

**TOOTH WHITENING PROCEDURES AND ORTHODONTIC TREATMENT:
A SURVEY OF ORTHODONTISTS**

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A thesis submitted to the faculty of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements for the degree of Master of Science in the
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ABSTRACT

MAURA E. SLACK: Tooth Whitening Procedures and Orthodontic Treatment:
A Survey of Orthodontists
(Under the direction of Dr. Ceib Phillips)

Introduction: Esthetics is increasingly important in modern dentistry, but there are no published reports about how tooth whitening is utilized within contemporary orthodontic practices in the United States. **Methods:** A weighted sample of American Association of Orthodontists members were surveyed to quantitatively and qualitatively assess orthodontists' current practices regarding tooth whitening procedure. **Results:** 1,182 surveys were eligible for analysis. Nationwide, 88.8% orthodontists had patients who requested tooth whitening, while 76.2% of orthodontists had recommended whitening for some of their orthodontic patients, typically less than 25% of their total patient population. Approximately one-third (32.8%) of orthodontists provided whitening and nearly two-thirds (65.8%) referred whitening procedures to other dental professionals. **Conclusion:** Almost all orthodontists encounter patients who request whitening procedures and the majority recommend their use for a small percentage of their patients. The proportion of orthodontists who refer out such procedures is nearly double the proportion that provides these procedures.

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TABLE OF CONTENTS

LIST OF TABLES.....	vi
LIST OF FIGURES.....	.vii
I. LITERATURE REVIEW	1
A. REFERENCES	11
II. MANUSCRIPT.....	16
A. INTRODUCTION	16
B. MATERIALS AND METHODS	18
C. RESULTS.....	20
D. DISCUSSION	24
E. CONCLUSION	27
F. FIGURES.....	28
G. TABLES.....	31
H. REFERENCES.....	45
III. APPENDIX A: SAMPLE TELEFORM SURVEY.....	34
IV. APPENDIX B: RESPONDENTS BY REGION.....	36
V. APPENDIX C: NATIONAL SURVEY RESPONSES, WEIGHTED	37
VI. APPENDIX D: REGIONAL SURVEY RESPONSES, UNWEIGHTED	38
VII. APPENDIX E: REGIONAL FREQUENCY RESPONSES, UNWEIGHTED	39
VIII. APPENDIX F: TYPE OF REFERRAL UTILIZED BY REGION	44

LIST OF TABLES

Table 1. Weighted Sampling Frame	31
Table 2. National Results.....	32
Table 3. Odds Ratio for Outcomes Relative to South Atlantic Region	33

LIST OF FIGURES

Figure 1.1 Delivery Options for Tooth Whitening	2
Figure 2.1 Sample Response.....	28
Figure 2.2 Recommendation of OTC Whitening Products (% of Patients).....	28
Figure 2.3 Recommendation of Custom Tray-Applied Whitening Gel (% of Patients).....	29
Figure 2.4 Referral of Whitening Procedures (% of Patients)	29
Figure 2.5 Utilization of Referrals Nationwide, Weighted	30

I. LITERATURE REVIEW

TOOTH WHITENING

Background

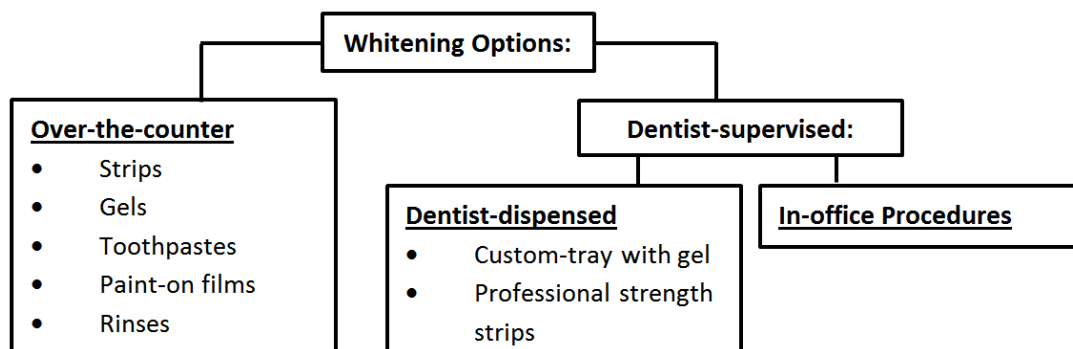
The demand for tooth whitening has grown exponentially in the last twenty years as cosmetic procedures become more acceptable and desirable by the general public. Patients frequently ask dental professionals about the advantages and disadvantages of different whitening options, and it is imperative that the dental community base its recommendations on sound scientific evaluations conducted in well-designed and independent studies.

The precise mechanism underlying the dental whitening process is not fully understood; however, it is believed to be an oxidative reaction. Hydrogen peroxide is the active ingredient in tooth whitening agents. As hydrogen peroxide degrades, free radicals are produced and are able to diffuse rapidly through both enamel and dentin. These free radicals are strong oxidizers able to cleave double bonds of pigmented compounds into small molecules that either diffuse out of the tooth or absorb less light (1-3).

Many delivery options for tooth whitening are available today and they can be classified as over-the-counter (OTC) or dentist-supervised. OTC whitening product options include gums, rinses, dentifrices, paint-on films, gels, and whitening strips (4). Dentist-supervised whitening procedures can be divided into dentist-dispensed whitening

products and in-office whitening procedures. Dentist-dispensed whitening products primarily consist of either custom trays with whitening gels typically containing 10-15 percent carbamide peroxide or professional strength whitening strips containing 14 percent hydrogen peroxide. Ten percent carbamide peroxide degrades into 3.35 percent hydrogen peroxide and 6.65 percent urea (1). In-office techniques usually use a 30-35 percent concentration of hydrogen peroxide, and they are often used in combination with an activating agent such as light or heat (1, 2, 5).

Figure 1. Delivery Options for Tooth Whitening



History

The use of peroxides as tooth whitening agents can be traced back more than a century. From the mid-to-late 1800s to the early 1900s, there were 40-60 articles each year about dental bleaching. Dentistry was in an era of affluence, and conservative techniques to preserve tooth structure were the standard. Most reports focused on bleaching non-vital teeth, although reports about the use of hydrogen peroxide to whiten individually discolored vital teeth were also included (2).

Although little was written about dental bleaching during World War I, the Great Depression, and World War II, articles began to reappear as the economy recovered and national communication improved in the 1940s and 1950s (2). In 1968, a serendipitous discovery was made by Dr. Bill Klusmier, an orthodontist in Fort Smith, Arkansas. He prescribed the use of an oral antiseptic product, *Gly-oxide*, to be used with orthodontic positioners for the purpose of reducing gingival inflammation. Not only did his patients' gingival health improve, Dr. Klusmier noticed that their teeth were also whiter. *Gly-oxide* contained 10 percent carbamide peroxide (6).

Although Dr. Klusmier shared his discovery at several table clinics at the Arkansas State Dental Society and the Southwestern Orthodontic Society, the technique went relatively unnoticed (2). Years later, Dr. John Munro, a general dentist in Tennessee independently recognized the tooth whitening effects of a 10 percent carbamide peroxide solution he was prescribing to control inflammation after periodontal root planing. His technique involved the fabrication of a vacuum-formed plastic splint and instructing patients to apply the oral antiseptic solution two to three times each day. Dr. Munro shared his findings with a manufacturer, which resulted in the production of the first commercial tooth whitening agent in 1988 (6).

One year later in 1989, Haywood and Heymann published the first clinical report of a bleaching technique being used by members of the Coastal Dental Study Club of North Carolina known as nightguard vital bleaching. Their technique utilized a more viscous 10 percent carbamide peroxide oral antiseptic product, *Proxigel*, in a vacuum-formed custom tray that was worn overnight for 2-5 weeks (7). Haywood and Heymann's article, coupled with the introduction of the first commercial tooth whitening

agent, is credited with dentistry's surge of interest in vital tooth bleaching (2, 6, 7). In fact, the custom-tray bleaching technique is now taught at nearly all United States dental schools (8).

Indications for Orthodontic Patients

Whitening products and procedures may be indicated for orthodontic patients for a number of reasons. A comprehensive review of each patient's esthetic concerns prior to initiating treatment may reveal dissatisfaction with tooth color in addition to the typical complaints regarding alignment and jaw relationships. Studies have shown that the majority of children feel their teeth are too yellow and they are more critical of their tooth color than their own parents and dentists (9). Younger patients also express a greater preference for white teeth than older patients, but adult patients still identify tooth color followed by poor tooth alignment as primary factors influencing their satisfaction with their dental esthetics (10, 11). Considering these findings, one can see why Lawson and colleagues believe dental professionals should address both the issues of color aberrations and tooth positioning prior to initiating orthodontic treatment (12).

Tooth whitening has also been recommended to reduce the appearance of one of the most common complications of orthodontic treatment – white spot lesions. After allowing time for the lesions to remineralize naturally, bleaching is recommended to reduce the contrast between the white spot lesion and adjacent enamel – a conservative approach before microabrasion or restorative treatments are considered (13). This camouflage technique has been shown effective by colorimetry and patients' evaluation of the outcome (14).

Furthermore, a randomized clinical trial, albeit small, found that patients reported greater satisfaction with their orthodontic outcome when it was followed by cosmetic whitening, irrespective of whether an in-office or take-home technique was used (15). Patients should be warned, however, that orthodontically debonded teeth initially respond more slowly than untreated teeth, but this difference become insignificant over a period of thirty days (16).

Perhaps the most overlooked application of whitening products and procedures in orthodontics is their ability to maintain or improve oral health during active treatment. It is important to note, however, that the reports regarding these benefits utilize carbamide peroxide, not hydrogen peroxide, and therefore these properties may be unique to whitening products that contain carbamide peroxide.

As early as 1978, the gingival benefits were demonstrated in orthodontic patients following the incorporation of carbamide peroxide into their daily oral hygiene regimen. Orthodontic patients who were instructed to apply *Gly-Oxide* daily in addition to normal toothbrushing demonstrated a statistically significant reduction in the gingival index and oral debris index when compared to patients who were instructed on toothbrushing alone (17). Furthermore, in patients where oral hygiene is withheld, the use of *Gly-Oxide* alone resulted in a statistically significant reduction in gingivitis relative to controls (18). The proposed mechanisms for the improvement of gingival health with carbamide peroxide include alteration of the plaque microflora, physical debridement properties of the hydrogen peroxide, and an increased concentration of local oxygen which could promote tissue healing (18, 19).

In addition, research has shown that the urea component of carbamide peroxide increases the salivary and plaque pH levels of the mouth, even overpowering the intrinsically acidic nature of the bleaching agent (20). This buffering capacity of urea elevates plaque and salivary pH levels far above the critical pH at which enamel and dentin begin to dissolve, resulting in a potentially cariostatic benefit of carbamide peroxide whitening agents (19). The use of carbamide peroxide-based whitening products and procedures during active orthodontic treatment could both improve gingival health and reduce caries susceptibility, although the clinical research to support this theory has not yet been completed.

Effectiveness and Shade Change Stability

The use of hydrogen peroxide to whiten teeth has been proven effective compared to placebo or no bleaching treatment in many studies (21-27). Although most studies involve adults, the effectiveness of hydrogen peroxide whitening strips and carbamide peroxide gel delivered in custom-trays also has been demonstrated in children and adolescents (28, 29).

There are marked differences in the efficacy of various whitening products in the short term. The concentration of hydrogen peroxide in a whitening gel greatly affects the number of applications required to produce an ideal shade outcome (30). For example, whitening strips containing 14 percent hydrogen peroxide provide a greater improvement in tooth color and faster whitening onset than whitening strips containing only 6 percent hydrogen peroxide after two weeks (31). Similarly, the overnight use of 15 percent

carbamide peroxide gel in a custom-tray is more effective than the use of a 10 percent carbamide peroxide gel after 2-4 weeks (32).

Many studies have compared the effectiveness of different delivery options in the short term as well. A paint-on gel of 18 percent carbamide peroxide is less effective than a whitening strip of 6 percent hydrogen peroxide or custom-tray delivered whitening gel of 5 percent carbamide peroxide (33, 34). A meta-analysis comparing the effectiveness of whitening strips with a 5.3-6.5 percent concentration of hydrogen peroxide to custom-tray delivered whitening gel found the strips to be more effective than the gel when 10 percent carbamide peroxide was used in the trays; however, the custom-tray delivered whitening technique was more effective when a gel containing more than 15 percent carbamide peroxide was used (4).

Although most tooth whitening studies have reported their findings over the short term (2-4 weeks), the difference in effectiveness appears to diminish when results are evaluated over a longer period (6-12 weeks) (32, 35, 36). While tooth whitening is both time and dose dependent, it appears that in the long run, the final shade change is independent of the concentration of bleaching agent and is more time dependent (37). In other words, higher concentrations of bleaching agents will work faster, but given enough time, lower concentrations will work just as well.

Several studies report stability of the color improvement for 6 or more months (22, 24, 26, 38-41). Two long-term studies of patients who used custom-tray applied whitening gel for tetracycline-stained teeth showed that the majority of patients maintained whitening improvement over 5 and 7 years (42, 43). Based on the current color stability data, it is recommended that patients be advised that the degree and

stability of whitening cannot be determined prior to treatment; however, the shade improvement is likely to persist for 2-3 years (2, 40, 41).

Side Effects

A number of side effects have been reported with dental whitening treatment, but tooth sensitivity and gingival irritation are the most common (1, 4). One study showed that tooth sensitivity was more frequent with whitening strips, while gingival irritation was more frequent with custom-tray delivered whitening gel; however, the incidence of these complaints varies widely (1, 4, 44). Improper fit of the custom tray itself can cause gingival irritation (2). Although it would seem intuitive that a higher concentration of bleaching agent would cause more tooth sensitivity and gingival irritation, studies generally have contradicted this theory (32, 45).

The development of tooth sensitivity does not seem to be related to patient age, gender, pulp size, dental arch treated, or presence of exposed dentin or cementum, caries, or leaking restorations (2, 46). The risk of sensitivity does increase with more frequent application of the whitening agent or the presence of gingival recession (46, 47). Anecdotally, it has also been suggested that a history of generalized hot and cold sensitivity or reports of sensitivity during dental prophylaxis are also good predictors of tooth sensitivity during tooth whitening (46). Sensitivity can be reduced or prevented by treating the teeth with desensitizing agents containing an active 3 percent potassium nitrate and 0.11 percent fluoride for 30 minutes prior to whitening (48). Moreover, both tooth sensitivity and gingival irritation seem to resolve independently with a reduction in

the duration or frequency of bleaching agent application or complete termination of the whitening treatment (49).

Less frequently reported side effects of whitening treatment include sore throat, burning palate, unpleasant taste, and a laxative effect (primarily due to the glycerin component of the whitening agent) (1). Cervical root resorption has been associated with internal bleaching of non-vital teeth; however, this process is poorly understood. The resorption could be related to a prior history of trauma, pH of the bleaching agent, or the historical use of heat during intracoronal tooth whitening procedures (50, 51).

Finally, the effect of whitening agents on the integrity of enamel or restorative materials has been questioned. Although there is *in vitro* evidence that more acidic bleaching agents cause more surface erosive effects than less acidic bleaching agents, other research has showed that whitening agents alone do not cause significant changes to enamel hardness or roughness (52-54). Tooth whitening agents can cause restorative surface changes that vary by material and exposure time, but the changes are of questionable clinical significance and can be reduced by polishing restoration surfaces prior to bleaching (55, 56).

Hydrogen Peroxide: Safety Concerns

Hydrogen peroxide is a ubiquitous compound. It is a popular topical antiseptic agent whose oxidative capacity can inactivate both viruses and bacteria. Hydrogen peroxide has also been used in food processing, and it is present in vegetables, wine, fruit juices, and coffee. In fact, it even occurs naturally within the body as a normal

intermediate metabolite and an important component of phagocytic cells such as neutrophils and macrophages (5, 6).

Nevertheless, it is well known that free radicals are formed as hydrogen peroxide degrades, and free radicals can damage proteins, lipids, and nucleic acids. In fact, it is thought that damage in cells by free radicals is the main mechanism associated with carcinogenesis, aging, stroke, and other degenerative diseases (6).

Considering the risks associated with free radicals, the toxicity of hydrogen peroxide and carbamide peroxide has been studied extensively. Fortunately, the body has several endogenous mechanisms to repair damages and the outcomes appear to be dose-related. All studies indicate that at the doses administered for tooth whitening, there have been no reports of allergic reaction, general toxicity, genotoxicity, or carcinogenicity in humans (2, 5, 6, 50, 57). Nevertheless, concern still persists among some who question whether OTC whitening agents are being overused or abused, and have recommended additional regulation and investigation (50, 58).

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II. MANUSCRIPT

INTRODUCTION

The field of tooth whitening changed dramatically in the late 1980s when the first commercial tooth whitening agent became available and the nightguard vital bleaching technique was first described in the literature (1, 2). Fueled by direct consumer marketing and the media's role in reporting scientific advances, the focus of tooth whitening shifted from the bleaching of individually discolored non-vital teeth or tetracycline-stained teeth to a general desire for a 'whiter smile' for an esthetically-conscious public. The demand for tooth whitening has grown almost exponentially in the last twenty years, and tooth whitening products are now one of the most popular oral care product categories (3). Today, whiter teeth may even be culturally important, as research has shown that an individual's dental appearance can influence how he or she is perceived by others (4-7).

Whitening procedures may be indicated for orthodontic patients for a number of reasons. The majority of children feel their teeth are too yellow and children are more critical of their tooth color than their own parents and dentists (8). Younger patients also express a greater preference for white teeth than older patients, although adult patients still identify tooth color and poor tooth alignment as primary factors influencing their satisfaction with their dental esthetics (9, 10). Considering these findings, it has been

suggested that issues of both color aberrations and tooth positioning should be discussed prior to initiating orthodontic treatment (11).

Tooth whitening also has been recommended to reduce the appearance of one of the most common complications of orthodontic treatment – white spot lesions. After allowing time for the lesions to remineralize naturally, bleaching is recommended to reduce the contrast between the white spot lesion and adjacent enamel – a conservative approach before microabrasion or restorative treatments are considered (12). This camouflage technique has been shown effective by colorimetry and patients' evaluation of the outcome (13). Furthermore, a randomized clinical trial found that patients reported greater satisfaction with their orthodontic outcome when it was followed by cosmetic whitening, irrespective of whether an in-office or at-home technique was used (14).

Perhaps the most overlooked application of whitening agents in orthodontics is their ability to maintain or improve oral health during active treatment. As early as 1978, gingival benefits were demonstrated in orthodontic patients by the incorporation of carbamide peroxide into their daily oral hygiene regimen (15). Research also has shown that the urea component of carbamide peroxide causes a rise in the salivary and plaque pH levels of the mouth, overcoming the intrinsically acidic nature of some bleaching agents (16). This buffering capacity of urea elevates plaque and salivary pH levels far above the critical pH at which enamel and dentin begin to dissolve, resulting in a potentially cariostatic benefit of carbamide peroxide whitening agents (17). The use of carbamide peroxide-based whitening products and procedures during active orthodontic treatment could both improve gingival health and reduce caries susceptibility, although the clinical research to confirm this theory is still lacking.

Currently, there are no data reporting how whitening products and procedures are utilized by orthodontists in the United States (US). The purpose of this study was to conduct a nationwide survey of private-practice American Association of Orthodontists (AAO) members to quantitatively and qualitatively assess orthodontists' current practices regarding tooth whitening procedures.

MATERIALS AND METHODS

Survey development. The data collection instrument was designed specifically for this project. The instrument was pilot-tested by eight private practice orthodontists who teach part-time in the Department of Orthodontics at the University of North Carolina at Chapel Hill School of Dentistry. Their comments regarding clarity, content, and length were used to develop the final national survey.

The final questionnaire consisted of close-ended items on practitioner demographics and frequency categories of current practice behaviors regarding patient requests for whitening procedures and provider recommendation, provision, and referral of whitening procedures. If whitening procedures were recommended, provided, or referred, the survey asked which types of procedures were utilized.

The project was approved by the University of North Carolina at Chapel Hill Biomedical Institutional Review Board and the AAO Survey Review Committee.

Survey participants and procedures. The sampling frame consisted of the 9,160 active AAO members in the US obtained directly from the AAO in October 2010. The sampling frame was organized by the nine geographic regions used in the *Journal of Clinical Orthodontics* (JCO) Orthodontic Practice Surveys (18). Because the numbers of

orthodontists varied among the regions, a weighted random sample was drawn from each region, yielding a total sample of 3,601 (Table 1). The sampling procedures were designed to obtain information for a representative sample of orthodontists practicing in the US.

Email addresses for the potential respondents were located using the AAO online and paper member directories. For those with an email address, an email was sent describing the project, explaining their rights as research participants, and asking them to complete an online survey (Qualtrics Labs Inc., Provo, UT). Reminder emails were sent one and two weeks after the initial contact for a total of three electronic contacts. After closing the electronic version of the survey, a paper questionnaire (Cardiff TeleForm, Vista, CA) was mailed to all non-respondents and to those members who did not have an email address initially available. The mailing included a postage-paid envelope and cover letter. To maintain confidentiality, all electronic and paper surveys were numerically coded and participants were asked not to include any personal information on the survey. To prevent duplicate mailings, a linkage file was maintained by the Primary Investigator (M.E.S.) and destroyed at the end of the study. Respondents were excluded if they refused to complete the survey, the survey was illegible, or the respondent was not currently working in a private orthodontic specialty practice.

Data collection and analysis. Data from the electronic surveys were downloaded from the Qualtrics online account and merged with the paper survey responses after the Teleform questionnaires were scanned and entered into an Access database (Microsoft Access 2010, Redmond, WA). The primary outcomes (receipt of whitening requests from patients, active engagement in recommending whitening procedures, active

engagement in providing whitening procedures, and active engagement in referring whitening procedures) were analyzed separately by logistic regression. The geographic region of the country and community size of the orthodontic practice were considered primary explanatory variables. The estimates from each logistic regression (Proc Surveyfreq; Proc Surveylogistic – SAS version 9.2, Cary, NC) were adjusted for the unequal probabilities of selection and non-response and a finite population correction was used, because of the high sampling rate, when variance estimates were determined (Table 1). The level of significance was set at 0.05.

RESULTS

Response rate. Data collection began on June 7, 2011 and ended on December 2, 2011. Four hundred forty-five electronic surveys were completed and 777 paper surveys were returned, for a total of 1,222 surveys. Thus, the overall national response rate was 33.9%. Forty-one surveys did not meet the inclusion criteria and were excluded prior to analysis (Figure 1).

Sample characteristics. Respondents to the survey represented all geographic regions of the United States. The response rates were similar for the geographic regions, although the East North Central region had the highest response rate (38.1%) and the New England (28.5%), Mountain (28.6%) and Middle Atlantic (28.9%) regions the lowest. Most respondents practiced full-time (average 31.7 hours per week) and were quite experienced (average 20.7 years post-graduation). Mountain region respondents completed their training most recently (average 13.5 years post-graduation), while New

England respondents had the most years of experience (average 22.0 years post-graduation). Communities of all sizes were represented nationwide (Table 2).

Survey Results: Patient Requests. Nationwide, 88.8% of orthodontists reported that patients had requested whitening procedures within the last six months (Table 2). Of these orthodontists, nearly 78% reported that fewer than 25% of their patients requested whitening.

Geographic region of the country ($p = 0.004$) had a statistically significant effect on the proportion of orthodontists that had patients request whitening procedures, while community size ($p = 0.40$) did not. The region with the highest percentage of orthodontists whose patients made whitening requests was in the East South Central region (95.2%), while the West North Central region had the lowest (82.1%).

Relative to North Carolina (NC) and other states in the South Atlantic region, orthodontists in the East South Central, East North Central, Mountain, and West South Central regions were more likely to receive whitening requests, while orthodontists in the New England, Middle Atlantic, West North Central, and Pacific regions were less likely to receive whitening requests (Table 3).

Survey Results: Recommendation. Approximately three-fourths of orthodontists nationwide (76.2%) had recommended whitening procedures for some of their orthodontic patients within the last six months (Table 2). Most orthodontists who recommended whitening procedures did so for less than 25% of their patients; however, a small percentage (12% for adults and 14% for adolescents) recommended OTC whitening products for more than 75% of their patients (Figure 2).

Nationally, OTC whitening products were the most frequently recommended option for both adults and adolescents, closely followed by at-home (dentist-supervised) options and lastly, in-office whitening procedures. The mean minimum age of a patient for which these orthodontists would recommend whitening was 14.9 years.

Geographic region of the country ($p = 0.0006$) had a statistically significant effect on the proportion of orthodontists who recommended whitening procedures, while community size ($p = 0.16$) did not. Overall, the West North Central region had the lowest percentage of orthodontists who recommended whitening procedures for their orthodontic patients (65.1%), while more than 80% of the respondents from the South Atlantic (81.2%), East South Central (80.6%), Mountain (83.3%), and West South Central (82.%) regions had recently recommended whitening procedures.

Relative to NC and other states in the South Atlantic region, orthodontists in the New England, Middle Atlantic, East South Central, East North Central, West North Central, and Pacific regions were less likely to recommend whitening procedures for their orthodontic patients (Table 3). Orthodontists in the Mountain and West South Central regions were slightly more likely to recommend whitening procedures than South Atlantic orthodontists.

Survey Results: Provision. Only 32.8% of orthodontists nationwide provided whitening procedures within their orthodontic practice within the last six months (Table 2). Moreover, the vast majority of orthodontists who provided whitening procedures within their specialty practice did so for less than 25% of their patients. A small percentage (13% for adults and 10% for adolescents), however, provided custom-tray applied gel for home use to more than 75% of their patients (Figure 3).

For both adults and adolescents, custom tray-applied gel for home use was the most frequent whitening option chosen by orthodontists nationwide who provide whitening procedures, followed by OTC products and professional-strength whitening strips. The mean minimum age of a patient for which these orthodontists would provide whitening was 14.6 years.

Geographic region of the country ($p < 0.0001$) had a statistically significant effect on the proportion of orthodontists that provided whitening procedures, but community size ($p = 0.46$) did not. Fewer than 20% of respondents from the New England (19.8%) and West North Central (19.2%) regions provided whitening procedures within their specialty practice, while more than half of the respondents from the Mountain region (54.4%) provided some form of whitening product or procedure within their orthodontic specialty practice.

Relative to NC and other states in the South Atlantic region, orthodontists in the New England, Middle Atlantic, East South Central, East North Central, and West North Central regions were less likely to provide whitening procedures for their orthodontic patients (Table 3). Orthodontists in the Mountain, West South Central, and Pacific regions were more likely to provide whitening procedures within their specialty practice than South Atlantic orthodontists.

Survey Results: Referrals. Nationwide, 65.8% of orthodontists recently referred whitening procedures to other dental providers (Table 2). Neither geographic region of the country ($p = 0.21$) nor community size of the practice ($p = 0.67$) had a statistically significant effect on the active referral of whitening procedures. When those orthodontists who had recently referred whitening procedures to other providers were

asked what percentage of patients who requested whitening and to whom whitening was recommended were subsequently referred, one-third (33.6%) did so for more than 75% of these patients (Figure 4).

When orthodontists who refer whitening procedures out of their orthodontic practice were asked which type of referrals they had recently suggested, 83.3% had referred for professional-strength whitening strips, 72.8% for in-office bleaching with light activation, 50.0% for custom tray-applied whitening gel, and 49.9% for in-office bleaching without light activation (Figure 5). A generic referral (specific whitening treatment to be determined by the other practitioner) was the least common, as only 43.2% of referring orthodontists had used this type of referral within the prior six months.

DISCUSSION

The overall response rate of 34%, although low, was comparable to other surveys of orthodontists in the United States. Recently published surveys of AAO members report response rates ranging from 18% to 39% (19-23). For example, a similar nationwide survey of a sample of AAO members (1,000) regarding current practices relative to the use of soft tissue lasers yielded a response rate of 33% (22). The response rate was likely affected by respondents who, although the survey asked them to return a blank survey if not eligible, chose not to respond because they had recently retired or practiced within an academic institution rather than a private practice scenario. It is also reasonable to assume that some orthodontists chose not to respond because they did not utilize whitening agents at all, or perhaps felt that the use of tooth whitening agents in orthodontics was inappropriate for practice management or safety reason.

Hydrogen peroxide is the active bleaching agent in most whitening products, and as it degrades, free radicals are produced which are able to diffuse rapidly through both enamel and dentin. These free radicals are strong oxidizers and are able to cleave double bonds of pigmented compounds into small molecules that either diffuse out of the tooth or absorb less light (24-26). Nevertheless, it is well known that free radicals also can damage proteins, lipids, and nucleic acids (1). Considering the risks associated with free radicals, the toxicity of hydrogen peroxide has been studied extensively. All studies indicate that at the doses administered for tooth whitening, there have been no reports of allergic reaction, general toxicity, genotoxicity, or carcinogenicity in humans (1, 25, 27-29, 29). Regardless, concern still persists among some who question whether OTC whitening agents are being overused or abused, and have recommended additional regulation and investigation (27, 30).

Overall, the results from the US orthodontists are similar to the only other published data on the current utilization of whitening procedures by dental professionals, a recent survey of orthodontists and general practitioners in the United Kingdom (UK). While 89% of orthodontists in the United States reported that they recently had patients request whitening, 92% of both UK groups stated that bleaching had been requested. More US orthodontists (33%) than UK orthodontists (23%) provided whitening procedures, although both groups preferred at-home bleaching options compared to in-office techniques. The majority of US (66%) and UK (76%) orthodontists refer whitening procedures out of their specialty practices (24).

In our sample, there was a discrepancy between the proportion of orthodontists who had patients request whitening procedures (89%) and the proportion of orthodontists

who recommended whitening procedures (76%). This difference may be entirely appropriate, as whitening procedures may not be indicated for every patient who requests them – e.g., an adult patient with numerous composite or ceramic restorations. On the other hand, this discrepancy could also be attributed to a lingering paternalistic philosophy on the part of orthodontists who feel that whitening procedures should be reserved as a cosmetic option for adults alone despite their adolescent patients' potential dissatisfaction with tooth color. Furthermore, some orthodontists may withhold a recommendation of whitening procedures due to lingering safety concerns.

Many factors might contribute to the provision and referral decision of an orthodontist. The statistical analysis indicated that geographic region had a significant effect on the proportion of orthodontists who actively recommend and provide whitening procedures, although no such effect was noted for referrals. The decision to provide whitening services could be heavily influenced by the norms for the scope of orthodontic practice within a given region. It could also be affected by differences in the patient population's disposable income or the general economic status of a particular region. Aside from regional differences, the decision is likely influenced by multiple practice management considerations such as additional overhead expenses, allocation of chairtime for the management of bleaching side effects, or the potential impact on referral sources.

This survey clearly demonstrates that a high percentage of orthodontists have patients who request whitening procedures, highlighting the need for orthodontists to stay current with whitening research. Additionally, orthodontic/whitening-specific research, such as clinical trials to demonstrate whether the use of whitening agents during active orthodontic treatment could reduce caries susceptibility, reduce the incidence of white

spot lesions, or increase overall satisfaction with treatment, are needed to help establish evidence-based practice decisions for orthodontists. Post-treatment investigation into the influence of whitened teeth (with or without a history of white spot lesions) on societal judgments of an individual's esthetics and personality would also be useful as we strive to recommend and provide the best for our patients.

CONCLUSIONS

- Because most orthodontists will encounter patients who request whitening products and procedures, a familiarity with the rapidly-evolving whitening literature is prudent for practitioners.
- Geographic region of the country had a statistically significant effect on the proportion of orthodontists who received whitening requests, recommended whitening products and procedures, and provided whitening products and procedures within their orthodontic specialty practice.
- Nationwide, the majority of orthodontists refer whitening procedures to other dental professionals, although a minority provide whitening services within their orthodontic practice.

MANUSCRIPT FIGURES

Figure 1. Sample Response

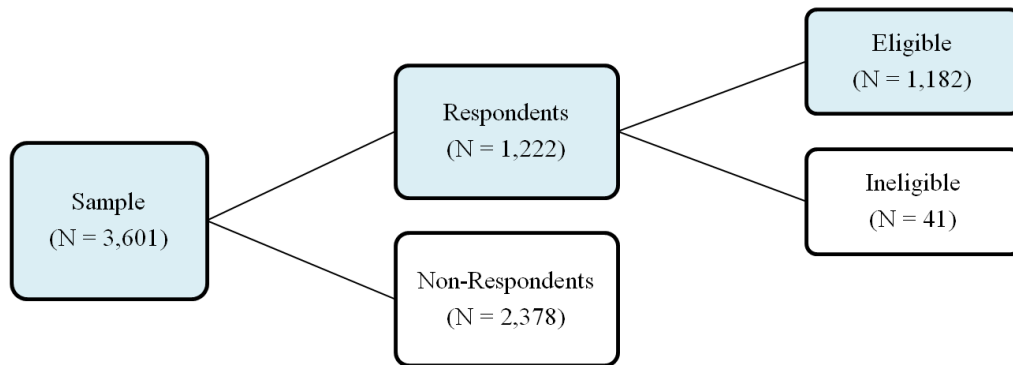


Figure 2. Recommendation of OTC Whitening Products (% of Patients)

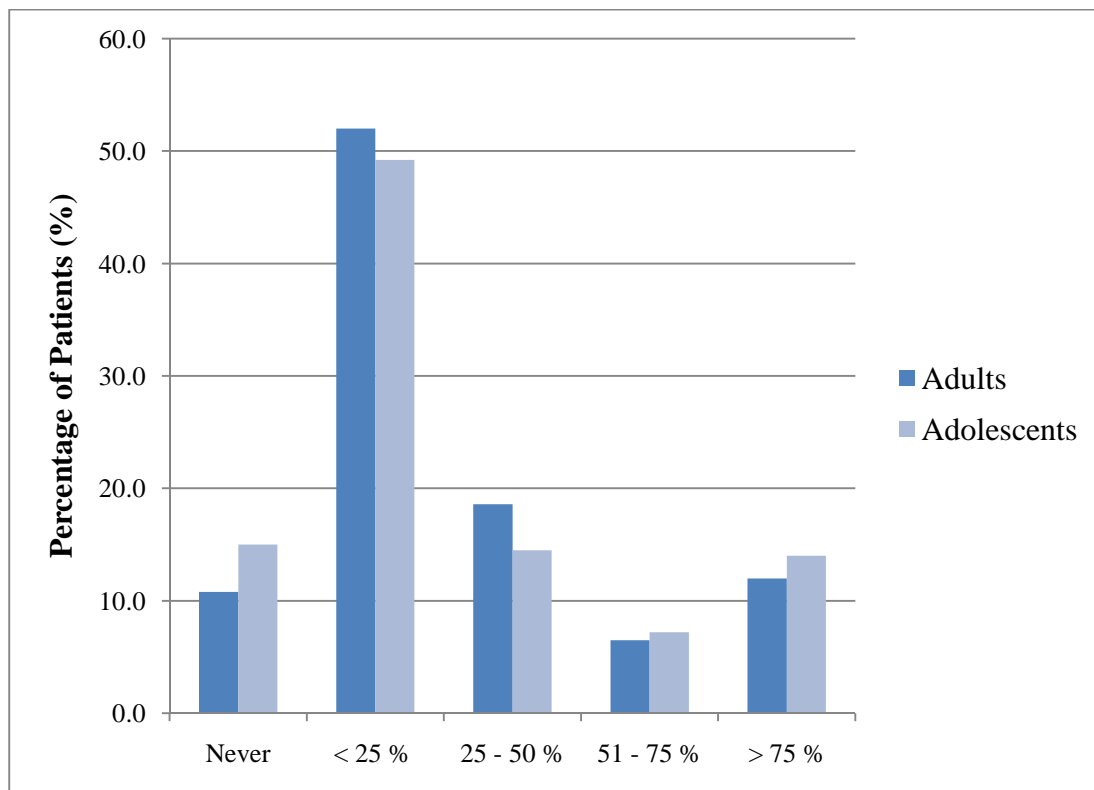


Figure 3. Recommendation of Custom Tray-Applied Whitening Gel (% of Patients)

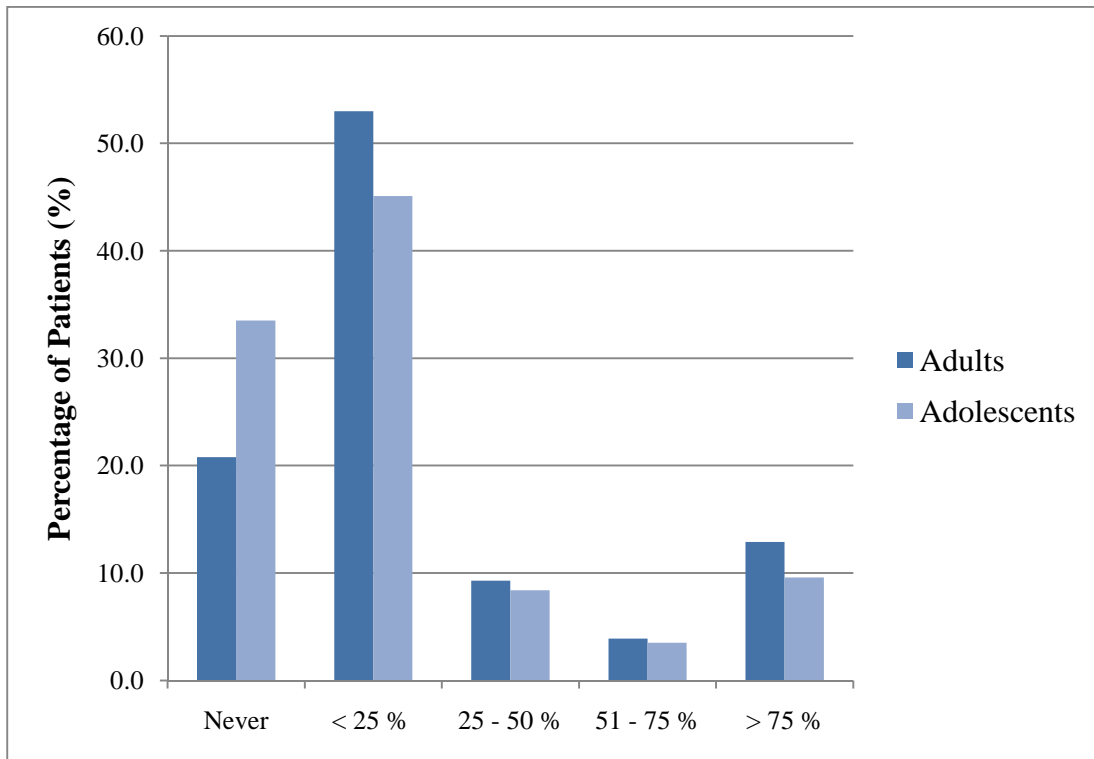


Figure 4. Referral of Whitening Procedures (% of Patients)

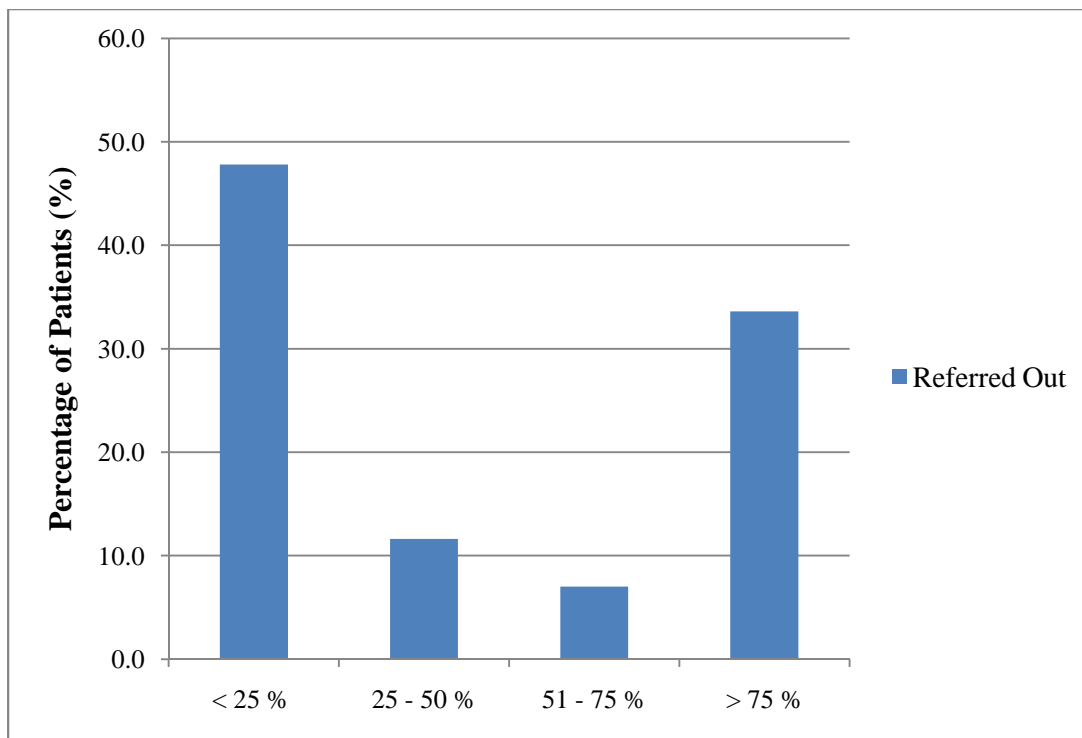
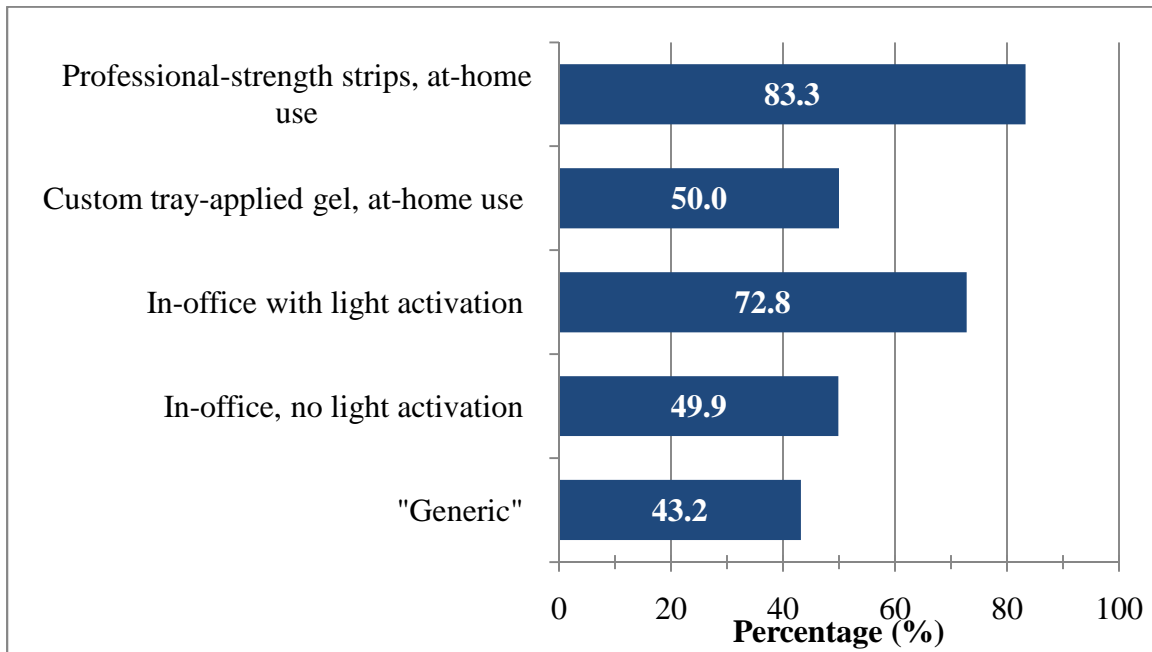


Figure 5. Utilization of Referrals Nationwide, Weighted



MANUSCRIPT TABLES

Table 1. Weighted Sampling Frame

	Sampling Frame (Initial)	Sampled	Response Rate	Sampling Weight
New England CT, ME, MA, NH, RI, VT	574	319	28.5%	0.82
Middle Atlantic NJ, NY, PA	1361	471	28.9%	1.30
South Atlantic DE, DC, FL, GA, MD, NC, SC, VA, WV	1600	497	36.8%	1.13
East South Central AL, KY, MS, TN	459	280	36.8%	0.58
East North Central IL, IN, MI, OH, WI	1252	457	38.1%	0.94
West North Central IA, KS, MN, MO, NE, ND, SD	528	305	34.8%	0.64
Mountain AZ, CO, ID, MT, NV, NM, UT, WY	718	360	28.6%	0.91
West South Central AR, LA, OK, TX	945	409	32.5%	0.92
Pacific AK, CA, HI, OR, WA	1663	503	30.4%	1.43

Table 2. National Results

	Mean	(95%CI)
Years in Practice	20.7	19.8 - 21.5
Hours/Week in Practice	31.7	31.3 - 32.0
Community Size	%	(95%CI)
Rural	9.7	8.1 - 11.3
Small City	31.4	28.9 - 34.0
Large City	34.5	31.9 - 37.2
Metro	24.3	21.9 - 26.7
% Orthodontists	%	(95%CI)
Whitening Procedures Requested	88.8	87.0 - 90.6
Whitening Procedures Recommended	76.2	73.9 - 78.6
Whitening Procedures Provided	32.8	30.2 - 35.4
Whitening Procedures Referred Out	65.8	63.2 - 68.5
	Mean	(95%CI)
Minimum Age Recommendation	14.9	14.7 - 15.1
Minimum Age Provision	14.6	14.4 - 14.9

Table 3. Odds Ratio for Outcomes Relative to South Atlantic Region

	Odds Ratio Patient Request	Odds Ratio Recommend	Odds Ratio Provision
New England CT, ME, MA, NH, RI, VT	0.75	0.65	0.54
Middle Atlantic NJ, NY, PA	0.80	0.76	0.60
South Atlantic DE, DC, FL, GA, MD, NC, SC, VA, WV	*REF*	*REF*	*REF*
East South Central AL, KY, MS, TN	2.12	0.88	0.86
East North Central IL, IN, MI, OH, WI	1.21	0.59	0.77
West North Central IA, KS, MN, MO, NE, ND, SD	0.48	0.40	0.48
Mountain AZ, CO, ID, MT, NV, NM, UT, WY	1.03	1.20	2.37
West South Central AR, LA, OK, TX	1.67	1.05	1.31
Pacific AK, CA, HI, OR, WA	0.55	0.49	1.14

III. APPENDIX A: Sample TeleForm Survey

UNC SCHOOL OF DENTISTRY
Department of Orthodontics
Tooth Whitening Procedures and Orthodontic Treatment

ID #:

Please use a BLACK BALLPOINT PEN. Read each question carefully and provide your most appropriate response. Choose only ONE response per question. Fill in circles completely or fill in the boxes as needed. When completed, please return the survey in the enclosed envelope. Thank you again for your participation.

Do you currently practice in a private specialty practice of orthodontics? ☐ Yes ☐ No
If no, your survey is complete. Please return the survey in the enclosed envelope (no additional questions need to be answered).

DEMOGRAPHICS

1. Year of orthodontic program graduation:

2. Average number of hours per week engaged in private practice orthodontics:

3. Geographic region where your main office is located:

- ☐ New England (CT, ME, MA, NH, RI, VT) ☐ West North Central (IA, KS, MN, MO, NE, ND, SD)
☐ Middle Atlantic (NJ, NY, PA) ☐ Mountain (AZ, CO, ID, MT, NV, NM, UT, WY)
☐ South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA, WV) ☐ West South Central (AR, LA, OK, TX)
☐ East South Central (AL, KY, MS, TN) ☐ Pacific (AK, CA, HI, OR, WA)
☐ East North Central (IL, IN, MI, OH, WI)

4 Size of community where your main office is located:

- ☐ Rural (under 20,000 population) ☐ Large city (50,000-500,000 population)
☐ Small city (20,000-50,000 population) ☐ Metropolitan (over 500,000 population)

PRACTICE ACTIVITY

Section 1 - RECOMMENDATIONS:

1. In the past 6 months, have any of your patients requested any form of whitening procedures (in-office, at-home, or OTC)? ☐ Yes ☐ No

If yes, In the past 6 months, approximately what percentage of patients (0-100%) requested information about whitening? %

2. In the past 6 months have you recommended any form of whitening procedures (in-office, at-home, or OTC) for your patients? ☐ No - Please Skip to Section 2
☐ Yes

If yes, what is the minimum age that you would recommend any form of whitening procedure?

3. In the past 6 months to approximately what percentage of your patients have you recommended each of the following categories of whitening procedures? Note: The percentages do not need to total to 100%.

ADULTS (> 18 years)

	Never	< 25%	25-50%	51-75%	> 75%
a. In-office procedures (i.e. light-activated bleaching, chair-side bleaching, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Take-home (supervised) whitening procedures (i.e. custom trays, doctor-dispensed whitening agents, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Over-the-counter whitening products (i.e. whitening gels/strips, toothpastes, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

ADOLESCENTS (12- 18 years)

	Never	< 25%	25-50%	51-75%	> 75%
a. In-office procedures (i.e. light-activated bleaching, chair-side bleaching, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Take-home (supervised) whitening procedures (i.e. custom trays, doctor-dispensed whitening agents, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Over-the-counter whitening products (i.e. whitening gels/strips, toothpastes, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section 2 - WHITENING SERVICES PROVIDED WITHIN ORTHODONTIC PRACTICE:

1. In the past 6 months have you provided any form of whitening procedure (in-office, at-home, or OTC) within your orthodontic specialty practice?

- ☐ No - Please Skip to Section 3
☐ Yes

If yes, what is the minimum age that you would provide any form of whitening procedure within your orthodontic specialty practice?

2. In the past 6 months to approximately what percentage of your patients have you provided each of the following categories of whitening procedures within your orthodontic specialty practice? Note: The percentages do not need to total to 100%.

ADULTS (> 18 years)

	<u>Never</u>	<u>< 25%</u>	<u>25-50%</u>	<u>51-75%</u>	<u>> 75%</u>
a. In-office bleaching (without light activation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. In-office bleaching (with light activation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Custom tray-applied whitening gels for home use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Professional-strength whitening strips for home use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Over-the-counter whitening products (i.e. whitening gels/strips, toothpastes, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

ADOLESCENTS (12-18 years)

	<u>Never</u>	<u>< 25%</u>	<u>25-50%</u>	<u>51-75%</u>	<u>> 75%</u>
a. In-office bleaching (without light activation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. In-office bleaching (with light activation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Custom tray-applied whitening gels for home use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Professional-strength whitening strips for home use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Over-the-counter whitening products (i.e. whitening gels/strips, toothpastes, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section 3 - WHITENING SERVICES REFERRED OUT:

1. In the past 6 months have you referred any of your patients to other practitioners for whitening procedures?

- ☐ No - End of Survey ☐ Yes

2. In the past 6 months approximately what percentage of the patients who request and to whom you recommend whitening procedures have you referred to other practitioners?

- ☐ None ☐ < 25% ☐ 25-50% ☐ 51-75% ☐ > 75%

3. In the past 6 months which whitening procedures have you referred out of your orthodontic specialty practice? (Select all that apply)

- ☐ "Generic" referral (specific whitening treatment to be determined by other practitioner)
☐ In-office bleaching (without light activation)
☐ In-office bleaching (with light activation)
☐ Custom tray-applied whitening gels for home use
☐ Professional-strength whitening strips for home use

THANK YOU FOR YOUR PARTICIPATION!

IV. APPENDIX B: Respondents by Region

Geographic Region	Response Rate (%)	Years of Practice Median (IQR)	Hrs/Wk in Practice Median (IQR)	Community Size (%)
New England CT, ME, MA, NH, RI, VT	28.5 (N = 91)	22.0 (13.0 - 33.0)	32.0 (28.5 - 36.0)	Rural 15.7 Small City 65.2 Large City 18.0 Metropolitan 1.1
Middle Atlantic NJ, NY, PA	28.9 (N = 136)	21.5 (10.5 - 28.5)	32.0 (28.5 - 36.0)	Rural 18.0 Small City 42.9 Large City 21.1 Metropolitan 18.0
South Atlantic DE, DC, FL, GA, MD, NC, SC, VA, WV	36.8 (N = 183)	18.0 (11.0 - 28.0)	32.0 (30.0 - 35.0)	Rural 4.5 Small City 32.0 Large City 36.5 Metropolitan 27.0
East South Central AL, KY, MS, TN	36.8 (N = 103)	19.0 (6.0 - 28.0)	32.0 (30.0 - 35.0)	Rural 8.7 Small City 25.2 Large City 47.6 Metropolitan 18.5
East North Central IL, IN, MI, OH, WI	38.1 (N = 174)	21.0 (14.0 - 30.0)	32.0 (30.0 - 35.0)	Rural 14.1 Small City 30.6 Large City 35.9 Metropolitan 19.4
West North Central IA, KS, MN, MO, NE, ND, SD	34.8 (N = 106)	20.0 (12.0 - 27.0)	32.0 (30.0 - 36.0)	Rural 11.6 Small City 23.3 Large City 36.0 Metropolitan 29.1
Mountain AZ, CO, ID, MT, NV, NM, UT, WY	28.6 (N = 103)	13.5 (7.0 - 27.0)	32.0 (30.0 - 36.0)	Rural 5.9 Small City 29.4 Large City 32.4 Metropolitan 32.4
West South Central AR, LA, OK, TX	32.5 (N = 133)	21.0 (8.0 - 32.0)	32.0 (30.0 - 36.0)	Rural 6.1 Small City 18.5 Large City 34.6 Metropolitan 40.8
Pacific AK, CA, HI, OR, WA	30.4 (N = 153)	21.0 (12.0 - 30.0)	32.0 (26.0 - 32.0)	Rural 6.0 Small City 23.2 Large City 45.0 Metropolitan 25.8

V. APPENDIX C: National Survey Responses, Weighted

	Never	< 25 %	25 - 50 %	51 - 75 %	> 75 %
Nationwide					
REQUESTED (N = 1007)	0.6	77.9	17.2	3.0	1.3
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 848)	55.1	35.1	6.1	1.6	2.1
Take-Home Whitening (N = 847)	15.1	50.8	17.7	6.5	9.9
OTC Whitening Products (N = 858)	10.8	52.0	18.6	6.5	12.0
Adolescents					
In-Office Whitening Procedures (N = 834)	73.0	23.1	2.5	0.6	0.9
Take-Home Whitening (N = 819)	28.5	48.6	12.0	3.9	7.0
OTC Whitening Products (N = 852)	15.0	49.2	14.5	7.2	14.0
PROVIDED					
Adults					
In-Office, no light activation (N = 358)	89.9	8.5	1.4	0.0	0.3
In-Office, with light activation (N = 355)	89.8	8.8	0.8	0.3	0.3
Custom Tray-applied Gel for Home Use (N = 370)	20.8	53.0	9.3	3.9	12.9
Professional-strength Whitening Strips (N = 349)	58.8	29.2	6.5	2.7	2.8
OTC Whitening Products (N = 350)	49.3	34.5	8.1	3.9	4.3
Adolescents					
In-Office, no light activation (N = 356)	91.6	7.3	0.9	0.0	0.3
In-Office, with light activation (N = 350)	93.9	5.0	1.1	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 366)	33.5	45.1	8.4	3.5	9.6
Professional-strength Whitening Strips (N = 349)	65.1	24.8	5.6	1.5	3.0
OTC Whitening Products (N = 348)	52.7	30.7	8.1	3.8	4.7
REFERRED OUT (N = 772)	*	47.8	11.6	7.0	33.6

VI. APPENDIX D: Regional Survey Responses, Unweighted

Geographic Region	Orthodontists with Patients Who Request Whitening	Orthodontists Recommending Any Whitening Procedures (%)	Minimum Age to Recommend Median (IQR)	Orthodontists Providing Any Whitening Procedures	Minimum Age to Provide Median (IQR)	Orthodontists Referring Out Whitening Procedures (%)
New England	85.7	74.7	16.0 (14.0 - 16.0)	19.8	16.0 (16.0 - 16.0)	62.6
Middle Atlantic	88.2	77.0	16.0 (14.0 - 16.0)	22.8	15.0 (13.0 - 16.0)	69.1
South Atlantic	90.1	81.2	14.5 (13.0 - 16.0)	34.4	15.0 (13.0 - 16.0)	61.3
East South Central	95.2	80.6	14.0 (13.0 - 15.0)	31.1	14.5 (14.0 - 15.0)	75.7
East North Central	92.0	73.0	15.0 (14.0 - 16.0)	28.2	14.0 (13.0 - 16.0)	70.1
West North Central	82.1	65.1	14.0 (13.0 - 16.0)	19.2	14.0 (13.0 - 15.0)	65.1
Mountain	90.3	83.3	14.0 (14.0 - 16.0)	54.4	14.0 (13.0 - 16.0)	65.1
West South Central	94.0	82.4	14.0 (13.0 - 16.0)	42.1	14.0 (13.0 - 16.0)	68.4
Pacific	83.4	69.5	15.0 (14.0 - 17.0)	37.5	14.0 (13.0 - 16.0)	61.6

VII. APPENDIX E: Regional Frequency Responses, Unweighted

Geographic Region	Never (%)	< 25 % (%)	25 - 50 % (%)	51 - 75 % (%)	> 75 % (%)
New England					
REQUESTED (N = 75)	1.3	86.7	10.7	0.0	1.3
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 65)	61.5	35.4	0.0	1.5	1.5
Take-Home Whitening (N = 65)	24.6	56.9	10.8	6.2	1.5
OTC Whitening Products (N = 67)	9.0	62.7	11.9	4.5	11.9
Adolescents					
In-Office Whitening Procedures (N = 63)	77.8	22.2	0.0	0.0	0.0
Take-Home Whitening (N = 64)	46.9	45.3	6.3	1.6	0.0
OTC Whitening Products (N = 66)	16.7	56.1	13.6	3.0	10.6
PROVIDED					
Adults					
In-Office, no light activation (N = 17)	82.4	17.7	0.0	0.0	0.0
In-Office, with light activation (N = 17)	94.1	5.9	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 18)	33.3	50.0	11.1	0.0	5.6
Professional-strength Whitening Strips (N = 16)	56.3	31.3	6.3	6.3	0.0
OTC Whitening Products (N = 17)	23.5	47.1	17.7	5.9	5.9
Adolescents					
In-Office, no light activation (N = 18)	88.9	5.6	5.6	0.0	0.0
In-Office, with light activation (N = 18)	88.9	5.6	5.6	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 18)	55.6	38.9	5.6	0.0	0.0
Professional-strength Whitening Strips ((N = 17)	64.7	29.4	0.0	5.9	0.0
OTC Whitening Products (N = 17)	35.3	41.2	5.9	5.9	11.8
REFERRED OUT (N = 56)	*	51.8	7.1	3.6	37.5
Middle Atlantic					
REQUESTED (N = 113)	0.0	82.3	13.3	4.4	0.0
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 96)	45.8	39.6	11.5	0.0	3.1
Take-Home Whitening (N = 95)	16.8	48.4	17.9	7.4	9.5
OTC Whitening Products (N = 98)	4.1	53.1	23.5	4.1	15.3
Adolescents					
In-Office Whitening Procedures (N = 93)	65.6	28.0	4.3	1.1	1.1
Take-Home Whitening (N = 90)	37.8	41.1	12.2	3.3	5.6
OTC Whitening Products (N = 96)	10.4	47.9	13.5	6.3	21.9
PROVIDED					
Adults					
In-Office, no light activation (N = 30)	96.7	3.3	0.0	0.0	0.0
In-Office, with light activation (N = 30)	86.7	13.3	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 31)	22.6	61.3	6.5	3.2	6.5
Professional-strength Whitening Strips (N = 29)	55.2	27.6	6.9	6.9	3.5
OTC Whitening Products (N = 28)	60.7	17.9	7.1	3.6	10.7
Adolescents					
In-Office, no light activation (N = 30)	96.7	3.3	0.0	0.0	0.0
In-Office, with light activation (N = 30)	93.3	6.7	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 31)	35.5	48.4	6.5	0.0	9.7
Professional-strength Whitening Strips (N = 29)	55.2	31.0	6.9	0.0	6.9
OTC Whitening Products (N = 29)	58.6	17.2	10.3	0.0	13.8
REFERRED OUT (N = 94)	*	39.4	12.8	9.6	38.3

South Atlantic					
REQUESTED (N = 158)	0.6	71.5	20.3	5.7	1.9
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 140)	58.6	34.3	2.1	2.1	2.9
Take-Home Whitening (N = 141)	14.2	51.8	14.9	8.5	10.6
OTC Whitening Products (N = 143)	16.8	53.2	15.4	7.0	7.7
Adolescents					
In-Office Whitening Procedures (N = 136)	75.7	20.6	2.9	0.0	0.7
Take-Home Whitening (N = 137)	24.1	51.8	10.2	5.8	8.0
OTC Whitening Products (N = 142)	16.9	52.1	12.7	9.2	9.2
PROVIDED					
Adults					
In-Office, no light activation (N = 61)	93.4	4.9	1.6	0.0	0.0
In-Office, with light activation (N = 60)	91.7	6.7	0.0	1.7	0.0
Custom Tray-applied Gel for Home Use (N = 60)	16.7	55.0	6.7	3.3	18.3
Professional-strength Whitening Strips (N = 58)	56.9	29.3	8.6	3.5	1.7
OTC Whitening Products (N = 59)	45.8	39.0	10.2	5.1	0.0
Adolescents					
In-Office, no light activation (N = 61)	93.4	3.3	3.3	0.0	0.0
In-Office, with light activation (N = 59)	94.9	3.4	1.7	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 60)	26.7	45.0	8.3	5.0	15.0
Professional-strength Whitening Strips (N = 58)	65.5	24.1	5.2	3.5	1.7
OTC Whitening Products (N = 59)	49.2	33.9	10.2	6.8	0.0
REFERRED OUT (N = 110)	*	48.2	12.7	3.6	35.5
East South Central					
REQUESTED (N = 93)	1.1	75.3	18.3	4.3	1.1
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 78)	55.1	38.5	5.1	1.3	0.0
Take-Home Whitening (N = 80)	11.2	51.2	18.9	11.2	7.5
OTC Whitening (N = 79)	6.3	50.6	24.1	7.6	11.4
Adolescents					
In-Office Whitening Procedures (N = 77)	68.8	27.3	2.6	1.3	0.0
Take-Home Whitening (N = 78)	15.4	59.0	15.4	5.1	5.1
OTC Whitening Products (N = 79)	5.1	49.4	17.7	12.7	15.2
PROVIDED					
Adults					
In-Office, no light activation (N = 30)	90.0	6.7	3.3	0.0	0.0
In-Office, with light activation (N = 29)	96.6	3.5	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 30)	30.0	40.0	13.3	3.3	13.3
Professional-strength Whitening Strips (N = 27)	77.8	18.5	0.0	3.7	0.0
OTC Whitening Products (N = 28)	39.3	46.4	0.0	3.6	10.7
Adolescents					
In-Office, no light activation (N = 30)	96.7	3.3	0.0	0.0	0.0
In-Office, with light activation (N = 28)	96.4	3.6	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 30)	33.3	40.0	6.7	6.7	13.3
Professional-strength Whitening Strips (N = 28)	75.0	14.3	3.6	0.0	7.1
OTC Whitening Products (N = 29)	41.4	37.9	0.0	6.9	13.8
REFERRED OUT (N = 77)	*	35.1	10.4	14.3	40.3

East North Central					
REQUESTED (N = 152)	0.0	84.2	12.5	1.3	2.0
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 120)	48.3	41.7	6.7	2.5	0.8
Take-Home Whitening (N = 118)	16.9	54.2	13.6	5.1	10.2
OTC Whitening Products (N = 117)	5.1	53.0	22.2	7.7	12.0
Adolescents					
In-Office Whitening Procedures (N = 120)	75.8	23.3	0.0	0.0	0.8
Take-Home Whitening (N = 112)	33.0	45.5	12.5	0.9	8.1
OTC Whitening Products (N = 117)	10.3	47.0	19.7	10.3	12.8
PROVIDED					
Adults					
In-Office, no light activation (N = 45)	82.2	17.8	0.0	0.0	0.0
In-Office, with light activation (N = 44)	88.6	11.4	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 45)	24.4	55.6	4.4	6.7	8.9
Professional-strength Whitening Strips (N = 47)	46.8	36.2	8.5	4.3	4.3
OTC Whitening Products (N = 43)	51.2	27.9	11.6	4.7	4.7
Adolescents					
In-Office, no light activation (N = 45)	80.0	20.0	0.0	0.0	0.0
In-Office, with light activation (N = 44)	93.2	6.8	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 44)	34.1	50.0	4.6	6.8	4.6
Professional-strength Whitening Strips (N = 46)	54.4	30.4	8.7	2.2	4.4
OTC Whitening Products (N = 43)	53.5	27.9	11.6	4.7	2.3
REFERRED OUT (N = 121)	*	52.1	8.3	7.4	32.2
West North Central					
REQUESTED (N = 84)	3.6	82.1	14.3	0.0	0.0
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 65)	53.8	38.5	3.1	1.5	3.1
Take-Home Whitening (N = 65)	20.0	49.2	10.8	7.7	12.3
OTC Whitening Products (N = 68)	2.9	60.3	14.7	7.4	14.7
Adolescents					
In-Office Whitening Procedures (N = 65)	66.2	29.2	0.0	3.1	1.5
Take-Home Whitening (N = 64)	29.7	51.6	7.8	4.7	6.3
OTC Whitening Products (N = 67)	4.5	61.2	11.9	6.0	16.4
PROVIDED					
Adults					
In-Office, no light activation (N = 20)	95.0	5.0	0.0	0.0	0.0
In-Office, with light activation (N = 20)	85.0	10.0	5.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 20)	30.0	50.0	5.0	10.0	5.0
Professional-strength Whitening Strips (N = 20)	65.0	30.0	5.0	0.0	0.0
OTC Whitening Products (N = 19)	68.4	26.3	5.3	0.0	0.0
Adolescents					
In-Office, no light activation (N = 20)	90.0	10.0	0.0	0.0	0.0
In-Office, with light activation (N = 20)	90.0	5.0	5.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 20)	40.0	45.0	10.0	0.0	5.0
Professional-strength Whitening Strips (N = 20)	65.0	25.0	10.0	0.0	0.0
OTC Whitening Products (N = 19)	68.4	21.1	10.5	0.0	0.0
REFERRED OUT (N = 67)	*	47.8	7.5	6.0	38.8

Mountain					
REQUESTED (N = 90)	1.1	66.7	27.8	4.4	0.0
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 82)	63.4	29.3	4.9	2.4	0.0
Take-Home Whitening (N = 83)	13.2	47.0	20.5	7.2	12.1
OTC Whitening Products (N = 83)	21.7	51.8	13.3	8.4	4.8
Adolescents					
In-Office Whitening Procedures (N = 80)	78.8	18.8	1.3	1.3	0.0
Take-Home Whitening (N = 82)	22.0	47.6	18.3	4.9	7.3
OTC Whitening Products (N = 82)	29.3	40.2	17.1	8.5	4.9
PROVIDED					
Adults					
In-Office, no light activation (N = 50)	92.0	6.0	0.0	0.0	2.0
In-Office, with light activation (N = 50)	94.0	6.0	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 56)	12.5	62.5	5.4	5.4	14.3
Professional-strength Whitening Strips (N = 50)	72.0	20.0	4.0	0.0	4.0
OTC Whitening Products (N = 50)	62.0	26.0	0.0	8.0	4.0
Adolescents					
In-Office, no light activation (N = 49)	93.9	4.1	0.0	0.0	2.0
In-Office, with light activation (N = 50)	98.0	2.0	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 56)	21.4	58.9	5.4	1.8	12.5
Professional-strength Whitening Strips (N = 50)	76.0	18.0	4.0	0.0	2.0
OTC Whitening Products (N = 50)	64.0	22.0	2.0	8.0	4.0
REFERRED OUT (N = 65)	*	63.1	12.3	1.5	23.1
West South Central					
REQUESTED (N = 121)	0.8	68.6	24.0	3.3	3.3
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 106)	62.3	23.6	9.4	0.9	3.8
Take-Home Whitening (N = 104)	11.5	43.3	22.1	8.7	14.4
OTC Whitening Products (N = 103)	13.6	41.8	20.4	8.7	15.5
Adolescents					
In-Office Whitening Procedures (N = 104)	76.9	18.3	1.9	1.0	1.9
Take-Home Whitening (N = 100)	22.0	47.0	14.0	7.0	10.0
OTC Whitening Products (N = 101)	13.9	48.5	13.9	5.9	17.8
PROVIDED					
Adults					
In-Office, no light activation (N = 50)	86.0	10.0	4.0	0.0	0.0
In-Office, with light activation (N = 49)	87.8	8.2	2.0	0.0	2.0
Custom Tray-applied Gel for Home Use (N = 53)	15.1	47.2	15.1	1.9	20.8
Professional-strength Whitening Strips (N = 47)	59.6	29.8	8.5	0.0	2.1
OTC Whitening Products (N = 50)	42.0	44.0	10.0	2.0	2.0
Adolescents					
In-Office, no light activation (N = 49)	93.9	6.1	0.0	0.0	0.0
In-Office, with light activation (N = 48)	93.8	6.3	0.0	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 52)	28.9	44.2	13.5	3.9	9.6
Professional-strength Whitening Strips (N = 46)	65.2	26.1	8.7	0.0	0.0
OTC Whitening Products (N = 49)	42.9	42.9	10.2	0.0	4.1
REFERRED OUT (N = 90)	*	42.2	16.7	7.8	33.3

Pacific					
REQUESTED (N = 121)	0.0	83.5	14.9	0.8	0.8
RECOMMENDED					
Adults					
In-Office Whitening Procedures (N = 96)	53.2	35.4	7.3	2.1	2.1
Take-Home Whitening (N = 96)	12.5	54.2	24.0	1.0	8.3
OTC Whitening Products (N = 100)	11.0	50.0	19.0	5.0	15.0
Adolescents					
In-Office Whitening Procedures (N = 96)	69.8	24.0	5.2	0.0	1.0
Take-Home Whitening (N = 92)	27.2	52.2	10.9	2.2	7.6
OTC Whitening Products (N = 102)	19.6	48.0	12.8	3.9	15.7
PROVIDED					
Adults					
In-Office, no light activation (N = 55)	89.1	9.1	1.8	0.0	0.0
In-Office, with light activation (N = 56)	87.5	10.7	1.8	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 57)	24.6	47.4	14.0	3.5	10.5
Professional-strength Whitening Strips (N = 55)	56.4	32.7	5.5	1.8	3.6
OTC Whitening Products (N = 56)	46.4	37.5	8.9	1.8	5.4
Adolescents					
In-Office, no light activation ((N = 54)	90.7	9.3	0.0	0.0	0.0
In-Office, with light activation (N = 53)	92.5	5.7	1.9	0.0	0.0
Custom Tray-applied Gel for Home Use (N = 55)	43.6	34.6	10.9	3.6	7.3
Professional-strength Whitening Strips (N = 55)	67.3	23.6	3.6	1.8	3.6
OTC Whitening Products (N = 53)	54.7	32.1	7.6	1.9	3.8
REFERRED OUT (N = 92)	*	51.1	12.0	8.7	28.3

VIII. APPENDIX F: Type of Referral Utilized by Region

Geographic Region	"Generic" - procedure to be determined by other practitioner (%)	In-office bleaching, no light activation (%)	In-office bleaching with light activation (%)	Custom tray-applied whitening gel for home use (%)	Professional- strength whitening strips for home use (%)
New England	57.1	42.9	75.0	64.7	85.0
Middle Atlantic	53.9	63.0	76.9	70.4	87.9
South Atlantic	43.2	57.9	75.0	56.8	82.1
East South Central	31.6	35.0	65.0	42.9	90.5
East North Central	50.0	51.3	69.2	43.2	82.9
West North Central	23.8	27.3	73.9	50.0	79.2
Mountain	42.9	59.1	76.2	35.0	79.2
West South Central	45.8	41.7	72.0	34.8	76.0
Pacific	30.4	40.9	69.6	41.7	85.2

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