Analysis of Secondary Data to Determine the Relationship Between Age and Power Toothbrush Use

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Abstract

The purpose of this research is to determine the relationship between power toothbrush use and a person's chronological age. Additionally, the relationship between the gingival bleeding index (GBI) scores with relation to manual and electronic toothbrush use based on age group was determined. The Diffusion of Innovation and Social Cognitive theories were used to predict and interpret the study results. After approval was received from the Institutional Review Board at Nova Southeastern University, a retrospective de-identified data set was assembled and analyzed. Secondary data was analyzed to look for a relationship between chronological age and power toothbrush use and GBI scores. Chi-square tests with corresponding odds ratio calculations was used to find a statistically significant relationship between age and type of toothbrush use. This test indicated that a person 45 years and older was 1.4 times more likely to use a power toothbrush and a person 65 years and older was 1.7 times more likely to use a power toothbrush. Additionally, a Wilcoxon-Mann-Whitney test was used to determine that GBI scores are statistically significantly lower in the power toothbrush group, indicating less disease. The median rank sum of GBI scores was lower for the power toothbrush user.

Keywords: Biofilm, Chronic Disease, Dentition, Gingival, Gingivitis, Periodontal disease, Gingival Bleeding Index, Dental prophylaxis, Etiological influence, Supragingival Plaque

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Signature Page

We hereby certify that this dissertation, submitted by Kimberly R. Milleman, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirement for the degree of Doctor of Philosophy (Ph.D.) in Health Science.

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Analysis of Secondary Data to Determine the Relationship Between Age and Power Toothbrush Use

Chapter 1: Introduction

Introduction to the Chapter

This chapter begins with a brief background of biofilm and periodontal disease, as well as their link with several chronic diseases. This link sets the stage for the issue being investigated, possible prevention, and self-management of many chronic diseases in older adults through the use of power toothbrush technology.

Background to the Problem

Oral and Systemic Health

It has been known for decades that gingivitis and periodontal disease are responsible for approximately 95% of all inflammatory disease around the dentition intraorally (Page et al., 1978). Recent published research demonstrates the positive correlation between an inflamed oral environment and multiple systemic diseases and metabolic disorders displaying inflammatory characteristics such as cardiovascular disease, diabetes, respiratory disease, obesity, Alzheimer's disease, and pancreatic cancer (Al-Zahrani et al., 2003; Konig et al., 2016; Taylor et al., 2013). Two systematic reviews demonstrated that increased oral hygiene can even prevent pulmonary infections and death in elderly people residing in nursing homes and hospitals (Pace & McCullough, 2010; Sjogren et al., 2008).

So how do we control this potentially life threating, preventable condition? Recent randomized clinical trials have shown a decrease in gingival inflammation and supragingival dental plaque through the use of power toothbrush technology (Klukowska et al., 2014; Mirza et al., 2019; Starke et al., 2019). While there are many studies analyzing the correlation between an inflamed state of gingivae and chronic diseases, there is a gap in the research looking at older adults who suffer from chronic disease and the use of power toothbrush technology. A study from 2010 demonstrated that frequent toothbrushing was associated with lower levels of cardiovascular disease and low-grade inflammation. This study included people aged 35 and up with a mean age of 50 but did not distinguish manual or power toothbrush use (de Oliveira et al., 2010). If frequent toothbrushing can reduce inflammation intraorally and systemically, older adults might be able to self-manage chronic disease through the use of power toothbrush technology.

Quality of life

More research needs to be conducted on the aging population in the United States (US). The US Census Bureau reported in February 2020 that, by the year 2034, people 65 years and older will outnumber people under the age of 18. This will be the first time for this startling statistic in US history (Medina et al., 2020). Due to this prediction, quality of life research in the elderly population will need to become more prevalent than ever. In 2012 the American Journal of Public Health reported that people who reported themselves in poor (rather than good) health also reported lower oral health related quality of life (Griffin et al., 2012). Unlike other systemic diseases, poor oral health is preventable. If left untreated, poor oral health will not resolve and can seriously effect quality of life (Department of Health and Human Services, 2000). Additionally, research has proven that not treating oral disease such as gingivitis and periodontal disease could diminish quality of life but also puts the elderly at an increased risk for additional adverse health outcomes (de Oliveira et al., 2010; Minassian et al., 2010; Pace & McCullough, 2010; Simpson et al., 2010; Sjogren et al., 2008). Since we know that good oral health is crucial to healthy aging and essential to the general health and well-being of everyone, this dissertation research could help improve quality of life in the elderly by examining plaque control habits and gingivitis levels that contribute to other systemic diseases and metabolic disorders (Department of Health and Human Services, 2000). Prevention and chronic disease management are the future of healthcare.

The National Health and Nutrition Examination Survey (NHANES) is a nationwide series of cross-sectional surveys that combine interviews and physical exams to assess the health and nutritional status of adults and children (Centers for Disease Control and Prevention National Center for health Statistics, n.d.). Using data from NHANES, in 2012 researchers confirmed previously published research demonstrating a strong correlation between poor oral health and poor general health. Moreover, after analysis of the NHANES data, researchers found that the elderly (age 50-64) who reported poor general health, were three times more likely to report a less satisfying life due to poor oral health (Griffin et al., 2012). If oral health and general health and well-being could be positively influenced in the elderly through the use of power toothbrush technology, the feasibility of free or discounted power toothbrushes to all Medicare recipients should be examined.

Statement of the Problem

The primary purpose of this research is to determine if power toothbrush use is significantly related to a person's chronological age. A secondary purpose is determining the relationship between the gingival bleeding index (GBI) scores, age and manual or electric toothbrush use.

Relevance

This study has provided a link between research looking at the use of power toothbrush technology and a person's chronological age. If power toothbrush use and a person's chronological age are significantly related, Medicare policy could be reevaluated to include providing a free power toothbrush to all Medicare recipients to help prevent and control chronic intraoral inflammation that may contribute to other chronic diseases. It is much more inexpensive to prevent disease than to treat it. Additionally, this research could have an impact on the Healthy People 2020 and 2030 oral health objective by reducing the proportion of adults aged 45 an older with moderate or severe periodontitis through simple dental plaque biofilm control by using power toothbrush technology (*Healthy People 2020*, 2020).(U.S. Department of Health and Human Services Office of Disease Prevention and Health Promotion, n.d.).

Elements

Theories

Social Cognitive

Risk status is one of the predominant variable's researchers have studied in developing periodontal disease. Risk factors known to contribute to periodontal disease are genetics, medication, bleeding upon probing of the gingivae, presence of dental plaque, lifestyle influences, and age (Darcey & Ashley, 2011). Investigators have looked at periodontal disease from a Social Cognitive perspective, linking the causes to an interrelated relationship between continuing processes of personal elements, environmental factors, and behavior (Bandura, 1977; Tedesco et al., 1993). Current research literature reveals a strong positive correlation ($r = 0.251$) between age and the development of periodontal disease (Tadjoedin et al., 2017). Even though there are strong underpinnings to the Social Cognitive perspective involved in the causation and progression of periodontal disease, the presence of the dental plaque biofilm has been cited as one of the greatest risk factors. Research indicates that the foundation to treating periodontal disease is anti-infective therapy "aimed at controlling the biofilm" (Pihlstrom et al., 2005, p.

1815). Therefore, research has demonstrated that the dental plaque biofilm is one of the major risk factors contributing to the onset and progression of periodontal disease. On the other hand, research also shows a link between the behaviors and personal choices contained in Social Cognitive Theory and periodontal disease onset and progression. I am proposing that the risk factors associated with periodontal disease include personal choices such as type of toothbrush used and dental plaque biofilm control. This dissertation research looking into the correlation between chronological age and type of toothbrush use could help bridge the gap in knowledge as to the tendency for periodontal disease to increase as people age. If older adults are not using power toothbrush technology as much as their younger counterparts, this could help explain the increase in periodontal disease.

Diffusion of Innovation

For nearly a century, researchers have studied diffusion of innovation. Over that time, we have discovered that innovations such as powered toothbrush technology use two different communication channels. The first channel is formal media such as newspapers, the Internet, and television. This form of commination creates awareness and knowledge that reaches the masses and informs them about the very existence of an innovation or idea. The second channel is more informal and relies on communication between people. People tend to talk with friends, family, and coworkers about things that they are interested in, have been thinking about, or have recently tried (Ryan & Gross, 1943). Therefore, if a vulnerable group of individuals has limited access to formal media, or if their social network is limited, they might not adopt a new technology simply because they have not heard of the new innovation. This could be one reason why older adults have not adopted power toothbrush technology.

Additionally, diffusion of a new idea occurs over time. Adoption of a new innovation or idea by the masses tends to be slow at first and gradually increases in rate until most people eventually accept and adopt the new innovation. This decision-making process is made up of several individual conclusions obtained through the two communication channels discussed earlier. Ultimately, this decision-making process might take hours or months and involves active and passive collection and analysis of information that allows for an informed decision about adopting the innovation. This decision-making process includes knowledge (awareness that the innovation exists and how it works), persuasion (attitude toward the innovation), decision (accepting or refusing the innovation), implementation (trying the innovation), and confirmation (committing to use the new innovation) (Ryan & Gross, 1943). In addition to having the awareness of powered toothbrush technology, the vulnerable older adult population might benefit from a dental professional persuading and educating them on the benefits of using the technology. On the other hand, if the dental professional is aware of the older adult being on Medicare and on a fixed income, they might shy away from recommending the technology due to out-of-pocket costs that can be up to $250 for an electric brush. Moreover, if all Medicare recipients received an electric brush as part of Medicare's preventive services, dental professionals would be more inclined to recommend this innovative technology to older adults.

People who decide to accept a new innovation fall into specific categories based on when they adopt the new idea. For example, the first 2.5% of people to adopt a new idea are called innovators and tend to like experimentation. Early adopters (13.5% of the population) are the next to adopt, and the early majority (34%) falls next in line. The early majority adopts later than early adopters because they have less access to information. The late majority (34%) and the laggards (16%) are the last two groups to adopt the new idea. The late majority typically likes the advantages of the new innovation, but it takes them longer to obtain the resources to finally adopt the idea. The laggards have an affinity for the conventional way of doing things and are extremely traditional. Typically, this group has a limited social network, limited time and money, and do not have access to information (Ryan & Gross, 1943). It could be theorized that the vulnerable older adult population tends to be traditional and to appreciate the conventional way of doing things. These traits could explain a slower rate of adoption of power toothbrush technology. Additionally, with a narrow social network and possibly limited money, this dissertation research might demonstrate that the older adult population falls into the laggard group when adopting power toothbrush technology.

Research Questions

What is the relationship between power toothbrush use and a person's chronological age? What is the relationship between the gingival bleeding index (GBI) scores, age and manual or electric toothbrush use?

Hypotheses

The hypothesis for this investigation is power toothbrush use will be significantly related to a person's age. The secondary hypothesis is that power toothbrush use will be significantly related to GBI scores.

Definitions of Terms

Biofilm. A complex, sticky matrix of bacteria that communicates and forms on a three-dimensional level.

Chronic Disease. An ailment lasting at least one year that necessitates ongoing medical care or limits daily activities.

Dentition. Teeth in the mouth.

Gingival. The gum tissue around the teeth.

Gingivitis. Redness and inflammation of the gum tissue indicating disease.

Periodontal disease. A disease of the bone in the oral cavity that can be caused from excess dental plaque and calculus in the mouth and lead to loss of teeth.

Gingival Bleeding Index. Scoring method looking at the areas on the gums that bleed when probed.

Bias. Prejudice in one direction.

Dental prophylaxis. Dental cleaning.

Etiological influence. The possible cause of disease.

Supragingival Plaque. Dental plaque above the gumline.

Description of Variables

Chronological age will function as the independent variable, while the dependent variable for this investigation will be use of power toothbrush technology and GBI scores.

Rationale

This dissertation research has helped bridge the gap of knowledge in research looking at the use of power toothbrush technology and a person's chronological age and GBI scores. Medicare policy needs to be reevaluated to explore the feasibility of including a free power toothbrush to all Medicare recipients to help control chronic intraoral inflammation that contributes to other chronic diseases. It is much more inexpensive to prevent disease than to treat it. Additionally, this research could have an impact on the Healthy People 2020 and 2030 oral health objectives by reducing the proportion of adults aged 45 and older with moderate or severe periodontitis through simple dental plaque biofilm control by using power toothbrush technology (*Healthy People 2020*, 2020) (U.S. Department of Health and Human Services Office of Disease Prevention and Health Promotion, n.d.).

Assumptions

Some reasons can be assumed but not necessarily verified as to why older adults have not adopted power toothbrush technology. One motive could be due to older adults being on a fixed income and not being able to afford such technology.

Another reason could be explained with the Diffusion of Innovation theory. People who decide to accept a new innovation fall into specific categories based on when they adopt the new idea. The late majority (34%) and the laggards (16%) are the last two groups to adopt the new idea. It takes the late majority longer to acquire the resources to adopt the innovation, but they eventually utilize the new technology. The laggards have an affinity for the conventional way of doing things and are extremely traditional (Simons-Morton et al., 2012). The choice to use a powered or manual toothbrush is an individual choice that can be affected by budget, availability, and recommendation from a dental professional. It can be assumed that older adults have a more limited social network, restricted time and money, or simply do not have access to information about power toothbrush technology.

Summary of the Chapter

This chapter presented a brief background to the problem and a problem statement. The risk factors associated with periodontal disease were discussed through the lens of Social Cognitive Theory. The Diffusion of Innovation Theory was used to explain possible reasons why the vulnerable older adult population might not adopt power toothbrush technology. The variables for the investigation were outlined, and a strong rationale for conducting the investigation was presented.

The remainder of this formal dissertation research is organized into three chapters. Chapter 2 includes a review of the literature that addresses current research and looking at the missing links. Chapter 3 will look at the methodology and IRB college/center review. This will include the instruments used to gather the data, the specific procedures involved in the study, the sample to be included in the study, reliability and validity requirements, timeline, and anticipated limitations.

Chapter 2: Review of the Literature

Introduction to the Chapter

Chapter 2 will provide a historical overview of our knowledge regarding the benefits of power toothbrush use compared to a manual toothbrush in management of chronic disease. Additionally, a gap in knowledge will be revealed regarding the use of a power toothbrush in the older adult population. Next, readers will be presented with current theory and research that is specific to risk factors associated with the progression of gingivitis and periodontal disease. This will address the current empirical evidence about the correlation between age and power toothbrush use and will explain how this research will impact the current breath of knowledge.

Historical Overview

Biofilm Contribution to Periodontal Disease

Over the last sixty years, researchers have demonstrated that the dental plaque biofilm is the main etiological influence triggering periodontal disease. One study from 1961 studied patients over a five-year period and placed subjects on a dental examination recall of up to four times per year. During this examination, patients were given very clear oral hygiene instruction and a dental prophylaxis to control dental plaque levels. This meticulous dental biofilm control contributed to a significant decrease in loss of teeth due to caries and periodontal disease (Lövdal et al., 1961). Expanding on those findings, in 1971 researchers looked at periodontal attachment loss associated with periodontal disease over a three-year period. One group was given oral hygiene control instruction and recalled for a dental prophylactic examination every three months. On the other hand, the second group did not receive any oral hygiene instruction or dental treatment. These researchers found a direct correlation between periodontal attachment loss over the three-year period due to the lack of dental plaque biofilm control (Suomi et al., 1971). A biofilm containing dental plaque bacteria is the principal etiology of periodontal disease and untreated periodontal disease can lead to tooth loss (Burt et al., 2005). Untreated periodontal disease can cause of myriad of adverse systemic health effects. Unfortunately, the National Institute of Dental and Craniofacial Research reports that periodontitis in older adults (65 years and older) is two times that of the younger population (30-44) (National Institute of Dental and Craniofacial Research, 2018). A 2010 Cochrane systematic review demonstrated improved metabolic control in type 2 diabetics who were treated for periodontal disease (Simpson et al., 2010).

Healthy People 2020 (HP2020) lists reducing the proportion of adults aged 45 to 74 years with moderate or severe periodontitis as one of the Oral Health objectives for 2020 (*Healthy People 2020*, 2020). Due to the fact that people are living longer, Healthy People 2030 (HP2030) has the same Oral Health objective without the upper age limit (U.S. Department of Health and Human Services Office of Disease Prevention and Health Promotion, n.d.). Research has proven a direct correlation between periodontal disease and dental plaque and between periodontal disease and age (Haffajee & Socransky, 1994; Tadjoedin et al., 2017) . If periodontal disease can be controlled in the vulnerable older adult population through the use of power toothbrush technology, every Medicare recipient should receive a free or discounted power toothbrush.

Summary of Literature

Plaque is the most predominant risk factor for gingivitis, and gingivitis is the most prevalent risk factor in the development of periodontal disease. Therefore, in most cases, if dental plaque biofilm is kept under control, development of periodontal disease will be less widespread. Long term control of this biofilm could prevent the progression of periodontal disease and help the elderly population maintain their dentition longer (Aspiras et al., 2013). Adequate evidence exists to support the reduction of plaque and gingivitis with the use of a powered toothbrush. The Cochran Database of Systematic Reviews lists three systematic reviews involving the use of powered toothbrushes. The most recent was published in 2020 and looked at oscillating-rotating power toothbrushes. A total of fifteen randomized controlled clinical trials were used for analysis. Statistically significant outcomes for whole-mouth plaque reduction ($p < .01$) and gingival bleeding sites ($p < .001$) were observed with the use of an oscillating-rotating power toothbrush. All the articles used in this review had a low or unclear risk of bias established by the Cochrane risk of bias tool. It is unlikely that important or relevant studies were missed due to the thorough search methods outlined in the article. The researchers limited their search to 2009 through 2019. Not one included study discussed allocation concealment. Therefore, researchers could have influenced which participants were assigned to each group. The systematic review did not discuss if the researchers in any included study were contacted to ask about the allocation concealment. Additionally, there was no mention contacting experts to inquire about unpublished studies and no studies were added to the final review from a hand search (Clark-Perry & Levin, 2020). Another systematic review was published in 2014 and looks at powered toothbrush use compared to a manual toothbrush. Fifty-six randomized controlled trials were included for analysis that consisted of 4624 study subjects. This study showed some evidence that a powered toothbrush provided statistically significant reductions in both plaque and gingivitis when compared to a manual toothbrush. The systematic review was done according to the standard Cochrane methodological approaches, including data extraction by at least two reviewers and risk of bias assessments. Five clinical trials had a high risk of bias, five had a low risk, and 46 had an unclear risk of bias. Data was categorized into two groups: a short-term group that consisted of one to three months, and a long-term group consisting of more than three months. As expected, plaque and gingivitis reductions were greater in the long-term use group (Deacon et al., 2010). Finally, a systematic review first published in 2003 and updated in 2014 for new studies looked at powered versus manual toothbrushing for oral health. The authors concluded that use of a powered toothbrush reduces plaque (11%-21%) and gingivitis (6%-11%) more than a manual toothbrush in the both short and long term randomized clinical trials. A total of 56 randomized, controlled clinical trials were included for analysis involving 5068 participants. This systematic review had a high percentage (82%) of trials with an unclear risk of bias. Additionally, five trials had a high risk of bias and the remaining five were the only ones with a low risk of bias. The authors of this systematic review reported that quality long-term studies are lacking and needed to determine the effectiveness of power toothbrushes on the prevention of periodontal disease (Yaacob et al., 2014).

Most of the previously discussed studies in these systematic reviews looked at all power toothbrush modes of action, such as counter oscillation, rotation oscillation, circular, ultrasonic, and ionic. In February 2021 the Journal of the American Dental Association published a systematic review where researchers looked at only two of the most common power toothbrushes, oscillating rotating (OR) and side-to-side (SS). The SS brush is commonly referred to as sonic toothbrush. These researchers assessed the efficacy of OR verses SS brushes on the reduction of plaque and gingivitis. This review included 24 trials and almost three thousand patients. The results demonstrated no statistically significant difference between the OR or SS power toothbrush in 4-week plaque reduction or gingivitis. Therefore, the authors concluded that neither the OR or SS brush is superior for plaque or gingival index reduction (El-chami et al., 2021). These findings have important practical implications for clinicians when recommending a power toothbrush for better oral health. Both the OR and SS power toothbrush modes of action are safe and effective for plaque and gingivitis control but both have an immensely different mouth feel during use. Therefore, the clinician should let the patient decide which brush to use and feel comfortable knowing that neither the OR or SS power toothbrush is superior.

The National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) reports that "90% of the nation's $3.5 trillion in annual health care expenditures are for people with chronic health conditions" (*Health and Economic Costs of Chronic Diseases*, 2020, para. 1). Susceptible groups such as minorities, older adults, and low-income adults are especially plagued with chronic health conditions. Older adults are exceptionally vulnerable to chronic health conditions because the risk of acquiring such conditions increases with age. Treating these chronic illnesses consumes 85% of the annual healthcare costs in the United States (Anderson, 2010). We can help older adults manage the weight of chronic illness in more cost-effective ways such as self-management and prevention.

Healthy People 2020 lists a goal of "improving the health, function, and quality of life of older adults" (*Older Adults*, 2020, para. 1). Additionally, Healthy People 2030 has a goal of "improve health and well-being for older adults" (Office of Disease Prevention and Health Promotion, n.d., para. 1). The Patient Protection and Affordable Care Act of 2010 implemented updates that included preventive features to Medicare. These prevention services included immunizations and cancer screenings to help prevent disease or cause early detection (*Preventive & Screening Services*, n.d.). Unfortunately, Medicare does not cover most dental care such as, cleanings, fillings, tooth extractions, dentures, dental plates, or other dental devices. Other health areas being placed on the forefront of disease prevention while oral care is being left behind. Additionally, federal attempts to reduce chronic illness in older adults include funding for Chronic Disease Self-Management Education and Older Americans Act programs that target low-income older adults (OLDER AMERICANS ACT OF 1965 [Public Law 89–73], 1965) . This research could reveal an underutilization of powered toothbrush technology in older adults and offer support for providing a powered toothbrush to all Medicare recipients. This would not only help control the chronic condition of periodontal disease, but would also help the Healthy People 2020 and 2030 older adult goal of "improving the health, function, and quality of life of older adults" (*Older Adults*, 2020, para. 1).

Very little research has been done regarding the benefits of power toothbrush use in older adults, although a 2004 study indicated that powered toothbrush use in older adults improved gingival health compared to use of a regular manual toothbrush. This crossover clinical trial contained only 15 subjects, and statistical significance was still achieved for both dental plaque and gingivitis. Unfortunately, the authors did not mention any form of examiner blinding for the dental plaque and gingivitis assessors. Additionally, the article states that all 15 subjects completed the manual toothbrush phase for the first crossover and went on to complete the powered toothbrush group for the second phase (Verma & Bhat, 2004). This introduces an additional bias if the group distribution was not randomized. Even though this type of research is scarce for older adults, multiple randomized clinical trials demonstrate the use of power toothbrush technology and reduction in dental plaque and inflammation of the gingivae on a general population (Mirza, Argosino, Ward, Ou, Milleman, & Milleman, 2019; Starke et al., 2019; Yaacob et al., 2014). More research needs to be done looking into whether older adults are adopting power toothbrush technology and how this technology helps manage and prevent chronic diseases.

Chapter 3: Methodology

Introduction to the Chapter

In this chapter, the specific sample employed in this research will be discussed along with the research method used and why it was chosen. Research procedures particular to this study will be explained, and data analysis methods will be discussed. Additionally, the resources and timeline required to conduct this study will be examined. Validity and reliability will be considered along with anticipated limitations and delimitations.

Research Design and Methodology

After the investigator received approval from the Institutional Review Board at Nova Southeastern University, data was analyzed on a retrospective cross-sectional privately owned data set of dental subjects meeting the inclusion criteria of self-reported use of either a power toothbrush or a manual toothbrush and recorded age. Subject files with missing age or type of toothbrush used, subjects that used both types of brushes, and edentulous subject files were excluded from the set. A de-identified sample of 2,016 subjects met the inclusion/exclusion criteria. Age was stratified three ways: (1) patients 65 years and older and patients between 18-64 years of age, (2) patients 45 years and older and patients between 18-44 years of age, and (3) Late Adolescence (18-21 years), Young Adult (22-30 years), Middle Adult (31-39 years), Late Adult (40-48 years), Early Elderly (49-57 years), Middle Elderly (58-66 years), and Senior (67 years and older). Subjects were further categorized 18-44 and ages 45 years and older in alignment with Health People 2020 and 2030 oral objectives. Likewise, to evaluate oral status for the Patient Protection and Affordable Care Act of 2010 and Centers for Medicare and Medicaid Services (CMS) programs population, a binary variable was created for ages 18-64 and ages 65 years and older. Four habits were recorded including smoking status, gum chewer, coffee and/or tea drinker, and flosser. The gender, ethnicity and handedness of the subjects were also classified. All data was then be loaded into and analyzed by IBM® SPSS® Statistics 26.

Rationale

Two Chi-square tests with corresponding odds ratio calculations were performed to analyze whether a statistically significant relationship exists between type of toothbrush usage and a person's age classification. To look at the secondary hypothesis of power toothbrush use being related to gingival bleeding index (GBI) scores the Wilcoxon-Mann-Whitney Test was used to compare the medians of the rank sums of GBI score number of sites for power toothbrush users versus manual toothbrush users. If the GBI scores were normally distributed, the Independent Samples t-test would have been used to compare the means. However, Q plots of the GBI score number of sites variable by the type of toothbrush use revealed a departure from normality in both groups. Spearman's rho correlation analysis was used to examine the relationship between age, toothbrush type and GBI score number of sites. A one-way analysis of variance was performed to compare the mean GBI score number of sites with respect to age groups. Furthermore, a post-hoc multiple comparison Tukey HSD test employed to identify age groups with significant differences. Finally, a two-way analysis of variance was performed to compare the mean GBI score number of sites with respect to age and type of toothbrush use.

Strengths and Weaknesses of Design

One possible strength of using a secondary data set for analysis is the vast number of subject files located at Salus Research. Data has been collected for 15 years on an electronic database. Additionally, using a secondary dataset for analysis is more cost-effective and time-saving than distributing a survey or doing phone interviews. Finally, another advantage to using this particular dataset is its accessibility. The investigator owns the database and the contents. Therefore, additional approval was not be needed.

Weaknesses include the possible change in power toothbrush technology over time, honesty in reporting, and a possible bias due to the location where the data was collected. The secondary dataset was taken from a dental research testing facility. The subject files located in the database are subjects who are interested in participating in dental research. This specific population could be hyper-aware of new technology in dental products and may not accurately represent the general population. Furthermore, the reliability of the data could be compromised if the subjects did not report their accurate use of either a power or manual toothbrush. Motivation to report inaccurate home use of a toothbrush could be due to participant bias. When subjects try to report what they think the investigator wants, participant bias exists (Gove & Geerken, 1977). Typically, this can be controlled by letting the subject know that their answers are completely confidential and that accuracy is valued. Unfortunately, since the investigator used de-identified secondary data for this investigation it was impossible to control for this possible bias.

Subjects

Sample Size

2,016 de-identified dental subject files were identified in this cross-sectional study to have both a chronological age recorded and use of either a power toothbrush or manual toothbrush. Two recorded measures of oral health of the subjects were the GBI number of bleeding sites and percentage of bleeding sites. 682 of the 2,016 subject files had GBI number of bleeding sites recorded and 203 of the 2,016 subject files had the GBI percentage of bleeding sites recorded.

Inclusion Criteria

The only inclusion criterion is the inclusion of a chronological age associated with self-reporting use of power or manual toothbrush.

Exclusion Criteria

De-identified subject files were excluded if there is no self-reporting of the type of toothbrush used on a daily basis, if both manual and power toothbrush use was reported, and edentulous subject files.

Characteristics

Only de-identified subject files that have a chronological age associated with a self-reported use of a manual or power toothbrush were used in this investigation.

Recruiting Procedures

No recruiting was involved due to the investigator's use of a de-identified, secondary data set.

Instruments and Measures

One index used to measure the health of the gingiva is the Gingival Bleeding Index (GBI). A full mouth bleeding assessment is performed based on the GBI. The gingiva is gently dried and lightly swept with a 0.5 diameter periodontal probe. During this exam, the probe is inserted into the gingival sulcus a gently stroked along the gingival margin. The gingiva is segmented into 6 sites per tooth (distobuccal, buccal, mesiobuccal and distolingual, lingual, mesiolingual surfaces). Bleeding or the absence of bleeding is assessed at each tooth site on a scale of 0 to 3, 0 = no bleeding, 1 = bleeding on gently probing, 2 = bleeding appears immediately upon gently probing, 3 = spontaneous bleeding which is present prior to probing (Weijden et al., 1994). The higher the GBI score, the more disease is noted. For this investigation, the GBI number of sites and percentage, indicative of amount of gingivitis, was analyzed in relationship to type of toothbrush use. All GBI exams were performed by a licensed, trained, and calibrated assessor and entered into the database owned by the investigator.

Reliability and Validity

Since reliability means that an investigation provides the same results each time it is conducted, the issue of socioeconomics needs to be addressed. Past research has proven that populations of high-income countries have better oral health (Albertsson & van Dijken, 2010). This investigation used original datasets that were collected from a middle-class community with very low unemployment. If this investigation were to be conducted at another site in a different socioeconomic demographic, power toothbrush use could be affected. Therefore, one threat to reliability would be the socioeconomic status of the community sampled. On the other hand, if the same demographics were employed, this research would be highly reproducible.

Another threat to reliability is the truthfulness of the subjects reporting their use of a power toothbrush. If subjects did not accurately report their use of a power toothbrush, reliability could be compromised. One way to counteract this reliability issue would be to have subjects bring their toothbrushes with them to the initial screening appointment. The de-identified subject files these secondary data were taken from did not require the subjects to present their current toothbrush.

Ethical Considerations and Review

In accordance with the requirements of the Code of Federal Regulations on Protection of Human Subjects, any activities involved with this investigation did not begin until approval was given from the Nova Southeastern University IRB (Office for Human Research Protections

[OHRP], 2009). Due to the nature of the investigator being a doctoral candidate at Nova Southeastern University, all IRB approvals took place with the Nova Southeastern University IRB. The investigator did not initiate any study procedures until IRB approval had taken place. No additional IRB approvals were needed for this investigation.

Due to the nature of this investigation involving de-identified secondary subject files, informed consent was not required from individual subjects. According to regulatory guidelines (21 CFR Parts 50, 56, and 312) and the International Conference on Harmonization (ICH)/Good Clinical Practice (GCP), informed consent was obtained in the original examination from which the secondary data will be taken (Public welfare general requirements for Informed Consent, 2003). Subjects were given ample opportunity to read the IRB-approved consent form and had all questions regarding the initial examination answered prior to signing the consent form. Each subject was given a signed copy of the exact consent form to retain for their records. Additionally, the original IRB-approved informed consent stated that data collected during the subjects' initial examination may be used for further research.

Funding

This investigation was funded by the investigator.

Data Collection Procedures

This research involved manually searching an existing database of de-identified, secondary data owned by the investigator. This database includes a chronological person's age and type of toothbrush used (manual or power). If the subject file included a person's chronological age and the type of toothbrush used, all additional data in the file was collected. These data included smoking status, coffee and/or tea usage, chewing gum usage, dental floss use, gender, Hispanic/non-Hispanic, and handedness. After manually searching the database for data that meets the inclusion/exclusion criteria, data was entered into a Microsoft Excel® spreadsheet.

Data Analyses

All data was loaded into and analyzed by IBM® SPSS® Statistics 26. Two Chi-square tests with corresponding odds ratio calculations were performed to analyze whether a statistically significant relationship exists between type of toothbrush usage and a person's age classification. To look at the secondary hypothesis of power toothbrush use being related to gingival bleeding index (GBI) scores the Wilcoxon-Mann-Whitney Test was used to compare the medians of the rank sums of GBI score number of sites for power toothbrush users versus manual toothbrush users. If the GBI scores were normally distributed, the Independent Samples t-test would have been used to compare the means. However, Q plots of the GBI score number of sites variable by the type of toothbrush use revealed a departure from normality in both groups. Spearman's rho correlation analysis was used to examine the relationship between age, toothbrush type and GBI score number of sites. A one-way analysis of variance was performed to compare the mean GBI score number of sites with respect to age groups. Furthermore, a post-hoc multiple comparison Tukey HSD test employed to identify age groups with significant differences. Finally, a two-way analysis of variance was performed to compare the mean GBI score number of sites with respect to age and type of toothbrush use. Statistical significance was defined as $p < 0.05$.

Summary of the Chapter

This chapter discussed many issues in the overall methodology, including the specific sample to be investigated and the research methods and rational. A detailed explanation of the research procedures specific to this study were explained, and data analysis methods were revealed. Furthermore, the strengths and weakness of the investigational design and study subjects was discussed. Additionally, a detailed description the clinical measure used to quantify gingivitis was provided and validity and reliability were analyzed and discussed.

Chapter 4: Results

Introduction to the Chapter

In this chapter, the results of the data analysis will be revealed. Results will be revealed from frequency data, chi-squared tests of independence with corresponding odds ratio calculations, Mann-Whitney U tests, Spearman's rho correlation analysis, one-way analysis of variance, post hoc multiple comparison Tukey HSD, and two-way analysis of variance. Several tables and figures will be used to help clarify the data. Additionally, a summary of the results will be discussed.

Data Analysis Results

In this cross-sectional investigation, 2,016 dental subjects were identified to have both an age recorded and use of either a power toothbrush or a manual toothbrush. Demographic and clinical characteristics by subject choice of toothbrush and for the sample overall are displayed in Table 1. 1,441 (71.5%) of the subjects were female and 59 (2.9%) of subjects were Hispanic. There was no significant difference in choice of toothbrush type by either gender or ethnicity. The majority of the subjects were right-handed (91.0%) and only 27 (1.3%) were ambidextrous. There was no association observed between handedness and type of toothbrush used. Not all subjects reported information on the four habits included in the study. 1,797 subjects reported smoking status and 153 (8.5%) were smokers. 1,794 subjects reported coffee and/or tea drinking status and 1,203 (67.1%) reported they were coffee and/or tea drinkers. There was no association between type of toothbrush used with either smoking status or coffee/tea drinker status. 1,794 reported gum chewing status and 1,024 (57.1%) reported they were gum chewers. 60.9% of power toothbrush users were gum chewers whereas 55.4% of manual toothbrush users were gum chewers. This difference in proportions was statistically significant (p = 0.029). 1,795 subjects reported use or non-use of dental floss use and type of toothbrush used. Those that flossed reported a higher percentage of power toothbrush use (p = 0.012). 83.1% of manual toothbrush users did not floss as opposed to only 78% of power toothbrush users that did not floss.

Table 1

Table Title

	Overall Number (%)	Power Toothbrush Number (%)	Manual Toothbrush Number (%)	p value
Total	2,016	657	1,359	
		Gender		0.865
Male	575 (28.5)	189 (28.8)	386 (28.4)	
Female	1441 (71.5)	468 (71.2)	973 (71.6)	
		Ethnicity		0.530
Hispanic	59 (2.9)	17 (2.6)	42 (3.1)	
Non-Hispanic	1957 (97.1)	640 (97.4)	1,317 (96.9)	
		Age Group A		0.001
18 to 45	1,042 (51.7)	305 (46.4)	737 (54.2)	
45 and over	974 (48.3)	352 (53.6)	622 (45.8)	
		Age Group B		< .001
18 to 64	1,765 (87.6)	548 (83.4)	1,217 (89.6)	
65 and over	251 (12.5)	109 (16.6)	142 (10.5)	
		Age Group C		< .001
18 to 21	149 (7.4)	39 (5.9)	110 (8.1)	
22 to 30	364 (18.1)	105 (16.0)	259 (19.1)	
31 to 39	330 (16.4)	103 (15.7)	227 (16.7)	
40 to 48	364 (18.1)	115 (17.5)	249 (18.3)	
49 to 57	336 (16.7)	95 (14.5)	241 (17.7)	
58 to 66	282 (14.0)	116 (17.7)	166 (12.2)	
67 and over	191 (9.5)	84 (12.8)	107 (7.9)	
		Handedness		0.375
Right	1834 (91.0)	606 (92.2)	1,228 (90.4)	
Left	155 (7.7)	44 (6.7)	111 (8.2)	
Both	27 (1.3)	7 (1.1)	20 (1.5)	
		Smoking Status (n = 1,797)		0.196
Smoker	153 (8.5)	41 (7.3)	112 (9.1)	
Non-smoker	1,644 (91.5)	524 (92.7)	1,120 (90.9)	
		Gum Chewer (n = 1,794)		0.029
Yes	1,024 (57.1)	342 (60.9)	682 (55.4)	
No	770 (42.9)	220 (39.2)	550 (44.6)	
		Coffee/Tea (n = 1,794)		0.959

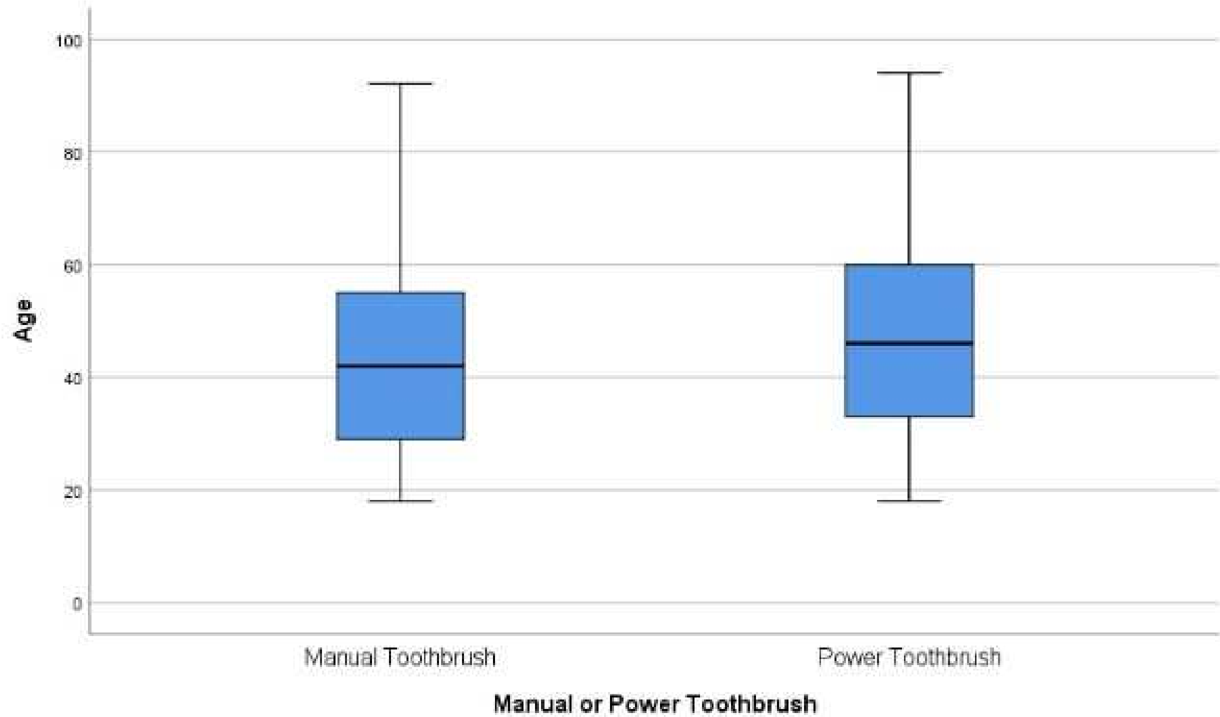
Yes	1,203	378 (67.1)	825 (67.0)	
No	591 (32.9)	185 (32.9)	406 (33.0)	
		Flosser (n = 1,795)		0.012
Yes	331 (18.4)	123 (21.8)	208 (16.9)	
No	1,464 (81.6)	440 (78.2)	1,024 (83.1)	

Note. $p < .05$ is statistically significant, $p < .001$ is highly statistically significant.

Figure 1 displays the boxplots of age as a continuous variable for the two types of toothbrush users. The median age for manual toothbrush users was 42 and the mean age was 43, whereas the median age for power toothbrush users for manual toothbrush users was 46 and the mean age was 46. A highly statistically significant relationship was observed between toothbrush use and the categorization of 7 age groups ($p < .001$). Categorizing age according to the Healthy People 2030 objectives, 1,042 (51.7%) of subjects were between 18 and 44 years of age and 974 (48.3%) were 45 years and over. The chi-square statistic from the test of independence between age group (age 45 and older and under 45 years) and type of toothbrush was 10.812 ($p = 0.001$). The prevalence odds ratio and corresponding 95% confidence interval was 1.367 (1.134, 1.648). In this secondary data set, an older person (45 years and older) was 1.4 times more likely to use a power toothbrush. Categorizing age according to the CMS population, 1,1765 (87.6%) of these subjects were between 18 and 64 years of age and the remaining 251 (12.5%) were 65 years and over. The chi-square statistic from the test of independence between age group (age 65 and older and under 65 years) and type of toothbrush was 15.326 which has a highly significant p-value ($p < .001$). The prevalence odds ratio and corresponding 95% confidence interval was 1.705 (1.302, 2.231). Subjects in this dataset eligible for Medicare were 1.7 times more likely to use a power toothbrush.

Figure 1

Manual or Power Toothbrush



Note. Boxplots of Actual Age by type of toothbrush

A nonparametric correlation analysis was performed on the actual age of the subjects with GBI score number of bleeding sites and manual or power toothbrush use. The Spearman's rho statistic was significant for each pairwise correlation. Age was inversely related to GBI score number of sites and had a weak relationship (r = -0.215, $p < 0.001$). There is a very weak inverse relationship between power toothbrush use and GBI score number of sites (r = -0.086, $p = 0.025$). There was a very weak positive relationship between age and power toothbrush use (r = 0.094, $p < 0.001$)

Table 2 lists the mean and median GBI scores along with respective standard deviation and interquartile range for both number of sites and percentage of sites by type of toothbrush used. The mean and median GBI score number of bleeding sites for power toothbrush users was 31.0 and 28.0 respectively, for manual toothbrush users the mean number of sites was 34.9 and median number of sites was 31.0. The normal approximation result of the Mann-Whitney U test, that compared the medians of the rank sums of GBI score number of sites for power toothbrush versus the manual toothbrush users, yielded a Z score of -2.238. This has a two-sided p-value of 0.025. Therefore, the null hypothesis of two sets of toothbrush users will have the same GBI score number of sites is rejected. The median rank sum of the GBI score number of sites was lower for the power toothbrush users. The median rank sum of the GBI score percentage of sites was not significantly different by toothbrush type.

Table 2

GBI Scores by Subject Choice of Toothbrush

	Mean ± SD	Median (IQR)	N	p - value
		GBI score (number of sites)		
Overall	33.8 ± 21.8	30 (20.0 – 47.0)	682	0.025
Power Toothbrush	31.0 ± 20.8	28.0 (18.0 – 40.0)	198	
Manual Toothbrush	34.9 ± 22.1	31.0 (20.0 – 49.0)	484	
		GBI score (% of sites)		
Overall	22.6 ± 9.9	20.8 (16.0 – 26.9)	203	0.397
Power Toothbrush	21.8 ± 9.8	20.8 (16.0 – 25.0)	63	
Manual Toothbrush	22.9 ± 9.9	20.9 (15.4 – 27.9)	140	

In Figure 2, the boxplots reveal a much lower 75th percentile GBI score number of sites for the power toothbrush users (40) than for the manual toothbrush users (49). The dispersion or width of the interquartile range is also smaller for the power toothbrush users (22) compared to the manual toothbrush users (29).

Figure 2

Boxplots of GBI score number of sites by type of brush

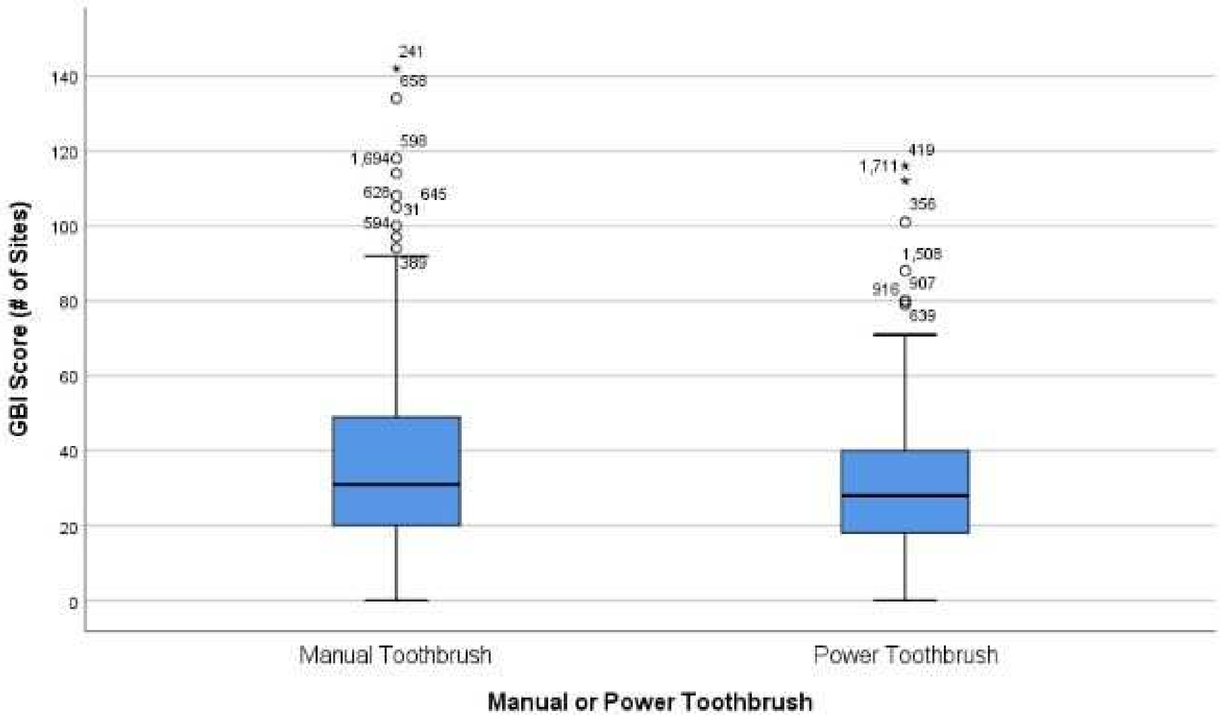


Table 3 lists the mean GBI score number of sites, 95% confidence intervals for means, standard deviations, minimum number of sites and maximum number of sites by the 7 age group classes. The mean GBI score number of bleeding sites was highest at 41.98 for the young adult group aged 22-30 years and was lowest at 28.03 for the middle elderly aged 58-66 years. To test if the mean number of sites were equal of each of the 7 age groups, a one-way ANOVA was ran after assessing approximate normality of GBI scores for each age group and homogeneity of the variances by way of Levene's test ($p = 0.321$). The result of the ANOVA was ($F(6,675) = 5.014$, $p < 0.001$). Therefore, the null hypothesis is rejected that the mean GBI scores were equal. To further determine which age groups had statistically significant differences, a Tukey HSD post hoc multiple comparisons test was conducted. The following pair mean differences were statistically significantly different: (1) Young Adult (22-30) — Early Elderly (49-57) = 11.999 number of sites ($p = 0.001$), (2) Young Adult (22-30) — Middle Elderly (58-66) = 13.949 number of sites ($p < 0.001$), (3) Young Adult (22-30) — Senior (67 and over) = 12.788 ($p = 0.038$), and (4) Late Adult (40-48) — Middle Elderly (58-66) = 8.080 ($p = 0.041$).

Table 3

GBI Score Number of Bleeding Sites by Age Group

				95% Confidence Interval for Mean			
Age Group	N	Mean	Std. Deviations	Lower Bound	Upper Bound	Minimum	Maximum
Late Adolescence (18-21)	15	39.13	19.708	28.22	50.05	7	70
Young Adult (22-30)	88	41.98	22.756	37.16	46.80	4	142
Middle Adult (31-39)	135	34.99	21.849	31.27	38.70	0	134
Late Adult (40-48)	158	36.11	23.574	32.40	39.81	1	116
Early Elderly (49-57)	141	29.98	20.556	26.56	33.40	0	108
Middle Elderly (58-66)	108	28.03	18.559	24.49	31.57	2	87
Senior (67 and up)	37	29.19	17.921	23.21	35.16	2	70
Total	682	33.79	21.781	32.15	35.42	0	142

Table 4 corresponds to the two-way analysis of variance (ANOVA) performed to analyze if a significant difference existed for the mean GBI score number sites with two factors: age 45 years and over or 18-44 years and type of toothbrush used. An examination of a plot of the residuals against predicted values was conducted to look for a departure from normality. The distribution of the residuals against the predicted values was approximately normally distributed. The Levene's Test of Equality of error variances was not significant (p = 0.245). Therefore, the assumption that the populations had the same variance was met. The SPSS output yielded Type III Sum of Squares with high significance for the model ($p <$ 0.001). Toothbrush type had a p-value of 0.086 and the binary age 45 and above or under 45 years variable was highly significant ($p < 0.001$). The interaction between age and toothbrush was insignificant (p = 0.722). This indicates that the binary age group did not depend on type of toothbrush used or vice versa.

Table 4

GBI Score Number of Sites by Age Group

Toothbrush Type	Age Group (years)	Mean	Std. Deviation	N
Manual	18-44	38.30	23.267	242
	45 and over	31.53	20.338	242
	18 and over	34.92	22.091	484
Power	18-44	35.80	20.660	81
	45 and over	27.73	20.337	117
	18 and over	31.03	20.802	198
Both Types	18-44	37.67	22.636	323
	45 and over	30.29	20.388	359
	18 and over	33.79	21.781	682

Note. 45 years and over vs 18-44 years

Similarly, a two -way analysis of variance (ANOVA) was performed where the dependent variable was GBI scores number of sites and the two independent factors were type of toothbrush and age group (65 years and over and 18-64 years). All ANOVA assumptions were met including homogeneity of the error variances (p = 0.258). The calculated F statistic for the model had a p-value = 0.028. The binary age group variable (65 years and over and 18-64 years) was statistically significant (p = 0.035). The type of toothbrush had a p-value = 0.075 and the interaction between age group and toothbrush type was not statistically significant (p = 0.441). therefore, the effect of toothbrush type did not depend on age group. Table 5 lists the actual means, standard deviations and N sizes for each of the toothbrush type by age group combination.

Table 5

GBI Score Number of Sites by Age Group

Toothbrush Type	Age Group (years)	Mean	Std. Deviation	N
Manual	18-64	35.19	22.206	450
	65 and over	31.24	20.460	34
	18 and over	34.92	22.091	484
Power	18-64	32.19	21.475	171
	65 and over	23.67	14.069	27
	18 and over	31.03	20.802	198
Both Types	18-64	34.37	22.031	621
	65 and over	27.89	18.176	61
	18 and over	33.79	21.781	682

Note. 65 years and over vs 18-64 years.

Summary

This chapter revealed the results of a secondary data analysis taken from a database located at Salus Research that the investigator owns. Results were revealed from frequency data, chi-squared tests of independence with corresponding odds ratio calculations, Mann-Whitney U tests, Spearman's rho correlation analysis, one-way analysis of variance, post hoc multiple comparison Tukey HSD, and two-way analysis of variance. Several tables and figures were used to help clarify the data.

Chapter 5: Discussion

Introduction to the Chapter

The first chapter of this dissertation began with a brief background of biofilm and periodontal disease, as well as their link with several chronic diseases. The next chapter provided a historical overview of our knowledge regarding the benefits of power toothbrush use compared to a manual toothbrush in management of chronic disease and revealed a gap in knowledge regarding the use of a power toothbrush in the older adult population. The second chapter also looked at current theory and research that is specific to risk factors associated with the progression of gingivitis and periodontal disease. The third chapter outlined the rational for use of two Chi-square tests with corresponding odds ratio calculations and the Wilcoxon-Mann-Whitney test. Furthermore, rational for use of Spearman's rho correlation analysis, one-way and two-way ANOVA, and a post-hoc multiple comparison Tukey HSD was reviewed. The research procedures particular to this study were explained. Additionally, the resources and timeline required to conduct this study were outlined. Validity and reliability issues were considered along with anticipated limitations and delimitations. Chapter 4 revealed the results of the data analysis. Results were presented and discussed from frequency data, chi-squared with corresponding odds ratio calculations, Wilcoxon-Mann-Whitney test, Spearman's rho correlation, one and two-way ANOVA, and a post-hoc multiple comparison Tukey HSD. The major findings from these tests were statistically significant validation for both the primary and secondary hypotheses. This chapter will give an in-depth analysis and interpretation of the results. Additionally, further discussion will be presented to support the use of a power toothbrush in the aging population.

Discussion and Interpretation of Results

The purpose of this dissertation study was to determine the relationship between power toothbrush use and a person's chronological age and the relationship between the gingival bleeding index (GBI) scores with relation to manual and electronic toothbrush use based on age group. To determine this relationship, an investigator owned, existing database was searched for files containing the inclusion criteria of power toothbrush use and a person's chronological age.

The directing theory for this research was The Diffusion of Innovation. The investigator theorized that if a vulnerable group of individuals has limited access to formal media, or if their social network is limited, they might not adopt a new technology simply because they have not heard of the new innovation (Simons-Morton et al., 2012). This could help explain why a specific age group had not adopted power toothbrush technology. The supplementary theory to help interpret results was the Social Cognitive theory. The primary objective of the social cognitive theory is to clarify how individuals regulate their behavior. This is accomplished through an extensive study of the self-regulatory process controlled by goal-directed behavior Simons-Morton et al., 2012). The investigator used The Social Cognitive theory to propose that risk factors associated with periodontal disease include personal choices such as type of toothbrush used and dental plaque biofilm control.

Research Questions

1) What is the relationship between power toothbrush use and a person's chronological age?
2) What is the relationship between the gingival bleeding index (GBI) scores, age and manual or electric toothbrush use?

Hypotheses

1) The hypothesis for this investigation is power toothbrush use will be significantly related to a person's age.
2) The secondary hypothesis is that power toothbrush use will be significantly related to GBI scores.

Two research questions were analyzed using a quantitative approach using two Chi-square tests with corresponding odds ratio calculations and the Wilcoxon-Mann-Whitney test, Spearman's rho correlation analysis, one-way and two-way ANOVA, and a post-hoc multiple comparison Tukey HSD.

Through this analysis of de-identified secondary data, a statistically significant relationship between age and type of toothbrush use was proven. In the sample that associates with the Healthy People 2020 and 2030 (45 years and older and under 45 years), an older person was 1.4 times more likely to use a power toothbrush. In the sample that associates with the Patient Protection and Affordable Care Act of 2010 and Centers for Medicare and Medicaid Services programs (65 years and older and under 65 years), an older person was 1.7 times more likely to use a power toothbrush. There was no association between type of toothbrush used and smoking status or coffee/tea drinking status. Intriguingly, there was a statistically significant ($p = 0.029$) difference in gum chewers between manual and power toothbrush users favoring the power toothbrush. This correlation between power toothbrush use and chewing gum use could indicate an increased attention to the oral environment and breath smell. Another reported habit of interest is dental floss use. The data sets that reported regular use of dental floss reported a higher percentage of power toothbrush use ($p = 0.012$). This could indicate that individuals that have invested money to purchase a power toothbrush care enough about their overall oral health to take the time to floss. When looking at this result through the lens of the Social Cognitive theory, the goal-directed behavior could be optimal oral health through the use of every available resource such as a power toothbrush and dental floss.

Literature Review

Overall, gingivitis and periodontal disease are largely preventable through plaque biofilm control. Past research has proven that using a power toothbrush is statistically significantly more effective in plaque biofilm removal and control of gingivitis and periodontal disease than a manual toothbrush (Klukowska et al., 2014; Mirza et al., 2019; Starke et al., 2019). This dissertation fits into previous research by confirming that GBI scores used to evaluate gingivitis, caused by the presence of dental plaque biofilm were lower in all age groups who use a power toothbrush. Furthermore, specific type of power toothbrush use was not recorded in this deidentified data set, yet all power toothbrush uses yielded a lower GBI score. Therefore, this dissertation research corroborated the results of the recent article released in the Journal of the American Dental Association revealing that there is no statistically significant different difference in the oscillating rotating or side-to-side actions of power toothbrushes (El-chami et al., 2021).

This research differs in previous research and expands our current breadth of knowledge by looking at specific age groups and power toothbrush use, especially the older adult population. By breaking out the population into 45 years and older, this research revealed that the subject 45 and years and older was 1.4 times more likely to use a power toothbrush and subjects 65 years and older were 1.7 times more likely to use a power toothbrush. These results were contrary to the expected outcomes, due to the predictions created from the Diffusion of Innovation and Social Cognitive theories. Past research has looked at periodontal disease from a Social Cognitive perspective, linking the cause to an interrelated relationship between continuing processes of personal elements, environmental factors, and behavior (Tedesco et al., 1993). Due to the fact that this population of subject data sets were taken from a research facility where people have volunteered to undergo a free dental evaluation, this Social Cognitive interrelated relationship could have been modified to favor a hyper sense of awareness of the subject's oral environment. The Social cognitive theory proposes that variability in response is due to individualized goals and people are directed according to these goals and their environment (Simons-Morton et al., 2012). Within this specific dental research environment, subjects could have a more targeted goal of good oral health that might explain a variability in responses. Through the lens of the Social Cognitive Theory, this investigator originally predicted that the older population would use the power toothbrush less due to their environment of having a fixed income, not wanting to change current old habits, or not having the current knowledge about power toothbrush use technology. On the other hand, when taking a closer look at the specific population being studied and their individual goals of quality oral heath, the Social Cognitive Theory does an excellent job of predicting the observed outcome.

Additionally, the investigator used the Diffusion of Innovation Theory to help predict the results by looking at the older population as laggards when adopting new power toothbrush technology. Laggards might have an attraction for the conventional way of doing things and are extremely traditional. Typically, this group has a limited social network, limited time and money, and do not have access to information (Ryan & Gross, 1943). The investigator in this research, theorized that the vulnerable older adult population might not want to give up their manual toothbrush due to their traditional nature and conventional way of doing things. These traits could have explained a slower rate of adoption of power toothbrush technology. Moreover, with a narrow social network and possibly limited money, this investigator predicted that the vulnerable older adult population would use the power toothbrush technology less that their younger counterparts.

On the contrary, this dissertation research has revealed the importance of oral health and power toothbrush technology adoption in older adults. Since older people might be more aware of their health, and willing to volunteer in a dental study, they might be more willing to give up old habits and adopt new ones to better their overall health. Older people in the demographic of the data set could have more awareness of health, more discretionary money, and more willing to spend their money on things to improve their health, rather than a weekend case of beer.

Additional interests uncovered by the results of this dissertation research was the fact that older adults used dental floss more than younger adults. The highest GBI scores were in the young adult group (22-30) with 42 bleeding sites. The lowest GBI scores were experienced in the 58-66 age group. This could be due to the younger group not having discretionary money, a busy lifestyle, or a feeling of invincibility at a younger age. On the other hand, at age 45 most Americans start to experience a mid-life awareness and begin to realize their perception of invincibility was a falsehood. This could possibly explain the 45 years and older group being 1.4 times more likely to use a power toothbrush than the younger equivalent.

Implications

Implications for Practice

This dissertation research helped bridge our gap of knowledge and provided insight into the use of power toothbrush use in the older population and levels of gingivitis by looking at the GBI scores. Due to the fact that GBI scores were lower in people who reported using a power toothbrush, Medicare policy should be reevaluated to include providing a free power toothbrush to all Medicare recipients. This will help control chronic intraoral inflammation that contributes to other chronic diseases. Additionally, this research revealed that the older population is willing to use power toothbrush technology. If Medicare policy was readjusted to include a free power toothbrush to Medicare recipients, these brushes could be given out with proper instructions on use at the dental office. Education on benefits and proper use of a power toothbrush could be billed directly to Medicare from dental offices.

Unfortunately, the Health Resources and Services Administration reported in December 2020 that over 60 million Americans reside in areas that have a shortage of dental health professionals (Bureau of Health Workforce Health Resources and Services Administration (HRSA) U.S. Department of Health & Human Services, 2020). Due to this alarming fact, in conjunction with the reality that people reporting poor health are more likely to seek a medical practitioner than a dental professional, oral health instruction could be blended with medical care and patients could be given a power toothbrush and instructions for use during a medical visit (National Center for Health Statistics, 2010). Moreover, an additional approach to servicing the elder patient in the dental office would be the formation of a new advanced geriatric dental hygienist as suggested at the Elders' Oral Health Summit in 2005 (Jones & Wehler, 2005). This dental health professional could expand effective preventive dental services, assess the specific needs of the elderly patient and recommend the use of innovative and effective technology, such as a power toothbrush.

Implications for Further Research

This dissertation research could be improved by using a non-contaminated sample that is more representative of the normal population. This research included a sample from a database of people who have participated in dental clinical trials. Many of these human clinical trials included evaluation of the safety and efficacy of different kinds of power toothbrushes. Some sponsors of the trials allowed study participants to keep their power toothbrush at the end of the study. Future studies should include a representative sample to help reduce the sampling error displayed in this research. A representative or random sample would give more accurate insight into the acceptability and usage of power toothbrush technology in the older population.

Limitations and Delimitations

Despite all the learnings, this dissertation research had several limitations. When dealing with human error, one delimitation is data processing errors. To help control for such errors, the investigator implemented a triple-check of the data entry by experienced data entry personnel to ensure accuracy. Additionally, data processing errors can also be caused by computer programming during data analysis (Johns Hopkins Bloomberg School of Public Health, 2012). For this dissertation research, the investigator utilized a qualified statistician to double-check all data analysis in the SPSS® program to help reduce data processing errors.

Another limitation was the sample itself. The sample was taken from a database of dental study participants who had previously participated in one or more oral care clinical trials. Some of these clinical trials evaluated the safety and efficacy of power toothbrushes. Many times, when research participants would complete a trial involving a power toothbrush, the participant would be allowed to keep their toothbrush. This could have caused a sample bias and an artificially inflated number of participants who use power toothbrush technology compared to a random sample. Another limitation could have been honesty in reporting the use of a power toothbrush. Many power toothbrush clinical trials have an exclusion criterion of not currently using a power toothbrush. Therefore, if a participant had reported in the past or currently using a power toothbrush, they would be excluded from a study. This might have caused dishonesty in reporting because participants wanted to participate in the clinical trial.

Recommendations

At the very minimum, the national cost of leaving periodontal disease untreated should be investigated. This revelation could help fuel a push for very basic preventive benefits, such a power toothbrush. With the US population getting older and knowledge that the risk of chronic medical conditions escalates with age, additional clinical trials should be conducted looking into the intraoral effects of power toothbrush use on people 65 years of age and older. This could be further expanded to look at the long-term interplay of power toothbrush use on extra-oral disease such as cardiovascular disease, diabetes, respiratory disease, obesity, Alzheimer's, and pancreatic cancer. Finally, research needs to be conducted looking at the oral health quality of life in the elderly population who use power toothbrush technology compared to manual toothbrush users.

Summary

This research expanded my appreciation of the use of theory to predict outcomes. People are complicated, changing, and unique individuals and it is hard to predict behavior in every setting. The population in this data set posed a special circumstance that gave me insight into just putting a laggard "label" on a specific group of individuals because they are elderly and might be resistant to change. Not only did this research open my mind to the possibility and humility that I might be wrong in my predictions, it gave me understanding and awareness into my own prejudices. I believe that the uniqueness of doing this research during a pandemic infiltrated with complete political and social unrest was not coincidence. It forced me into a heightened awareness of my surroundings the people in my space. Additionally, with the weight of the uncertain world weighing in on us at every angle, this research project has revealed my true nature to never give up and take breaks when needed.

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