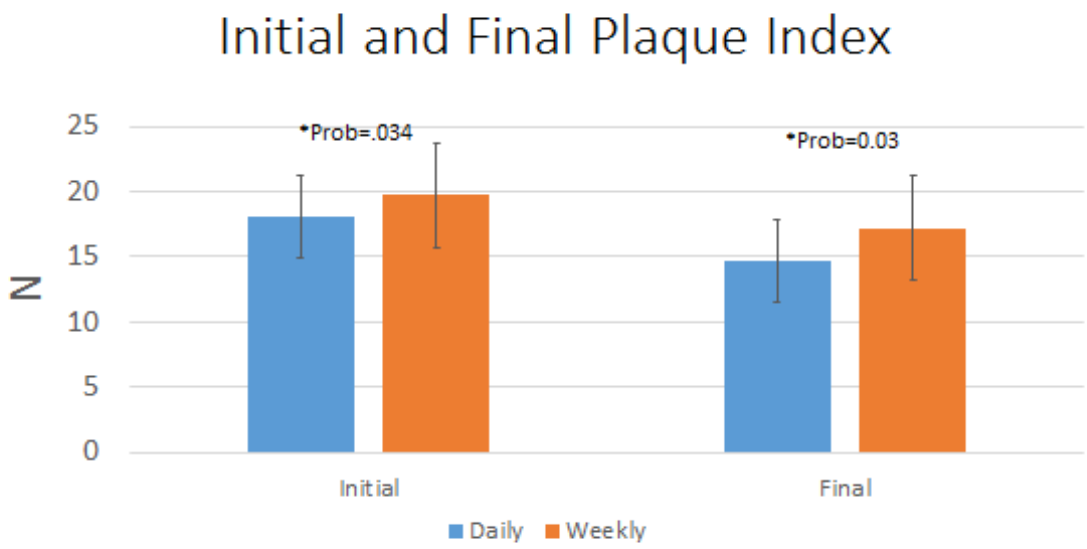


Figure 3B.

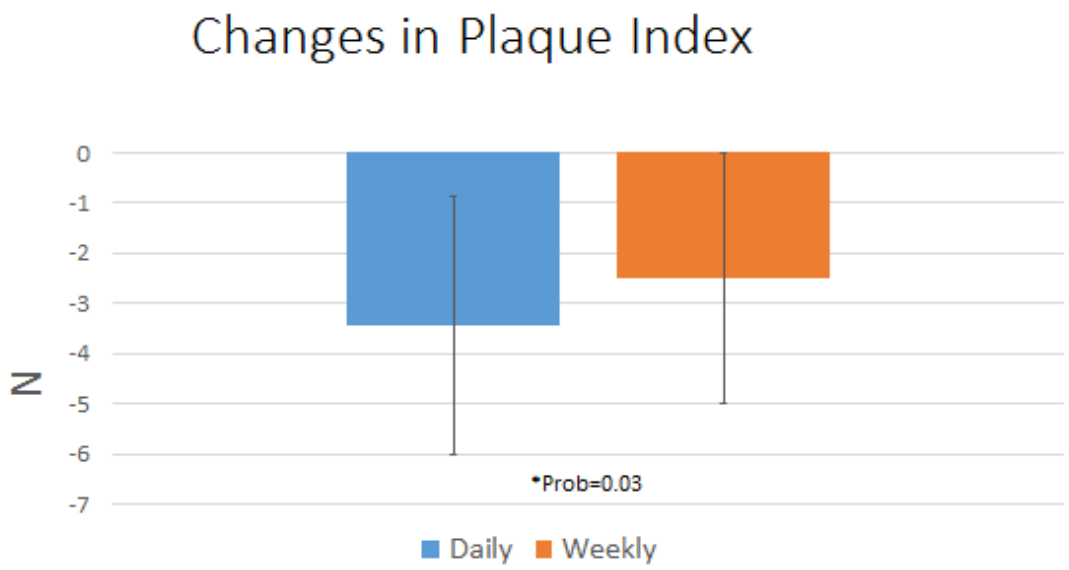


Figure4A.

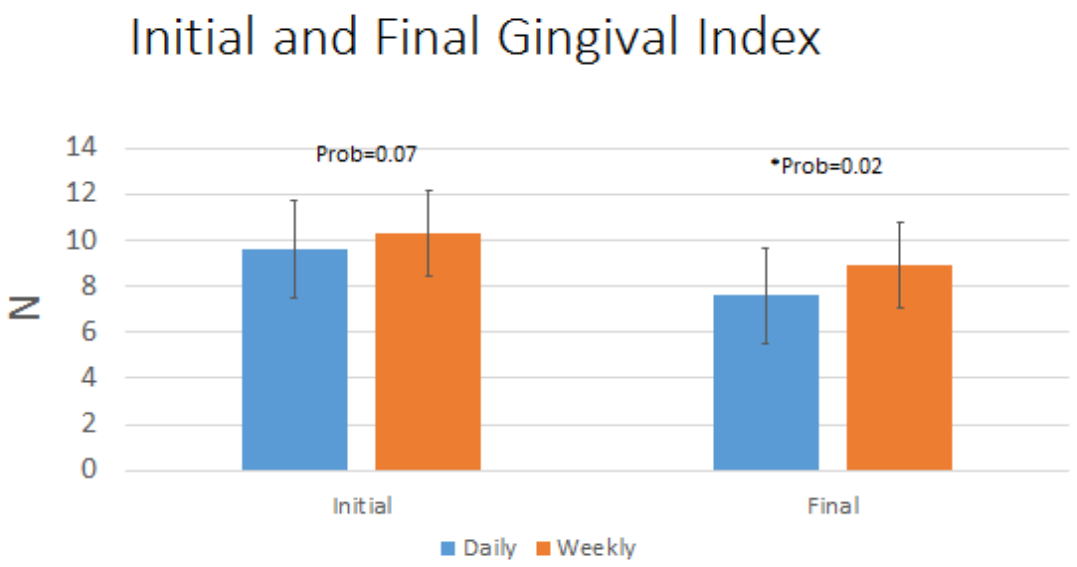
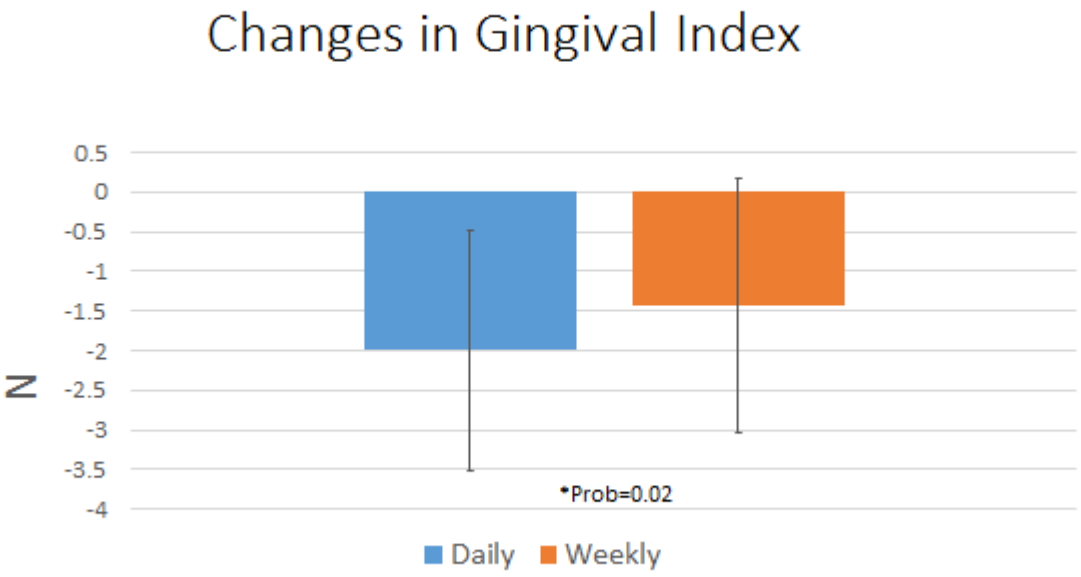


Figure4B.



APPENDIX B

TABLES

Table 1: Bleeding index, gingival index, and plaque index measurements.

Score	**Bleeding Index**
0	Absence of bleeding after 30 seconds
1	Bleeding observed after 30 seconds
2	Immediate bleeding
Score	**Gingival Index**
0	Normal gingival; absence of inflammation, bleeding, or swelling
1	Mild inflammation, slight edema and color change, but no bleeding
2	Moderate inflammation, redness, swelling, and bleeding on probing
3	Severe inflammation, marked redness and edema, spontaneous bleeding
Score	**Plaque Index**
0	No plaque
1	Discontinuous band of plaque at gingival margin
2	Up to 1-mm continuous band of plaque at gingival margin
3	Band of plaque wider than 1 mm but less than 1/3 of the surface
4	Plaque covering between 1/3 and 2/3 of surface
5	Plaque covering 2/3 or more of surface

Table 2: Number of sites detected at baseline(0) and final(1) for bleeding index(BI), plaque index(PI), and gingival index(GI) for daily text groups and weekly text group.

	DAILY		WEEKLY		
	Mean	**SD**	**Mean**	**SD**	**Probability Difference**
BI(0)	17.17	7.22	19.08	6.11	0.211
PI(0)	18.10	3.29	19.73	3.44	0.034
GI(0)	9.60	1.42	10.32	2.08	0.070

Table 3: Differences between daily text groups and weekly text group in number of sites detected in bleeding index(BI), plaque index(PI), and gingival index(GI).

	DAILY		WEEKLY		
	Mean	**SD**	**Mean**	**SD**	**Probability Difference**
BI	-8.24	5.46	-5.14	5.01	0.01
PI	-3.43	2.58	-2.51	2.49	0.03
GI	-2.00	1.51	-1.43	1.21	0.02

Table 4: Sex differences in number of sites detected in bleeding index(BI), plaque index(PI), and gingival index(GI).

	MALE		FEMALE		
	Mean	**SD**	**Mean**	**SD**	**Probability Difference**
BI	-7.15	6.11	-6.60	5.13	0.63
PI	-3.30	2.02	-2.81	2.81	0.91
GI	-1.59	1.95	-1.81	1.36	0.50

Table 5: Bleeding index(BI), gingival index(GI), and plaque index(PI) test correlations between initial (1) and final (2) measurements.

Correlations	**BI_1**	**BI_2**	**GI_1**	**GI_2**	**PI_1**	**PI_2**
BI_1	1					
BI_2	.674*	1				
GI_1	.453*	.446*	1			
GI_2	.318*	.509*	.643*	1		
PI_1	.539*	.539*	.333*	.373*	1	
PI_2	.466*	.560*	.450*	.432*	.750*	1

*Prob <.001

Table 6: Percentage of mesio-buccal(MB), buccal(B), and disto-buccal(DB) sites with no BOP for daily(0) and weekly(1) group.

	UR6	UL1	UL4	LL6	LR1	LR4
MB (0)	19.0%	61.9%	23.8%	42.9%	7.1%	*40.5%
MB (1)	10.8%	56.8%	35.1%	32.4%	13.5%	*13.5%
B (0)	47.6%	83.3%	47.6%	69.0%	33.3%	73.8%
B (1)	45.9%	83.8%	45.9%	56.8%	24.3%	67.6%
DB (0)	23.8%	52.4%	21.4%	*45.2%	11.9%	23.8%
DB (1)	13.5%	40.5%	21.6%	*13.5%	10.8%	24.3%

*Prob <.01

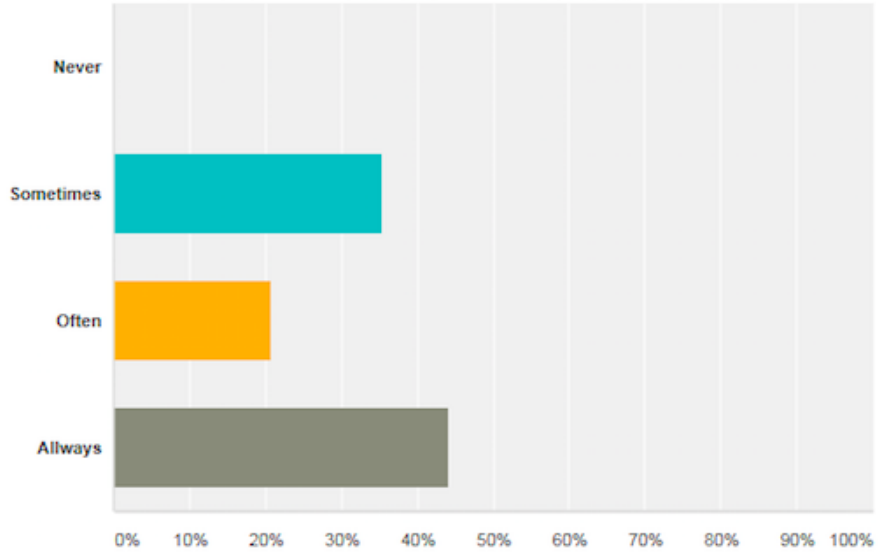
APPENDIX C

QUESTIONNAIRE

Q1 Customize Export

Did you actually read the text messages when they were sent?

Answered: 34 Skipped: 0

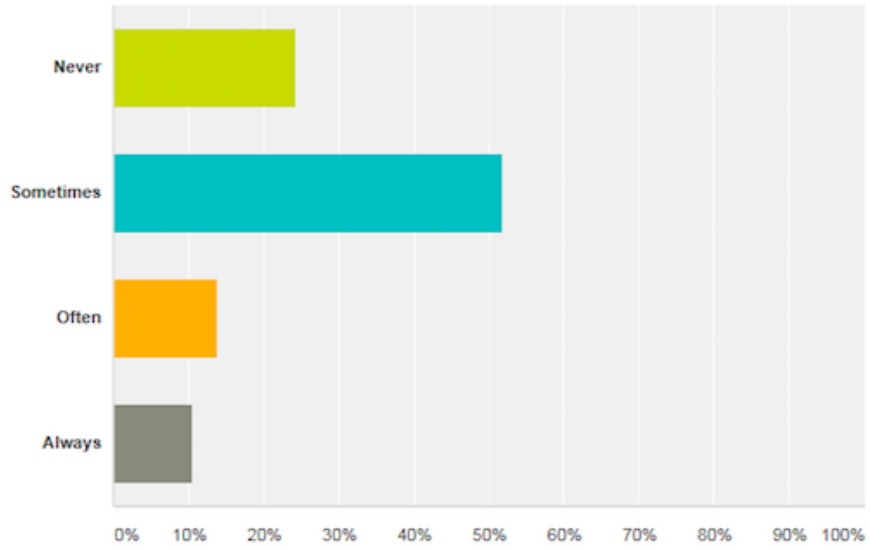


Answer Choices	Responses	
Never	0.00%	0
Sometimes	35.29%	12
Often	20.59%	7
Allways	44.12%	15
Total		34

Q2 Customize Export

Would you have liked to change the number of times you were reminded?

Answered: 29 Skipped: 5

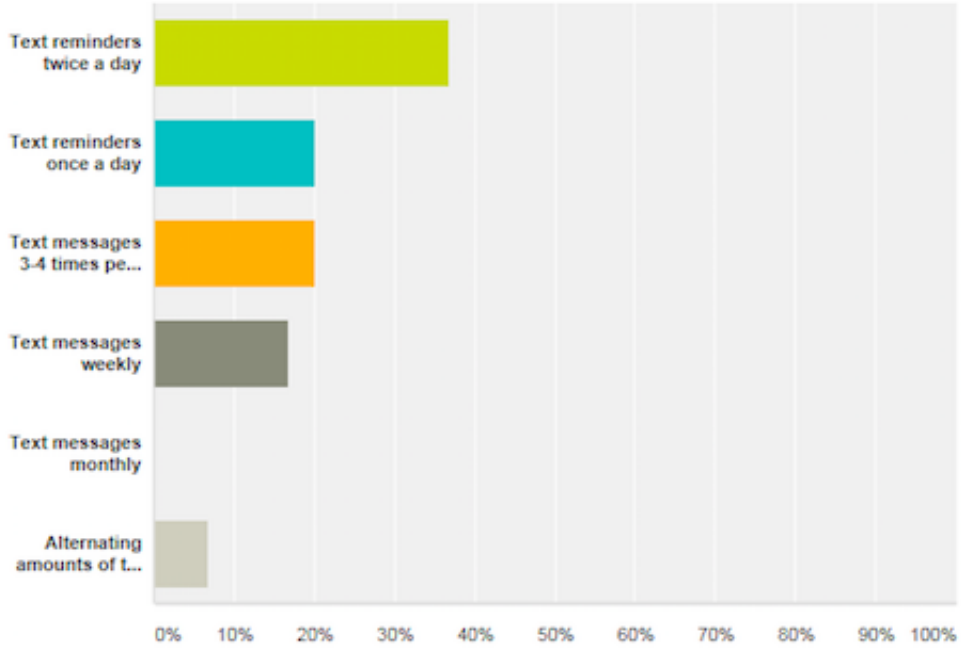


Answer Choices	Responses	
Never	24.14%	7
Sometimes	51.72%	15
Often	13.79%	4
Always	10.34%	3
Total		29

Q3 Customize Export

How often should text messages be sent to improve your brushing and flossing habits?

Answered: 30 Skipped: 4



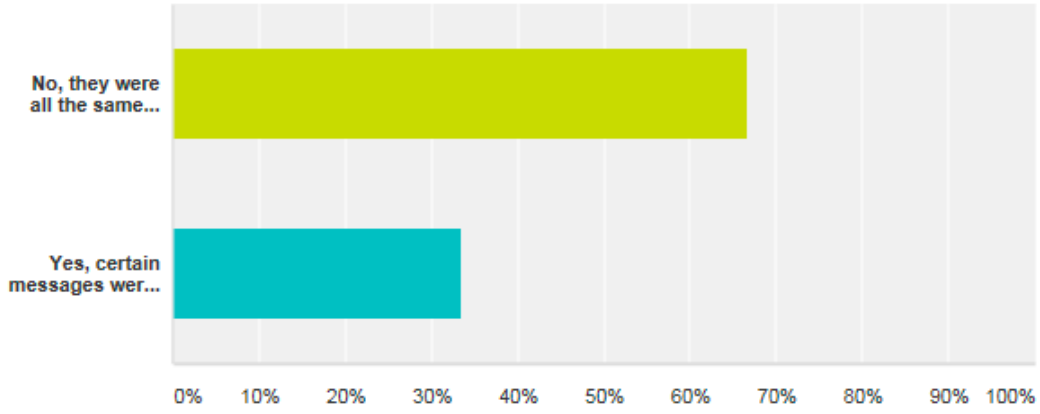
Answer Choices	Responses	
Text reminders twice a day	36.67%	11
Text reminders once a day	20.00%	6
Text messages 3-4 times per week	20.00%	6
Text messages weekly	16.67%	5
Text messages monthly	0.00%	0
Alternating amounts of text messages to keep you guessing(every week would be a different amount)	6.67%	2
Total		30

Q4

Customize Export

Did you think certain text messages were better than others?

Answered: 30 Skipped: 4

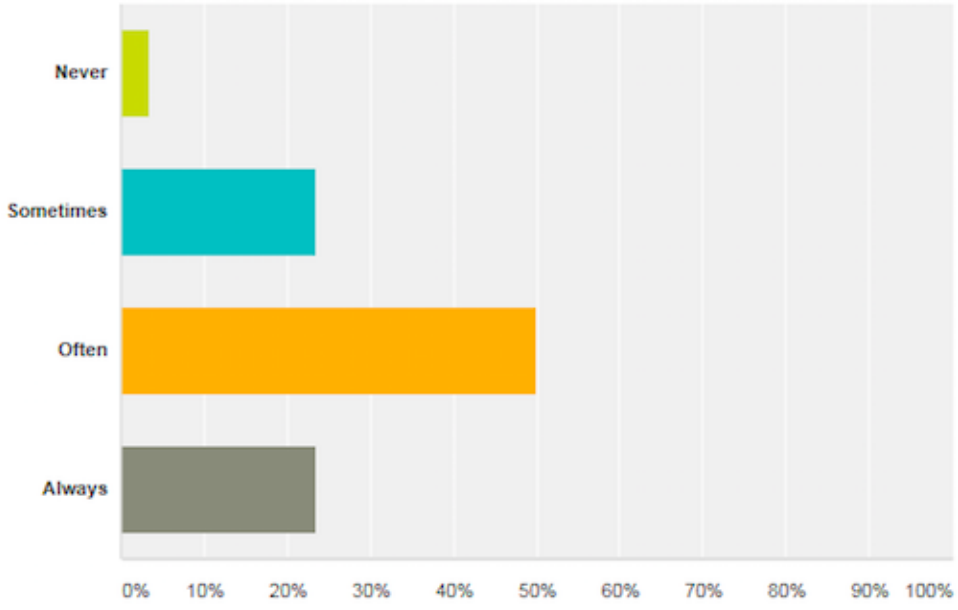


Answer Choices	Responses	
No, they were all the same to me.	66.67%	20
Yes, certain messages were better than others.	33.33%	10
Total		30

Q5 Customize Export

Did the reminders help you remember to brush your teeth?

Answered: 30 Skipped: 4

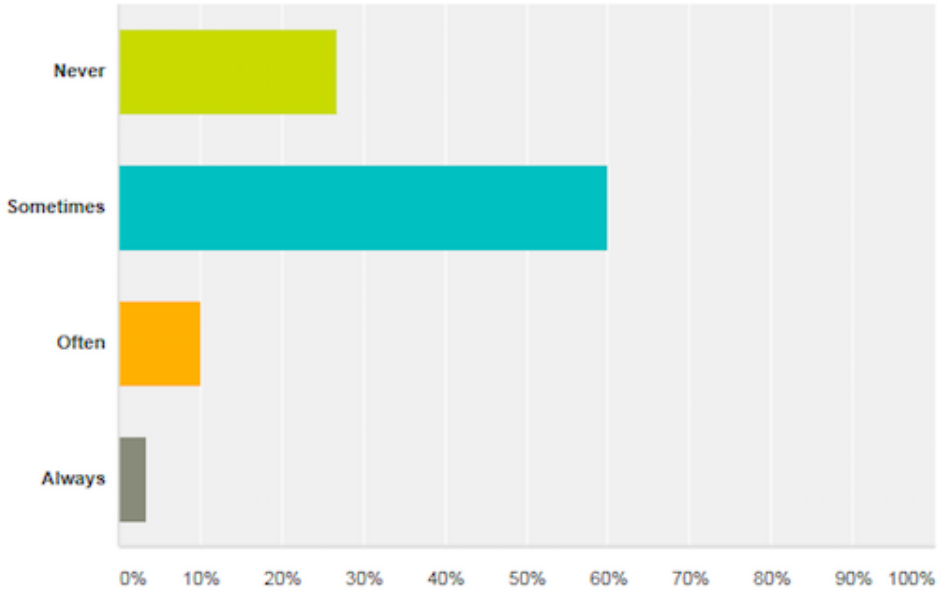


Answer Choices	Responses	
Never	3.33%	1
Sometimes	23.33%	7
Often	50.00%	15
Always	23.33%	7
Total		30

Q6 Customize Export

Was there a time you forgot to brush until the text reminder arrived?

Answered: 30 Skipped: 4



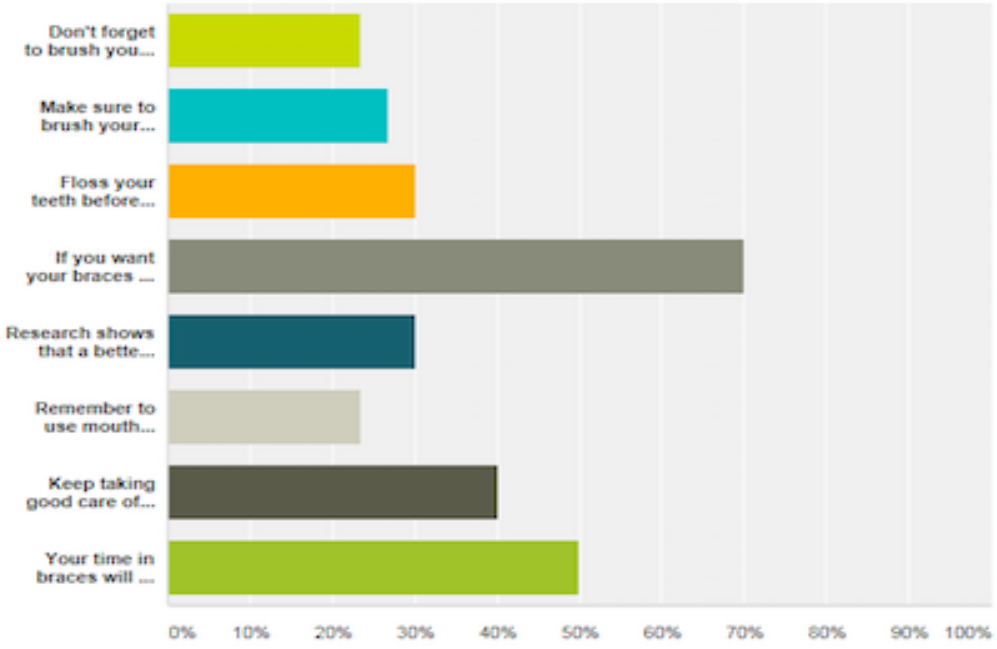
Answer Choices	Responses	
Never	26.67%	8
Sometimes	60.00%	18
Often	10.00%	3
Always	3.33%	1
Total		30

Q7

Customize Export

Which three messages do you think were the best?

Answered: 30 Skipped: 4



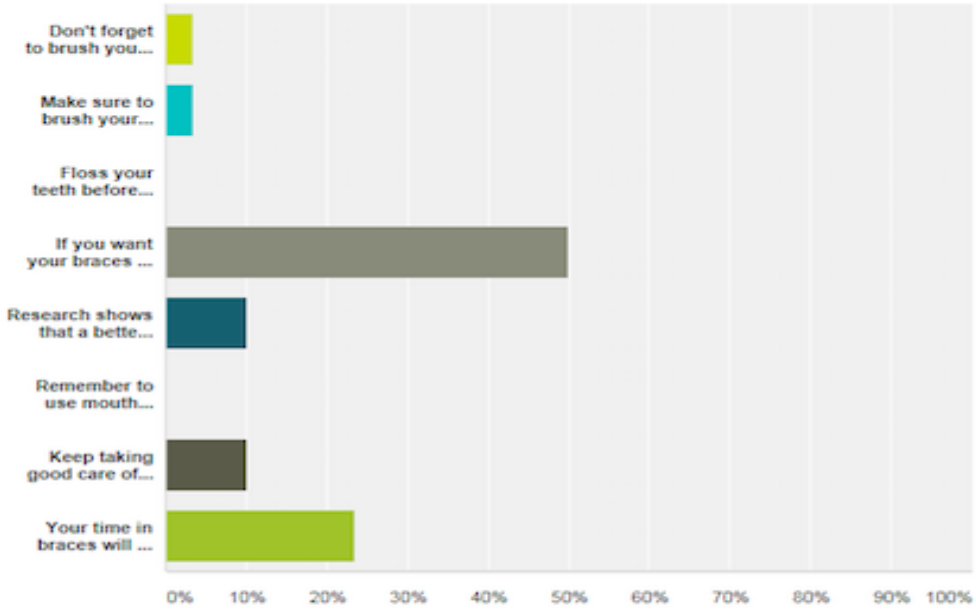
Answer Choices	Responses	
Don't forget to brush your teeth twice a day!	23.33%	7
Make sure to brush your teeth for at least two minutes!	26.67%	8
Floss your teeth before you go to sleep and remember to hug the teeth with your floss	30.00%	9
If you want your braces off faster...be sure to keep your mouth super clean!	70.00%	21
Research shows that a better smile leads to better paying jobs!	30.00%	9
Remember to use mouth rinses when you brush and floss to help the teeth stay extra clean!	23.33%	7
Keep taking good care of your teeth and you're going to have a great smile!	40.00%	12
Your time in braces will be shorter if you keep your mouth very clean!	50.00%	15

Total Respondents: 30

Q8 Customize Export

Which message made you want to brush your teeth?

Answered: 30 Skipped: 4

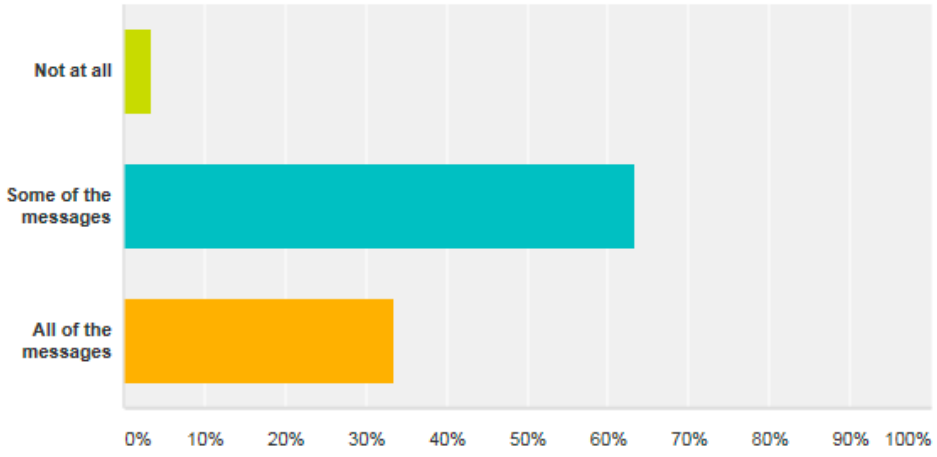


Answer Choices	Responses	
Don't forget to brush your teeth twice a day!	3.33%	1
Make sure to brush your teeth for at least two minutes!	3.33%	1
Floss your teeth before you go to sleep and remember to hug the teeth with your floss	0.00%	0
If you want your braces off faster...be sure to keep your mouth super clean!	50.00%	15
Research shows that a better smile leads to better paying jobs!	10.00%	3
Remember to use mouth rinses when you brush and floss to help the teeth stay extra clean!	0.00%	0
Keep taking good care of your teeth and you're going to have a great smile!	10.00%	3
Your time in braces will be shorter if you keep your mouth very clean!	23.33%	7
Total		30

Q9 Customize Export

Did the reminders help you understand the importance of brushing?

Answered: 30 Skipped: 4

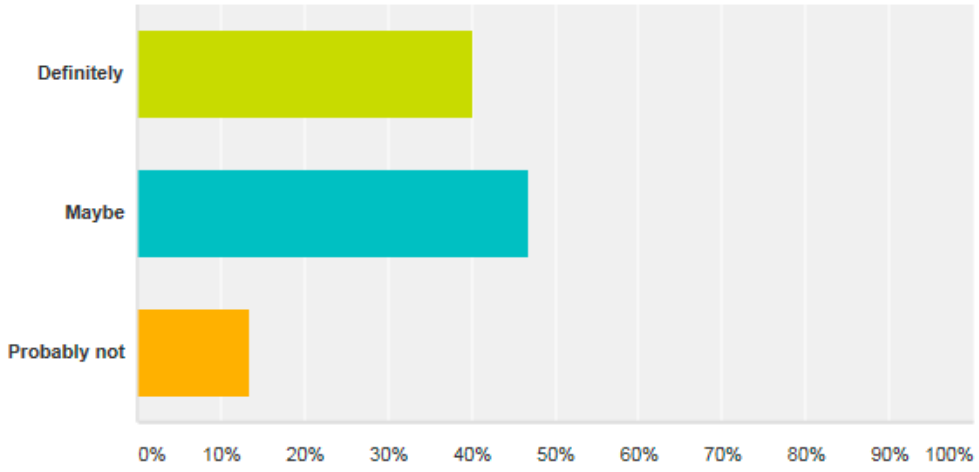


Answer Choices	Responses	
Not at all	3.33%	1
Some of the messages	63.33%	19
All of the messages	33.33%	10
Total		30

Q10 Customize Export

Do you think if you were able to win a prize for brushing your teeth that the messages would have been more fun?

Answered: 30 Skipped: 4



Answer Choices	Responses	
Definitely	40.00%	12
Maybe	46.67%	14
Probably not	13.33%	4
Total		30