Theory Based and Tailored Dental Messages for Children and Parents: Developing a Framework for a Brief Behavioral Intervention in Clinical and Non-Clinical Settings

Julia Mainelli
julia.mainelli@uconn.edu

Follow this and additional works at: https://opencommons.uconn.edu/srhonors_theses

Recommended Citation
https://opencommons.uconn.edu/srhonors_theses/636
Theory Based and Tailored Dental Messages for Children and Parents: Developing a Framework for a Brief Behavioral Intervention in Clinical and Non-Clinical Settings

Julia Mainelli

University of Connecticut

2019
# Table of Contents

## Title Page

1. **Background**  
   1.1. Caries Prevalence and Link with Obesity  
   1.2. Caries and Diet Quality  
   1.3. Caries and Teeth Brushing  
   1.4. Rapid Diet and Lifestyle Screener in Clinical Settings- Pediatric Adapted Likin Survey  
   1.5. Theories and Messaging  
   1.6. Parent Messaging  
   1.7. Research Goals and Hypothesis  

2. **Intervention Development**  
   2.1. Showing Need for Health Behavior Chain  
   2.2. Message Grouping Algorithm  
   2.3. Message Content Development  
      2.3.1. Applying Theories  
      2.3.2. Evidence Based ADA Recommendations  
      2.3.3. Message Framework  
   2.4. Implementing Messages in PALS  
   2.5. Delivering Messages  

3. **Showing the Need for Tailored Dental Messages in a Non-Clinical Setting**  
   3.1. Assessing Need in Non-Clinical Setting  
   3.2. Messaging in Non-Clinical Setting  

4. **Messaging Simulations and Pilot Testing**  
   4.1. Simulation with CCMC Data  
   4.2. Simulation with Non-clinical Setting Data  
   4.3. CCMC Pilot Data  

5. **Discussion**  
   5.1. Compare to Current Literature and Areas for Future Research  
   5.2. Strengths and Limitations  
   5.3. Conclusions  

**References**
1. BACKGROUND

Dental caries are highly prevalent worldwide, across all age and race/ethnicity groups. A relationship between caries and obesity has been found, with overall diet quality being one factor linking this relationship. The goal of this honors thesis is to develop a framework for a brief behavioral intervention to promote dental health in children, including a rapid behavioral screening with tailored messages. The messages will be based on the child’s screening responses and encourage him/her to follow healthy oral habits and diet behaviors, for reinforcement by parents and clinicians. This background aims to provide a review of critical literature on the prevalence of caries; correlation between caries and diet quality; the Pediatric Adapted Liking Survey as a rapid behavioral screening; the role of parents to reinforce children’s behaviors; and the potential of health promotion messages to improve diet quality and oral care among children.

1.1 Caries Prevalence and Linkages with Obesity

The National Health and Nutrition Examination Survey revealed that over 45% of youth in the United States ages 2-19 had caries. While the prevalence of caries is evident, there are some groups of children at highest risk. Highest rates of caries are observed among children from certain race/ethnicity groups including African Americans and Hispanics, as well as among those from lower income families (Flemming, 2018). According to the CDC, roughly 1 in 5 children, ages 5-11 years, have at least one tooth with untreated decay (Dye, Li, & Beltran-Aguilar, 2012). Treatment can certainly help already existing caries, these race/ethnicity and income disparities may limit access to affordable dental care. These disparities highlight the need for caries prevention that reaches all children.

The role that oral health has in a child’s overall well-being should be of concern to dentists and nearly all health care providers. Despite advancements in dental care, caries is still the most prominent health concerns. Poor oral hygiene can lead to disease of the mouth, but less
obviously can increase the risk of heart disease, diabetes, and cancer. For example, a cohort study of 755 participants over the course of 21 years identified that any sign of oral infection in the assessed children was associated with higher quantified subclinical atherosclerosis in adulthood (Pussinen et al., 2019). Dental caries was the main cause and sign of oral infection. Caries are characterized by any form of tooth decay or cavity, which can lead to these more serious health complications. Addressing this potential issue of oral hygiene early on in life is crucial to maintain ideal health in childhood and developing into an adult.

Moreover, it is important to consider that both caries and obesity are at epidemic levels, notably among youth. The comorbidity of obesity and caries has therefore been highly investigated. For example, a systematic review and meta-analysis of 14 papers and studies aimed to quantify the relationship between both conditions. A significant relationship was found between obesity and the prevalence of caries with an effect size of 0.104. Age and socioeconomic status were noted as significant moderators (Hayden et al., 2013). In parallel with these findings, a cross-sectional study across an entire Provence in China reported an association of obesity, measured by body mass index, and dental carries among school children and adolescents. Obese and overweight children had a 7 to 14% greater odds of caries than normal weight children (Li et al., 2017). A cross sectional study of 386 children ages 6-12 years old in Saudi Arabia also examined the relationship between dental caries and obesity and reported a positive and significant correlation between both mean number of decayed teeth and obesity ($r = 0.209$). Caries in deciduous teeth also was significantly higher among obese children, more so than in primary dentition. The highest BMI category had the most decayed or filled teeth, and the normal BMI category has the least. The researchers surmised that obesity plays a considerable
role in the prevalence of dental caries, especially among these primary school children (Abu El Qomsan, M A et al., 2017).

The findings of co-existence of excessive adiposity and dental caries across multiple studies supports the importance of promotion of oral health along with a healthy diet that also promotes a healthy weight.

1.2 Caries and Diet Quality

The purpose of this section is to review the scientific literature on the overall healthiness of the diet related to the risk of dental caries. That is, how the risk of dental caries is influenced by dietary consumption of foods/beverages associated with greater risk (e.g., sweets) as well as the consumption of foods associated with lower risk (e.g., vegetables). For this section, research was uncovered by using the following search:

("dental health" OR caries OR cavities OR "decayed teeth" OR "oral health") AND (child OR children OR teens OR adolescents) AND ("diet quality" OR "diet healthiness" OR "healthy eating index" OR Diet/*adverse effects/methods OR "dietary patterns")

Dental health, and specifically caries, has been strongly associated with many components of diet quality. One component is the consumption of fruits and vegetables. A cross-sectional, population-based study of older adults in Japan examined the association of eating these food groups with oral health-related quality of life. Independent of many other co-variates, a significant positive correlation was found between consumption of fruits and vegetables and the oral health-related quality of life for both men and women. Some of the adjusted co-variates included age, BMI, and smoking (Nanri et al., 2017). The oral health-related quality of life asked participants to report on concerns with oral health, oral health functioning, and oral pain.
Further review of literature focused the overall healthiness of the diet related to the risk of dental caries, specifically in children. The following search terms were used.

(vegetable OR vegetables) AND (caries OR "dental health" OR cavities OR cavity) AND children

One cross-sectional study investigated the association of healthy food items, attitudes towards these food items, and healthy eating behaviors with dental pain in 1,000 fifth grade students. The data were from the Texas Childhood Obesity Research Demonstration Project, which focuses on nutrition and physical activity. Dental pain was significantly correlated with consumption of unhealthy food items including, but not limited to, fruit juice, soda, frozen desserts, candy, sweet rolls, white pasta and rice, and French fries. Children who were willing to eat healthier and reported greater self-efficacy for healthy eating behaviors and reported less dental pain. These results highlight components of the whole diet and risk of poor oral health in children, supporting that messages need to go beyond just encouraging healthier overall diets (Nicksie et al., 2018). Similar findings were reported in a cross-sectional study of Egyptian children, which assessed the prevalence of dental and related dietary habits. Missing and filled teeth was positively correlated with age as well as the consumption of unhealthy foods such as candies, crackers, and chocolates. Conversely, consumption of healthy foods such as fruits and vegetables and dairy was negatively correlated with missing and filled teeth (Abbass et al., 2019). Likewise, a cross-sectional study in Brazil of the association between diet, oral hygiene, and dental caries among 245 12-year-old children. Data obtained from the self-reported questionnaires showed higher numbers of decayed, missing, or filled teeth was correlated with a lack of daily intake of vegetables (da Silveira, K S R, Prado, Abreu, Serra-Negra, & Auad, 2018). In summary, these above studies all confirm unhealthy nutrition as a significant risk factor.
for caries and poor oral health. Interventions should aim to increase consumption of healthy foods and reduce consumption of unhealthy foods in children to prevent caries and reduce risk of dental pain.

There are additional questions about the role of fruit juice on the risk of dental caries. Literature on the specific role of fruit and fruit juice in dental health was uncovered by the following search terms.

(fruit OR fruits) AND (caries OR "dental health" OR cavities OR cavity) AND children

A systematic review was performed on prospective cohort and randomized control studies to assess the relationship between consumption of 100% fruit juice and dental health in children. Randomized control trials from this review showed an increase in enamel loss, increase in erosion loss, more pronounced enamel softening, and increase in demineralization of enamel with consumption of 100% fruit juice (Liska, Kelley, & Mah, 2019). All these effects indicate a decline in dental health that can lead to more serious problems such as dental caries and eventual infection. The findings of this study are consistent with the cross-sectional analyses discussed above of a positive correlation between dental pain and fruit juice (Nicksic et al., 2018).

Importantly, however, whole fruits and vegetables are associated with decreased risk of caries. In a separate cross-sectional study, consumption of fruits and vegetables as snacks reduced indices of dental caries risk in children. This study examined three generations of 54 families and found that children with a high BMI had even higher rates of decayed, filled, or missing teeth when they never or almost never consumed fruits or vegetables (Goncalves, Moreira, Rauen, Rossi, & Borgatto, 2016). While intake of fruits as a healthy food choice has been associated with better dental health as shown in many of the above studies, the consumption of fruit juice, even if 100% fruit juice, is correlated with signs of poor oral health including decayed, missing, or filled
teeth. Fruit juice contains all of the sugars of whole fruits but lacks other nutritional benefits of whole fruits such as fiber. This shows that it is likely the high sugar level of fruit juice contributes to the risk of caries. Therefore, dental interventions should encourage whole fruit and limited limit fruit juice consumption.

Sugar intake, in particular, has also been identified as one of the most important aspects of a diet for dental health. A study done in Brazil investigated this relationship in nearly 1000 children ages 6, 12, and 18. The children were grouped based on levels of sugar consumption. In children of all ages, the higher sugar consumers had greater cavity prevalence compared to the lower sugar consumers. More specifically, the ratio between dental caries in children ages 6 and 18 was 66% higher in high sugar consumers in comparison to low consumers (Peres et al., 2016). Furthermore, a 2014 systematic review and meta-analysis investigated the association between sugar intake and dental caries (Moynihan & Kelly, 2014). From the systematic review of 50, primarily observational studies with children, 42 of the studies revealed a positive correlation between greater sugar consumption and great risk of caries.

1.3 Caries and Teeth Brushing

The purpose of this section is to review scientific literature on the association of teeth brushing with risk of caries. This includes number of times people brush a day, regardless of other oral hygiene practices. Research was uncovered by using the following search:

("dental health" OR caries OR cavities OR "decayed teeth" OR "oral health") AND (child OR children OR teens OR adolescents) AND ("tooth brushing" OR "teeth brushing") AND "randomized controlled trials" Filters: Humans, English

Teeth brushing has been identified as another major factor to caries prevention. A quantitative analysis of 25 studies revealed that infrequent brushing, categorized by self-report,
was associated with had higher number of caries than frequent brushers with a confidence interval of 95%. More specifically, brushing any amount less than two times per day was associated with greater risk of carious lesions compared with brushing two times a day or more (Holmes, 2016). In parallel with these results, a separate systematic review and meta-analysis of 33 studies investigated the impacts of the frequency of tooth brushing. It found that self-reported infrequent teeth brushers had both greater occurrence and frequency of carious lesions than those who reported frequent brushing (Kumar, S., Tadakamadla, & Johnson, 2016). It is also important to note that both of the systematic reviews/meta-analyses found the rate of caries to be more significant in primary teeth as compared to permanent teeth. Primary teeth are the teeth of all young children. Therefore, the presence of caries as a result of infrequent teeth brushing is applicable if not pertains most to a younger population. The elementary number of times one brushes daily has considerable value when it comes to its implications for one’s health and should be capitalized on as a factor. Given the higher prevalence of caries among lower income families (Ladewig et al., 2018), it is also relevant to note that teeth brushing in general is one of the only well-established preventative measures that has been deemed cost-effective. Prevention of caries by means of brushing is substantially more affordable than the treatment of tooth decay.

1.4 Rapid Diet and Lifestyle Screener in Clinical Settings- Pediatric Adapted Liking Survey

Clinical settings need behavioral screening measures that encourage accurate reporting and have reasonable utility for brief interventions. The Pediatric Adapted Liking Survey (PALS) is a screener that can be completed in just minutes, which allows it to be used efficiently in waiting rooms. While initially geared towards nutrition, it provides information pertinent to the child’s dental health, especially since diet quality influences dental health. One study investigating the use of PALS showed that it was feasible for a clinical setting with reasonable
validity and reliability with what is reported at home (Smith, Johnson, Oldman, & Duffy, 2019). When used in a clinical setting, it can allow for formation of tailored messages aimed at the prevention of dental caries and obesity. Further evaluation of PALS has also revealed that the responses can be formed into indices of diet quality and Healthy Behaviors that show criterion validity as well as internal reliability (Vosburgh, Smith, Oldman, Huedo-Medina, & Duffy, 2019). Thus, the child’s responses from the PALS can be analyzed by individual groups of foods such the child’s liking of sweets versus how much they like brushing their teeth as well as an index of overall diet quality index. These statistics about diet quality including sugar intake and teeth brushing are a start to determining overall risk of caries. The survey also simply asks children to report their liking of brushing, regardless of the amount they do it. Therefore, children who simply dislike brushing can be easily identified and hopefully have their attitudes positively influenced.

1.5 Theories and Messaging

The purpose of this section is to review scientific literature on theories of behavior change and health promotion messaging. This includes findings regarding motivators for behavior change and messaging efficacy.

Caries prevention for children should follow theories of behavior change according to an analysis of school-based caries interventions (Adair, Burnside, & Pine, 2013) This analysis specifically highlighted the lack of theory-based interventions in dental health. Instead, dental health interventions are often limited to strictly informative and instructional means. The analysis reported that the use of the behavior change theories is likely to improve efficacy as compared to interventions strictly regarding consequences of lack of change or pure oral hygiene instruction.
Any behavior change must first come include some sort of motivation, and, thus, the self-determination theory is largely applicable. This theory focuses on both the external and internal factors of motivation. One study reports on the aspects to intrinsic motivation and found that autonomy can increase motivation. Autonomy itself has been identified as an innate psychological need and therefore should be considered when trying to elicit an attitude or behavior change (Ryan & Deci, 2000). This is similar to the theory of planned behavior, which accounts for the idea that perceived control can shape one’s behavior. In fact, a review of the theory of planned behavior found that perceived behavioral control was one of two most often significant variables when it came to differences in intention, which significantly predicted behavior (Godin & Kok, 1996). This theory considers attitude and subjective norms as depicted in Figure 1 (Fishbein & Ajzen, 1975). One’s attitude, in combination with their environment or societal views and perceived behavioral control, contributes to overall intention to change behavior. The self-determination theory and theory of planned behavior are important to consider when developing the messages with goals of changing the behavior of children.

Figure 1. Theory of Planned Behavior Diagram. (Fishbein & Ajzen, 1975).
There is overwhelming evidence for the idea that dental interventions are more effective when they support patient autonomy, a major component to both the self-determination theory and theory of planned behavior. A randomized clinical trial tested promoting oral care through improving patient autonomy versus routine standard care with just instruction. The autonomy-supportive intervention included encouraging initiation and emphasizing personal choice. Such methods had stronger effect on personal growth as well as oral health, measured by levels of plaque and gingivitis than did non-theory-based instruction. Therefore, promoting oral care through making patients feel competent can not only improve their feeling of autonomy as well as improve their dental health (Halvari, Halvari, Deci, & Williams, 2019).

Theory-based intervention has further support from another pediatric dental pilot study. The program called Baby Steps used self-determination theory as well as strategies dealing with behavioral motivation with hopes of improving both nutrition and oral health. The participants included a caregiver and child from 6-36 months old who received the intervention in pediatric dental clinic. A successful 93% of caregivers reported positive behavior change at a 1-month post visit interview, where the adherence to goals was also assessed. Investigators used this evidence to claim that programs applying the self-determination theory and tailored guidance can be successful ways of motivating behavior change (Chomitz et al., 2019).

Health promotion messages, in particular, have been identified as useful in promoting behavior change and take advantage of behavior change theory. For example, the Fogg Behavior Model depicts how motivation, ability, and a prompt are all factors. While it does note that there is a positive correlation between motivation and ability as well as the likelihood of performing the desired behavior, it is the prompt itself that triggers the behavior. Fogg notes that a behavior will not happen without an appropriate trigger, even if both the ability and motivation to perform
it are high (J Fogg, 2009). For the purposes of the present thesis, children and families will complete the PALS, and based on their response, receive the prompted messages to trigger (encourage and reinforce) healthy behaviors in the children. Such messages have been successful in other studies, such as one regarding cervical cancer. Reminders through a short message service were aimed to increase participants’ knowledge and trigger preventative cervical cancer behaviors such as receiving a pap-test. The message trigger resulted in significant knowledge and behavior change, which allowed investigators to conclude that such technology is a promising intervention technique (Lee, Koopmeiners, Rhee, Raveis, & Ahluwalia, 2014). There is optimism that such a messaging technique will hold its success in the area of dental health as well.

1.6 Parent Messaging

Health promotion messages to parents about their children’s oral hygiene supplies a more comprehensive intervention than just to children alone. A study conducted in India investigated the attitude, knowledge, and behavior of parents towards the oral health of their children. The researchers reports that changing parental behavior and attitude regarding their children’s oral habits is more significant than only increasing their knowledge (Kumar, G., Dhillon, Vignesh, & Garg, 2019). Another study found that parents who focused on non-health benefits of brushing teeth (eg, cosmetic) were less likely to have children reach the recommended level of teeth brushing. Family routines also significantly associated with frequency of brushing (Trubey, Moore, & Chestnutt, 2015). Parental behavior and attitudes clearly play a key role in the oral health of children Therefore, a message to the parents in addition to the child about what they should be doing to promote their child’s oral health is advantageous.
According to self-determination theory, it is important to consider self-efficacy and perceived competence even when it comes to parenting. While some parents prefer being given clear direction, others would rather maintain feelings of control. A randomized study of adults investigated the effectiveness of health promotion messages that considered preferences for autonomy support. Groups were established based on their agreement or disagreement with a single statement regarding preferring to be told what to do. The experimental intervention therefore involved messages with autonomy-supportive communication. This included more encouraging messages that applied to the individual’s values. Parents who preferred autonomy and received these tailored messages increased their fruit and vegetable intake by 1.07 servings, whereas the control group (without messages matched to preferred autonomy) only increased fruit and vegetable intake by 0.43. There was clearly a significant difference in message impact (Resnicow et al., 2008). This shows the importance of taking individual differences in terms of preferences for autonomy into account to be most efficacious in behavior change.

1.7 Research Goals and Hypothesis

The overall goal of this thesis is to provide a framework for brief interventions to encourage proper oral care and nutrition in children to reduce risk of caries and improve overall health. The literature review was necessary to direct the development of evidence-based dental messages. Needed were algorithms based on PALS responses to deliver the child encouraging and/or reinforcing dental messages. Lastly, the new messages are to be piloted in Connecticut Children’s Medical center.

An investigation on the design of feasibility studies noted areas of focus that feasibility studies should address, including acceptability, demand, implementation, practicality, adaptation, integration, expansion, and limited-efficacy testing (Bowen et al., 2009). In terms of this study,
acceptability can be estimated based on the child’s response regarding how much they would like to change the behavior the message comments on. Demand has been assessed through the literature review of the prevalence and risk of caries. Although the present thesis only included limited-efficacy testing with a convenience sample, the PALS screener with tailored messages for children and parents is practical a similar protocol with diet and physical activity messages is already set in place.

2. INTERVENTION DEVELOPMENT

The purpose of this section is to first show the need for health behavior change among the surrounding population through analysis of previous PALS data from Connecticut Children’s Medical Center. It then describes the way in which messaging algorithms were developed to group the children. This is followed by explanation of the message content development, specifically with application of the behavior change theories.

2.1 Showing Need for Health Behavior Change

Identifying determinants related to the problem of poor oral health was crucial to establishing what behaviors needed to change. The literature review allowed the number of times teeth were brushed, overall diet quality, and specifically dietary behaviors toward and sugar intake to be important factors in the risk of caries. Previous Pediatric Liking Survey (PALS) data were used to explore the links between oral health data and liking for dietary components. The PALS survey was administered in the Pediatric Emergency Department of Connecticut Children’s Medical Center (CCMC), where responses in this clinical setting showed good to excellent correlation with those outside of the clinical setting (Smith, Johnson, Oldman, & Duffy, 2019). The data collection occurred from August 2016 to April 2018 by research assistants from University of Connecticut Undergraduate Research Assistant Program.
Participants included children ages 5-17 years old with a parent/guardian present who signed an informed consent form, totaling to 535 eligible enrollments. The joint distribution of liking of sweets to the reported number of times teeth were brushed a day in these 535 participants with allowed identification of different caries risk groups (Figure 2). The different quadrants reveal participants with concordance and discordant responses showing the need for different messages tailored to individual responses. Participants fell in each of the quadrants showing the ability to target tailored messages toward encouraging healthier behaviors as well as reinforcing healthy behaviors.

Figure 2. Scatter plot of PALS data comparing reported liking of sweets with teeth brushing frequency. The red group indicates the highest risk group for caries, with a low frequency of brushing (< 2 times a day) and high liking of sweets. The orange risk group also indicates moderately high risk with infrequent brushing but low liking of sweets. The moderate risk group in yellow includes frequent brushers (≥ 2 times a day) with a high liking of sweets. The lowest risk group in green includes frequent brushers with a low liking of sweets.
2.2 Message Grouping Algorithm

Based on this CCMC data set, a preliminary algorithm was deduced target children by group membership to receive messages based on their reported behaviors. The variables to identify these children was reported frequency of teeth brushing and level of liking of sweets or sugar sweetened beverages. The group of children at highest risk for dental disease and caries was ultimately defined by those who brush their teeth less than 2 times a day and reported a liking of sweets or sugar sweetened beverages over the median of 54 on the ±100 point liking scale. These high-risk children will receive an encouragement message about improving oral care as well as healthy snacking and drinking (Figure 3). The next group is comprised of children who do brush their teeth two times a day or more, but still have a high liking of sweets or sugar sweetened beverages, as reported of above 54. These children will get a reinforcement message of good oral care but an encouragement message more focused on increasing quality of nutrition (Figure 4). The children who reported teeth brushing 2 times a day or more and a low liking of sweets (defined as less than the median of 54) will receive a reinforcement message regarding oral care (Figure 5). Lastly, all children will receive a message about the teeth brushing standards and ways to improve enjoyment of teeth brushing (Figure 6).

2.3 Message Content Development

2.3.1 Applying Theories

In terms of the goals of this thesis, a child must be motivated to change their dietary and teeth brushing behaviors. The best-case scenario is to change their attitude about teeth brushing and eating habits so that the favorable actions are done on their own, rather than because they are told to. Applying the information from the literature review of self-determination theory and
theory of planned behavior, giving the child a sense of autonomy, and making them feel competent within the content of the messages will promote internalization. Therefore, the messages must apply to children’s values and be age appropriate. Table 1 specifically shows how each component to the Theory of Planned Behavior will be applied to the messages for children.

<table>
<thead>
<tr>
<th>Component of Theory of Planned Behavior</th>
<th>Application to Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude</td>
<td>Reported through liking of sweets and teeth brushing frequency in Pediatric Liking Survey</td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>Messages include phrases such as “grow strong and “bright and healthy” Connects to having a favorable appearance and increasing social acceptability</td>
</tr>
<tr>
<td>Perceived Behavioral Control</td>
<td>Phrase “2 min x 2” conveys simplicity of the behavior of teeth brushing Makes the child feel capable and promotes autonomy</td>
</tr>
<tr>
<td>Intention</td>
<td>Follow up question after message asking “How much would you like to try…” gauges motivation and promotes having a conscious plan to engage in behavior</td>
</tr>
</tbody>
</table>

Table 1. Applying the Theory of Planned Behavior to tailored messages.

Similarly, for parents, the messages will be theory based. They also will consider the style that parents prefer to be advised, based on a preliminary question regarding how they like being told what to do similar to as done in the study of Resnicow et al. (2008). Parents preferring autonomy will have a more encouraging message (Figure 7) while parents preferring simply being told what to do will have a message with more direct instruction (Figure 8).

2.3.2 Evidence-Based ADA Recommendations

It is important for the messages to contain accurate information as guidance. The brushing message therefore is based on American Dental Association guidelines. Their consensus recommendation is for individuals to brush their teeth for two minutes twice a day (Oral health topics, 2019). This is parallel with findings in the studies regarding this number significantly decreasing risk of caries (Holmes, 2016)(Kumar et al., 2016).
2.3.3 Message Framework

Communicating needs of behavior change can be approached in many ways, but largely either coming from a positive or negative standpoint. An investigation regarding children’s body weight yields important insights on how to approach behavior change in children. A meta-analysis was conducted on 38 associative studies. It was found that encouragement of healthy lifestyles by parents was associated with overall better well-being. In contrast, criticisms of body weight were associated with poorer physical self-perceptions (Gillison, Lorenc, Sleddens, Williams, & Atkinson, 2016). Given this, framework for the dental messages that need to elicit a behavior change will be based on positive encouragement. Children who already exhibit a desired behavior will get positive reinforcement, as depicted in Figure 5.

Another investigation on behavior change messages asked children to create messages regarding hand washing to see what content was liked. The messages made by children consistently addressed reminders and encouragement (99%) as well as education and information (89%) rather than social norms (14%). This is parallel with the above findings that informative messages framed in a more encouraging manner are best (Gillison et al., 2016). Moreover, pictures the children drew accompanying their messages notably depicted things not readily seen such as scary-looking germs on hands. It became obvious that the children thought this made the threat of germs and consequence of them more obvious (Rutter, Stones, & Macduff, 2019). Persuasion for children comes from tangible reasons why to do something, rather than just informative statements. Therefore, in addition to statements for the children that need to increase teeth brushing images of hurt teeth will be provided, as seen in Figure 3. This is in parallel to the images of scary germs, in order to make the treat of infrequent brushing clear. Images will also be included in the message for the children that need to decrease consumption of sugars, as seen
in Figure 4. These will show more tangible images of cavities, which may not be readily seen otherwise, to encourage brushing and encourage limiting sugars by showing a consequence of not doing so.

Overall, it is important to keep the message itself brief and fun, considering the population of recipients being children. As the handwashing study notes, a message is a form of brief communication and nearly all messages created by the children were short, while still getting the information across. (Rutter et al., 2019). Messages with more informal fonts and fun colors will also hopefully be perceived as more inviting.

**Figure 3.** Message for children reporting low brushing (< 2 times a day) and high liking of sweets (>54). This message is aimed to encourage better nutritional and oral care habits.

**Figure 4.** Message for children reporting high brushing (≥ 2) and high liking of sweets (>54). This message is aimed to encourage better nutritional habits.
Figure 5. Reinforcement message for children reporting high brushing (≥ 2) and low liking of sweets (< 54). This message is aimed to encourage children with good oral care to continue their habits.

Figure 6. Encouragement message for all children. This message is aimed to offer ways to increase the liking of teeth brushing, and therefore increase frequency of brushing.
Figure 7. Parent autonomy-supportive message. Message delivered to parents that prefer supportive messages rather than being told what to do. This message encourages parents to support healthy nutrition and teeth brushing for their child.

Figure 8. Direct parent message. Message delivered to parents that prefer being told what to do. This message gives parents directions on how to support healthy nutrition and teeth brushing for their child.

2.4 Implementing Messages in PALS

In order to implement the messages based on the PALS survey, the survey flow was directly edited in Qualtrics. Parameters were set for which criteria should yield which message based on the child’s responses and the algorithm deduced in section 2.2. The tailored messages in Figures 3, 4, and 5 were set to be randomized among other nutrition messages the child was able to receive. The message in Figure 6, aimed to increase liking of brushing and encourage it overall
was set to be sent to every child. After receiving a message, a second question was prompted to aim to get feedback on the particular message that was received, as seen in Figures 9, 10, and 11.

**Figure 9.** Feedback message prompted for children after receiving the message for a low liking of brushing and high liking of sweets.

**Figure 10.** Feedback message prompted for children that received the message for a high liking of brushing and high liking of sweets.
Figure 11. Feedback message prompted for children that received the message for a high liking of brushing and low liking of sweets, as well as the message sent to increase liking of brushing.

2.5 Delivering Messages

Participants for this part of the project were recruited in the same way as the participants from the data set discussed in part 2.1 (Showing Need for Health Behavior Change). A convenience sample of children ages 5-17 years old accompanied by a parent in the Pediatric Emergency Department of Connecticut Children’s Medical Center was used. Enrollment and data collection for the tailored child and parent dental messages began September of 2019 by trained research assistants from University of Connecticut’s Undergraduate Research Program. Exclusion criteria include history of behavioral or psychiatric health issues, a diagnosed eating disorder, severe illness, or non-English speaking. Before data collection, parent/guardians sign informed consent and children sign assent forms if they are at least 8 years old. This was approved by the University of Connecticut and CCMC Institutional Review Boards.

Data collection was first done by the research assistants on a tablet, including variables such as name, address, age, sex, race, insurance type, brief medical history, dental health, and internet access. Once the PALS was completed, tailored messages were presented on the screen.
to the child and parent based on their responses and message criterion. The follow up question based on the message was prompted last.

3. Showing the Need for Tailored Dental Messages in a Non-Clinical Setting

The purpose of this section is to first show the need for health behavior change among a child population in a non-clinical setting through analysis of previous PALS data from Windsor Public Middle School. It then describes the way in which a new messaging algorithm was developed to group the participants based on concordance and discordance between brushing liking and brushing frequency.

3.1 Assessing Need in Non-clinical Setting

In order to evaluate applicability of these dental messages based on child self-reported data in a nonclinical, a data set from July 2019 from Windsor Public Middle School was analyzed. All 7th grade students at this middle school were recruited in their science class, containing 10-20 students in each of the 15 total classes. This was therefore a convenience sample, conducted in early October of 2018. The opportunity to be a part of the study was announced and parents or students who did not want to participate submitted a Notification of Refusal Form.

To begin, the students self-reported liking of brushing was analyzed. The children reported their liking on the same labeled scale with PALS in a clinical setting and ranged from -100, representing hating it, to +100, representing loving it, as depicted in Figure 12. The spread of reports is depicted in Figure 13. A notable 158 of 378 students reported a low liking of brushing their teeth, defined as < 50. Theoretically, if children do not like doing something then it decreases the chance of the behavior. This is confirmed by the significant correlation ($\rho = 0.152, p < 0.01$) found between how much children reported liking brushing their teeth and the number of times a day they brush their teeth as depicted in Table 2. The children showing congruence
with a high liking of brushing and high frequency could receive the same reinforcement message as developed in Figure 5. The students who report congruency through a low liking of brushing and low frequency should receive a message emphasizing the dangers of not brushing their teeth as well as ways to improve liking of brushing, as in Figure 14.

**Figure 12.** *The seven-point horizontal visual analogue line scale.* This scale uses facial representations to report levels of liking/disliking for teeth brushing with ±100 as love/hate it, ±67 as really like/dislike it, ±33 as like/dislike it, and 0 as its okay.

**Figure 13.** *Distribution of self-reported liking of brushing from participants in a non-clinical setting.*
Table 2. Spearman Test of Liking of brushing compared to frequency in non-clinical PALS data set. A significant correlation is evident between how much children (N=378) reported liking brushing their teeth and the number of times they brush a day ($\rho = 0.152$, $p < 0.01$).

**Figure 14.** Message for students with a low frequency of brushing and low liking of brushing. This encouragement message is aimed to offer ways to increase enjoyment of brushing and increase frequency of brushing.

### 3.2 Messaging in Non-Clinical Setting

Despite the significant correlation between liking of brushing and frequency of brushing, there were notably outliers whom showed incongruency between these two variables. This is
given by a reported high liking of brushing teeth but infrequent brushing, as well as a reported low liking of brushing teeth but frequent brushing, as seen in Figure 15. This leads to a modification in the message algorithm from the previous data set. The children who brush frequently ($\geq 2$) but report a low liking ($< 50$) should be sent the message offering ways to make brushing more enjoyable, as in Figure 6, hopefully increasing the liking. On the other hand, the children that report a high liking ($\geq 50$) of brushing but do not brush frequently ($< 2$) should be sent a message emphasizing the importance of brushing, such as in Figure 16. These messages would be focused on brushing alone and aimed at increasing the congruency between reported attitudes and actions.

**Figure 15.** Scatterplot of participant's reported frequency of brushing versus liking of brushing from PALS administered in a non-clinical setting. Incongruency of reports through either a high liking of brushing and low frequency or low liking of brushing but high frequency are indicated in red. Concordant groups consistent of high liking of brushing and high frequency or low liking of brushing and low frequency are indicated in blue.
Figure 16. Tailored message for children who report high liking of brushing but low frequency, aimed to encourage more frequent brushing.

4. MESSAGING SIMULATIONS AND PILOT TESTING

The purpose of this section is to show simulations of what messages would be received by the children who participated in the studies providing the data sets that the message grouping algorithms were based. This is followed by pilot data from the most recent study, including actual delivery of messages in the clinical setting.

4.1 Simulation in CCMC Data

The algorithm developed in section 2.2 was applied to the 2018 data from patients in the clinical setting of Connecticut Children’s Medical Center. A high brush frequency is defined as $\geq 2$, a low brush frequency is $< 2$. A high liking of sweets is defined as $\geq 54$ and a low liking of sweets is $< 54$. Table 3 indicates the number of participants at CCMC who would receive each message based on their PALS responses. The algorithm could be applied to other clinical settings, such as dental offices. Patients could fill out PALS in the waiting room, allowing for
grouping prior to an appointment. This provides opportunity for further intervention, such as by motivational interviewing by health care providers. Dentists or hygienists can quickly identify their highest risk child patients early on, being in the category of low frequency of brushing and high liking of sweets.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Count</th>
<th>Message Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low frequency of brushing; High liking of sweets</td>
<td>37</td>
<td>Figure 3</td>
</tr>
<tr>
<td>Low frequency of brushing; Low liking of sweets</td>
<td>43</td>
<td>Figure 6</td>
</tr>
<tr>
<td>High frequency of brushing; High liking of sweets</td>
<td>117</td>
<td>Figure 4</td>
</tr>
<tr>
<td>High frequency of brushing; Low liking of sweets</td>
<td>101</td>
<td>Figure 5</td>
</tr>
</tbody>
</table>

Table 3. Message grouping and delivery simulation for a clinical setting. A high brush frequency is defined as $\geq 2$, a low brush frequency is $< 2$. A high liking of sweets is defined as $\geq 54$ and a low liking of sweets is $< 54$. The number of each message would be delivered to participants from the 2018 CCMC data set.

4.2 Simulation with Non-clinical Setting Data

The algorithm developed in section 3.2 was applied to the data from middle-schoolers in a non-clinical setting. The algorithm allows for tailored messages for students with incongruency in the liking of teeth brushing and frequency of teeth brushing. The following messages would be delivered to the indicated number of students based on their PALS responses. High brush frequently is defined as $\geq 2$ while anything $< 2$ is low. High liking of brushing is defined as $\geq 50$ while low liking is $< 50$. Table 4 indicates the number of participants from Windsor Middle School that would receive each message based on their PALS responses. Once again, congruency as well as discrepancy in frequency of brushing and liking of brushing provides opportunity for intervention. The algorithm allows for quick identification of children at high risk for caries, reporting low frequency and low liking of brushing. Perhaps the intervention
could be reinforced in the non-clinical settings of schools, in health classes or even simple messages around the school environment.

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Message Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>High brushing frequency; High liking of brushing</td>
<td>37</td>
<td>Figure 5</td>
</tr>
<tr>
<td>Low brushing frequency; High liking of brushing</td>
<td>43</td>
<td>Figure 16</td>
</tr>
<tr>
<td>High brushing frequency; Low liking of brushing</td>
<td>117</td>
<td>Figure 6</td>
</tr>
<tr>
<td>Low brushing frequency; Low liking of brushing</td>
<td>101</td>
<td>Figure 14</td>
</tr>
</tbody>
</table>

**Table 4.** Message grouping and delivery simulation for a non-clinical setting. High brushing frequency is defined as ≥ 2 while anything < 2 is low. High liking of brushing is defined as ≥ 50 while low liking is < 50. The number of each message would be delivered to participants from the 2019 Windsor Public Middle School data set.

### 4.3 CCMC Pilot Data

From October 6th to November 16th, there were a total of 22 children who received the overall dental message as depicted in Figure 6. The ages of the participants were 5-17 years old with an average age of 9.36 years, including 12 boys and 10 girls. Five of the children had body mass indexes signaling obesity, which is about 23% of participants tested. The average reported liking of brushing was 33.76 which corresponds to a low liking. Furthermore, the average parent reported liking of brushing was 33.52 which is nearly identical the average for children. The average number of cavities in children was 1.76 and average reported overall oral health was 3.18 on the 7-point Likert scale with 1 being excellent and 7 being poor. The follow up question to the dental health message asking “How much would you like to try brushing your teeth for TWO minutes TWO times a day” (Figure 11) yielded an average response at 48.86, being in between like and really liking it. The parental follow up message yielded a response average of 85.5, corresponding to in between really like and loving it.
The low-liking of brushing in children and parents confirms the need for both the child and parental intervention. The rating of overall dental health at 3.18 also corresponds to a point in between okay and good. There is clearly opportunity to increase the liking and frequency of brushing, just as the delivered tailored measure aims to do. Furthermore, the prevalence of obesity in this small sample confirms the threat of this epidemic, highlighting the importance of nutritional intervention in addition to improving oral care. With being theory based, the messages appear to be an appropriate trigger for behavior change as noted in the Fogg behavior model (J Fogg, 2009). The positive responses to the follow up questions inquiring about interest in changing the behavior show positive intent from the participants. This is a crucial aspect to the theory of planned behavior (Fishbein & Ajzen, 1975).

5. DISCUSSION

Overall, the need for widespread changes in behavior regarding oral care and nutrition behaviors among youth is evident, given the prominence of caries and obesity. These behaviors are not only determinants for dental health but overall health. The variation in self-reported behaviors and liking provide opportunity for the provision of tailored messages. Literature signifies that these are most efficacious when they are theory based, leading to the application of the theory of planned behavior and self-determination theory for purposes of this study. Preliminary data showed these targeted behavioral interventions to be feasible, having considerable potential for application in waiting rooms across many clinical settings.

5.1 Compare to Current Literature and Areas for Future Research

There have been many studies investigating the use of technology to improve oral health behaviors. For example, the Text2Floss study explored the effects of a week-long text messaging intervention to advance oral health behavior and knowledge of mothers with young children. The
pre-intervention survey showed no difference between control and experimental groups in any domain. In contrast, the post-intervention surveys showed the mothers in the experimental texting group to have significant increase in flossing and higher total and specific oral health knowledge. The experimental mothers also notably had decreased soda and sugary snack intake and increased attempts to positively change the oral health behavior of their children. This demonstrates that electronic messaging can be useful in changing not only oral health and dietary behavior of individuals but also their attempt to influence others (Hashemian, Kritz-Silverstein, & Baker, 2015). In connection to the PALS messaging intervention, the messages to the parents similarly attempt to change their behaviors towards their children’s oral health and dietary habits.

The “Keep on Brushing” study also tested motivational text messaging, but in young adults as opposed to parents. It aimed to increase frequency of toothbrushing in participants ages 18-24. After 9 weeks of the intervention, self-reported tooth brushing at least 2 times a day went from 51% at baseline to 73%, showing a significant increase, once again showing confirming the promising potential for technological intervention (Schluter et al., 2015). More aligned with the aims of the present thesis and brief behavioral intervention, the Brushing Reminder 4 Good Oral Health trial in the United Kingdom focuses on participants aged 11-13 years old in a classroom setting. This trial involves an in-class session on behavior change and tests the effectiveness of twice daily SMS reminders to brush teeth in comparison to a no SMS messaging control group. The findings of this may yield more insight on how the middle schoolers from the non-clinical Windsor Public Middle School data set would respond to the messages created above (Marshman et al., 2019).

Moreover, the current thesis applied to a clinical setting shows great potential for effective usage of the waiting room and patients’ time. An investigation done at Harvard Medical
School found that primary care waiting rooms throughout the health care system are usually not used to engage patients in health education. It was suggested that both printed and technological methods for delivering information can be effective (Beckwith et al., 2016). While the current thesis utilizes technology through the PALS completion and messaging on a tablet or Smartphone, paper handouts and pamphlets that can be taken home may further enforce the messages being delivered. A cross-sectional study on the effectiveness of health education materials in waiting rooms had more than two-thirds of participants report finding leaflets in the waiting room useful (Maskell et al., 2018). A further investigation surveyed 360 individuals on specifically pamphlets, and 90% reported wanting to receive a pamphlet during office visits. More importantly, 67% reported reading them and saving them, while only 2% threw them away without looking at them (Shank, 1991). This shows the potential for physical materials in addition to technological. Such pamphlets may have a lasting impact for tangibility and being an item that patients can take with them. Providers have been skeptical about using patients time in the waiting area for fear of it being negatively perceived, but the opposite has been found. Regardless of the form of the intervention, educational intervention in the waiting room has been significantly positively associated with patient satisfaction, as compared to a control group that experienced usual clinical care and no intervention (Oermann, 2018). Overall, the waiting room provides an excellent opportunity to improve visit satisfaction and patient knowledge, thereby also possibly improving health behaviors.

5.2 Strengths and Limitations

There are a couple notable limitations of this study. To begin, the data collected from the survey was self-reported, introducing higher possibility for inaccuracy. The non-clinical data were taken only from one middle school, minimizing its external validity and generalizability to
children of these ages in other areas. There was no control group for comparison to the experimental group. The full dental messages were tested prospectively only on a small number of children and fewer parents. Moreover, a leading strength of this study comes from the pure engagement of participants. It involved children as well as parents allowing for a more comprehensive intervention, and conveyed information whether it reinforced positive behaviors or encouraged advantageous behavior change. The messages also had strong roots in theory rather than being simply instructional.

5.3 Conclusion

It is evident that dental hygiene and dietary behaviors are crucial to not only oral health but overall health. Due to the large variability in individual liking and practices, tailored health behavior interventions are necessary to for positive behavior change. Future versions of this study could benefit from following up on oral health status after messaging, and possibly use data to show importance of follow up visits. Furthermore, there is potential for such interventions to be implemented in dental offices. Patients could fill out the survey pre-admission or in the waiting room, and have hygienists reinforce the prompted message with additional materials such as pamphlets on oral hygiene and obesity prevention. Lastly, participants would likely benefit from this intervention if it was longer. Delivery of text messages over an extended period or creation of private social media groups would further take advantage of technology for behavioral intervention.


