Paradigm Academic Press
Journal of Innovations in Medical Research
ISSN 2788-7022
OCT. 2023 VOL.2, NO.10

Critical Analysis of Electric Toothbrushes: Implications for Oral Care and Recommendations for Specific User Groups

Ming Huang[1]

[1] University of Glasgow, UK

Correspondence: Ming Huang, University of Glasgow, UK.

doi:10.56397/JIMR/2023.10.06

Abstract

Oral diseases have a lot of adverse effects on people's health. Oral care has become an important part of People's Daily maintenance of oral health. The purpose of this paper was to investigate the relationship between the type of electric toothbrush and a specific oral care population. This study will use the method of secondary research to review the relevant literature to answer the research questions. The results show that Oral-B is superior to Philips in both the treatment of gingivitis and plaque, but the Philips toothbrush still cleans better than a manual toothbrush. Secondly, children with disabilities can benefit from electric toothbrushes, because electric toothbrushes provide better plaque removal than manual toothbrushes. However, electric toothbrushes do not give disabled children the same cleaning results as ordinary people. Thirdly, in terms of enamel wear, sonic toothbrushes wear enamel more severely than vibrating toothbrushes. However, in terms of cementum, sonic toothbrush has less damage to cementum. In general, sonic toothbrushes are less harmful than vibrating toothbrushes. Practically speaking, this study suggests that ordinary consumers should choose Oral-B toothbrush more often than Philips toothbrush. Moreover, it is suggested that disabled children use electric toothbrushes to achieve better cleaning effect. However, as ordinary electric toothbrushes cannot make up for the defects of disabled children, it is suggested that relevant health institutions develop electric toothbrushes specially for disabled children. Furthermore, for those with sensitive and fragile teeth, the study recommends that they use a sonic toothbrush instead of vibrating toothbrush.

Keywords: tooth, electric toothbrushes, oral care, user-friendliness, safety

1. Introduction

Social and economic development has brought about dietary diversity, which also poses severe challenges to oral health (Azeem et al., 2019). Some scholars suggested using electric toothbrushes instead of traditional toothbrushes to maintain oral hygiene (Nakai et al., 2022; Nieri et al., 2020). This study aims to explore the relationship between electric toothbrush and user's oral care experience. Specifically, this study will address the following three research questions: First, to what extent does the brand of electric influence the user experience? To what extent does user-friendliness affect the experience of users with disabilities? Third, Are electric toothbrushes less harmful to teeth and gums than manual toothbrushes? This research is important because it can fill in the gaps in previous studies. For RQ1, Adam (2020) and Adam et al (2020) focused on the cleaning effect of different brands of electric toothbrushes, while ignoring the subjective experience of users. For RQ2, user friendliness is a pointer to the human characteristics of electric toothbrushes for specific populations. The electric toothbrushes used by Rai (2018) and Phadraig (2020) as research materials were customised, so it was necessary to check whether non-customised electric toothbrushes would lead to a better user's oral care experience. For RQ3, safety refers to whether there is damage to the oral mucosa or teeth during the use of an electric toothbrush. This is an important indicator of the user's oral care experience. However, there is disagreement over whether electric toothbrushes cause more tooth and gum damage than traditional toothbrushes, so further research is needed. Both oral health research institutions and consumers will benefit from this research.

In order to achieve the research purpose, this study will adopt the method of secondary research to review the relevant literature to answer the research questions. The structure of this paper is as follows: Firstly, the purpose of Introduction is to provide background and explain the purpose and value of the research. The next part is literature review, which will review previous studies on electric toothbrush and find gaps to guide the research direction. Then there is the methodological part, which aims to provide a methodological perspective for research and explain the secondary literature's selection and inclusion process. Next comes the Finding and Discussion part, which mainly analyses secondary literature and compares them with previous literature to reveal similarities and differences. The last part is Conclusion, which mainly expounds the main findings, practical significance and suggestions for future researchers.

2. Literature Review

2.1 Introduction

With the popularity of electric toothbrushes, the related research is also increasing rapidly (Azeem et al., 2019; Silva et al., 2020). Due to the clinical nature of medicine, most of the research on electric toothbrush in the previous literature are conducted by primary research (Tayal et al., 2020; Lyle et al., 2020). More specifically, the researchers used comparative experiments to investigate specific characteristics of electric toothbrushes (Humm et al., 2020; Tayal et al., 2020). The purpose of this literature is to compare and evaluate previous studies on electric toothbrushes. We hope to find the gaps and point out the direction for the following research. This literature review is mainly divided into three parts, namely, the type and user experience of electric toothbrush, the user-friendliness of electric toothbrush for the disabled, and the safety of electric toothbrush.

2.2 Type and User's Oral Care Experience of Electric Toothbrush

The majority of studies have focused on the impact of electric toothbrush brands on consumer experience. Firstly, Adam (2020) aims to investigate the advantages of Oral-B electric toothbrush in removing dental plaque compared with traditional toothbrush. This was a comparative study in which 27 participants were assigned to two groups. Thirteen people used traditional toothbrushes and another 14 used electric toothbrushes. At the beginning and end of the study, all participants were tested for dental plaque. The results show that electric toothbrush has better cleaning effect than traditional toothbrush. In addition, users of oral-B electric toothbrushes tended to report higher levels of satisfaction. The study's findings are supported by Thumay et al. (2022) and Hutter (2022).

Although the researchers claimed to control for variables, they did not specify how the toothbrush was used. In addition, the incorrect brushing method is also one of the reasons for the poor cleaning performance of traditional toothbrushes. Compared with the research design of Adam (2020), the research of Adam et al. (2020) used experimental methods to compare the cleaning effect of two different electric toothbrushes of Philips and Oral-B on users' dental plaque. Participants using both electric toothbrushes were asked to brush their teeth the same way, which added credibility to the study's findings. Finally, Adam et al. (2020) found that oral-B electric toothbrush with a round head and special bristles could better remove dental plaque. However, the flaw of the study is that it looked at the cleaning effectiveness of different types of electric toothbrushes from an objective perspective, rather than focusing on the subjective psychological perception of users.

2.3 User-Friendliness and Disabled User's Oral Care Experience of Electric Toothbrush

User-friendliness can be considered one of the most influential criteria in the consumer experience. In previous literature, the user-friendliness of electric toothbrush is defined as a series of humanised designs that affect consumer satisfaction (Humm et al., 2018). The most common user-friendly design is digital technology applied to electric toothbrushes. For example, Xue and Fang (2020) and Humm et al. (2020) both aimed to investigate the assistance of digital technology software to disabled electric toothbrush users. Both studies used single-blind, randomised controlled clinical trials. Participants in the experimental group were given electric toothbrushes with special procedures, while those in the control group were given traditional toothbrushes. At the end of the study, all participants were given user-friendly questionnaires. Notably, although there was no difference in plaque levels between the participants who used the electric toothbrush and the traditional toothbrush, more than 60% of the participants who used the electric toothbrush still thought they achieved better cleaning results and would recommend the electric toothbrush to their friends. In addition, the two studies had similar limitations. For example, the researchers didn't have a way to make sure participants followed protocols like brushing their teeth three times a day. Second, the researchers included only plaque index, a measure of cleanliness, and did not look at other measures, such as gum bleeding rates. The above deficiencies may lead to biased research results.

In addition, compared with Xue and Fang (2020) and Humm et al. (2020), Rai et al. (2018) aimed to evaluate the effectiveness of custom electric toothbrushes in maintaining oral health in patients with cerebral palsy. The researchers used experimental methods. Thirty patients with cerebral palsy, aged from 6 to 18 years, were randomly divided into two groups. The first group used a regular toothbrush and the second group used an

electric toothbrush. The results found that patients who used custom-made electric toothbrushes had an average reduction of more than 30 percent in plaque, compared with about 10 percent for those who used regular toothbrushes. Finally, Pater et al. (2020) and Phadraig et al. (2020) also pointed out in the same sense that for children and the elderly with visual impairment, the cleaning effect of dedicated electric toothbrush is superior to manual toothbrush. The limitation of the study is that the electric toothbrushes used by the participants were custom-made and not representative of ordinary electric toothbrushes on the market.

2.4 Safety of Electric Toothbrush and Manual Toothbrush

Electric toothbrushes are often questioned because they are considered to be less safe than conventional toothbrushes. Firstly, Yamada et al. (2020)'s study aimed to investigate oral penetration and infection caused by electric toothbrushes. Using the case study method, the researchers looked at three cases. Case 1 involved a disabled boy whose oral cavity was pierced by a malfunctioning electric toothbrush when he was brushing his teeth. In cases 2 and 3, the user slipped in the bathtub while brushing his teeth. In addition, cases 1 and 3 used a sonic toothbrush, and case 2 used a vibrating toothbrush. Research shows that the wrong shape of electric toothbrushes can cause cracks in the lining of the mouth. The drawback of case studies is that it is difficult for researchers to generalize findings, and because there is no standardised data analysis method, case studies are often biased by researchers. Similarly, Cronin's (1998) study aimed to investigate the safety of electric toothbrushes currently on the market. The study used randomised and parallel group trials. A total of 114 participants participated in the study, all of whom were selected by simple random sampling measurements. Before the study began, all participants underwent oral soft tissue, gum health and bleeding tests. Participants brushed their teeth for two minutes twice a day. The study lasted three months. At the end of the study, the researchers calculated artificial wear on the participants' oral tissue. Surprisingly, this study revealed completely different results from Yamada et al. (2020). The results showed that none of the groups using electric toothbrushes caused artificial oral wear. A limitation of this study is that participants received different brushing training than the general population.

Finally, Ng's (2020) study aimed to investigate the damage of electric toothbrushes to teeth and gums. Unlike studies by Yamada et al. (2020) and Cronin (1998), this is a secondary study based on literature. The researchers systematically reviewed electric toothbrush designs, materials and other applications. The results show that the design of electric toothbrush has great influence on user safety. Specifically, the design and material of the bristles is important as it is an important safety factor, in addition, the shedding of other parts can also cause harm to the user. But the problem with this document is that it's so old. Therefore, the differences with recent electric toothbrush technology cannot be eliminated.

2.5 Conclusion

To sum up, this literature has introduced relevant research from three aspects: electric toothbrush brand, user friendliness and safety. In general, in terms of brands, previous studies tend to focus only on the cleaning effect of different brands of electric toothbrushes, while ignoring the user's feelings. Secondly, in terms of user friendliness, customised toothbrushes can achieve better cleaning results for disabled users, but ordinary electric toothbrushes on the market seem to provide only a placebo effect. Therefore, it is necessary to further understand the needs of disabled users for the user friendliness of electric toothbrushes. Finally, there is no consistent answer on the safety of electric toothbrush, which needs further study.

3. Methodology

3.1 Introduction

The purpose of this chapter is to provide a methodological perspective for this study. This study will be a non-empirical and secondary research, and the author will use a literature-based research method to answer the research questions. Firstly, the author will introduce the research method of the so-called literature, then introduce the source of data, and finally, analyse the literature after screening.

3.2 Research Methods

The purpose of this study is to investigate the relationship between electric toothbrush design and user experience. Due to monetary and time limitations, this study will adopt a secondary-based approach. Secondary research means that the researcher does not conduct practical data collection but uses data from previous studies to answer research questions (Weston et al., 2019). Compared with primary research, secondary research greatly saves time and money for researchers. However, the quality of the data used cannot be guaranteed as the secondary investigator is not aware of the original data collection process (Sherif, 2018).

Document-based research is a critical review of existing knowledge in a particular field such as oral science (Katagiri & Min, 2019). In most cases, a literature review can be used as part of a paper, however, it can also be used as a separate study to critically review specific knowledge. As can be seen from the above statement, the

documentation-based approach emphasises a critical review of research materials. According to Corbett-Davies and Goel (2018), the critical review means that researchers should discriminate the purpose, methods and results of the literature according to its relevant background. For this study, the author will focus on whether the methods of previous empirical studies conform to scientific norms and use the findings of their datasets to answer the research questions proposed in this study through comparison and discussion.

In addition to the above, and more importantly, document-based research methods allow researchers to compare different studies and find knowledge that has commonalities (Faria et al., 2018). Moreover, by comparing previous studies, the author can also find the differences between their studies, which is the blank of future research. Finally, if the selected studies are quantitative (as most studies in the oral sciences are), the results of literature analysis can provide additional qualitative knowledge of research outcomes in this area.

3.3 Data Collection

In order to guide literature retrieval, it is necessary to establish neutral keywords. According to Sutton (2019), research questions can guide literature retrieval. Therefore, the author determined the following keywords: “electric toothbrush”, “safety”, “brand”, “user friendly”. Then, the author searched the literature in the University of Glasgow school library. The university library can display the general results of academic work in the area. Next, the author tried to search again in Google Scholar. Then, to avoid missing some useful literature because of synonyms and broader terminology. The author also uses the second category of keywords: “customised toothbrush”, “gum damage”, “manufacturer”, “humanisation”.

Through the search of the above two types of keywords, this study seeks to ensure the relevance of the available literature. In terms of the quantity of literature review, as mentioned above, documentation-based research requires researchers to critically review the purpose, methods and findings of the selected literature in light of relevant background (citation).

The data for this study comes from 16 different research papers. However, the author will focus on the 4 articles with the strongest correlation to the main topic. After comparing the data, the results are summarised and discussed with other literature.

3.4 Literature Inclusion Criteria

Since the screening of literature needs to be limited by the research topic, the literature selected for this study must meet at least one of the following three criteria. First, the selected literature needs to include at least two or more brands of electric toothbrushes that affect consumer experience. Second, the selected literature needs to focus on disabled people and examine whether the design of electric toothbrushes meets the needs of this special group. Third, the selected literature must contain an analysis of tooth and gum damage by different electric toothbrushes. The literature selected for this study needs to meet one or more of the above criteria to be included in this study.

In terms of data analysis, researchers will mainly analyze the purpose, methods and findings of the secondary literature, and place the secondary literature in a broader literature context for analysis.

4. Finding and Discussion

The purpose of this chapter is to critically analyse the selected literature and evaluate the quality of the literature in combination with the relevant background, to answer the questions of this study. Structurally, this study will first introduce the influence of electric toothbrush brand on user experience, then discuss the influence of electric toothbrush design on user experience of disabled people, and finally evaluate the damage of electric toothbrush to teeth and gums. The analysis of the above research topics is based on empirical research.

4.1 Toothbrush Brand and Cleaning Effect

Adam et al. (2020) aimed to compare the influence of the design of two brands of electric toothbrushes (Philips and Oral-B) on user experience. Procter & Gamble recently introduced a new electric toothbrush with a micro-vibration feature. Adam et al. (2020) attempted to use the method of reference group experiment to compare the influence of different designs on users between Oral-B electric toothbrush and Philips toothbrush, among which Philips toothbrush uses sonic technology. Patients with gingivitis and plaque were randomly assigned to use an Oral-B or Philips toothbrush twice daily for eight weeks. At the end of the experiment, the participants’ dental plaque levels were retested. The study involved 90 participants with an average age of 41. The results showed that dental plaque levels were significantly lower among users of Oral-B toothbrushes than among users of Philips electric toothbrushes.

Table 1. The relationship between toothbrush brand and gingivitis, plaque and cleaning effectiveness

Score mean/Difference	gingivitis	plaque	efficiency

Philips	0.269	0.324	0.123
Oral-B	0.437	0.458	0.158
traditional	0.242	0.300	Non

Source from: Adam et al. (2020), Neelima et al. (2017) and Jain (2013).

Table 1 shows how well the participants cleaned using three toothbrushes. According to the data in the figure, in each abscissa, the P-value of Oral-B electric toothbrush is greater than that of Philips electric toothbrush. It should be noted that the parameter in the figure refers to the P-value, which is the main measure of plaque and gingivitis levels. In addition, cleaning efficiency refers to the extent to which hidden areas inside the mouth are cleaned. Oral-B users achieved significantly better cleaning results out of the three toothbrushes.

In previous literature, different brands of electric toothbrushes tend to have their own technological advantages. However, electric toothbrushes with different technologies have different ability to remove plaque (Van & Slot, 2015). In addition, studies have shown that Oral-B toothbrush can more effectively clean hard-to-clean areas such as gum margins and the side of the tongue due to its use of micro-vibration technology (Grender et al., 2013). This paper believes that the research design of Adam et al. (2020) is effective because it accurately defines the key indicators. For example, the researchers considered “unhealthy” users who brushed their teeth at more than 10% of the bleeding site per brush, according to the American Society of Periodontitis and the European Federation of Periodontitis (Trombelli et al., 2018).

Therefore, the research results of Adam et al. (2020) prove the viewpoint of previous studies (Van & Slot, 2015). In addition, according to (Grender et al., 2013), a similar experiment was conducted on 462 participants, and the results showed that compared with Philips toothbrush, Oral-B toothbrush could clean into more concealed areas, for example, the cleaning effect of the lingual area increased by nearly 50%, and the cleaning effect of the sub-lingual area increased by 30%. Current control trials show that Oral-B toothbrushes on the market today remove plaque better than Philips toothbrushes in eight weeks. This is because Oral-B toothbrush uses more advanced technology.

4.2 Acceptance of Electric Toothbrush by Disabled Children

The study of Patel et al. (2021) aimed to compare the user experience of using electric toothbrushes and traditional toothbrushes in children with disabilities, as well as the effectiveness of removing dental plaque. The researchers used a control group of 60 children. Among them, there were 30 blind children and 30 deaf children. They were asked to clean their mouths using either an electric toothbrush or a manual one. The study lasted 15 days and participants were tested for dental plaque at the beginning and end of the study.

Table 2. Differences in the friendliness of electric and traditional toothbrushes for blind, deaf and general users.

Score mean/Difference	Visually impaired	Auditory impaired	Non-existent Health condition
Manual	0.14	0.15	0.242
Electric	0.30	0.34	0.458

Source from: Patel et al. (2021) and Adam et al. (2020).

Table 2 shows the effects of two types of children with disabilities (hearing impairment and visual impairment) using electric toothbrushes and compares these effects with those of the general population without training. The results showed that, for blind children, manual and electric toothbrushes achieved a plaque removal efficiency of 0.3 and 0.14, respectively. Second, for deaf children, their removal efficiency of dental plaque by electric toothbrush and manual toothbrush was 0.34 and 0.15 respectively. In addition, for untrained ordinary users, the cleaning effect was 0.458 when using an electric toothbrush and 0.242 when using a manual toothbrush. This indicates that electric toothbrush is more suitable for cleaning blind and deaf children than traditional toothbrush. Moreover, blind children are more likely to benefit from electric toothbrushes than deaf children.

In the previous literature, the oral condition of children with disabilities is even worse because their parents lack relevant oral care knowledge (Jain et al., 2013). Especially for blind children, their skills are limited, so they cannot use traditional toothbrushes to achieve oral cleaning effect. Therefore, people with visual impairment need to use electric toothbrushes to ensure effective removal of dental plaque (Sharma et al., 2012). For deaf children, even with hearing AIDS, they cannot understand the guidance from their parents. Therefore, oral diseases of deaf-mute children are mostly caused by lack of knowledge rather than lack of ability (Deri et al., 2013). For blind children or deaf children, the cleaning effect of traditional toothbrush is limited, so special

electric toothbrush is needed to complete oral cleaning (Sharma et al., 2012). The study of Patel et al. (2021) confirmed the above views, and additionally found that electric toothbrush was more helpful for blind children than for deaf children. This study argues that the study of Patel et al. (2021) has certain limitations, so its results are questionable. Therefore, the small sample size of this study weakens the external validity of the study. The authors suggest that more reliable studies can be conducted with long-term follow-up and larger samples.

4.3 Damage of Electric Toothbrush to Teeth

Loitongbam et al. (2020) conducted a study to compare the wear of three different electric toothbrushes on teeth. The study used a comparative trial method. First, the researchers prepared 80 periodontal damaged human teeth from men and women ages 35 to 65. In addition, the samples were stripped of teeth with implants and crowns. The human teeth were divided into four groups and cleaned using different electric toothbrushes. Brush the teeth for two minutes a day for a month. At the end of the experiment, the teeth were assessed for apparent wear using a 1000-fold electron microscope.

Table 3. Damage of enamel and cementum by different toothbrush techniques

Unit: Index of damage	Sonic toothbrush	vibrating toothbrush	manual toothbrush
enamel	10.5±4.06	9.9±3.47	9.7±4.05
cementum	7.6±3.95	8.6±2.45	9.0±2.70

Source from: Loitongbam et al. (2020).

Table 3 details the damage of three different toothbrushes on teeth. A higher index represents a greater degree of damage. According to the data, for enamel, acoustic toothbrushes showed the highest degree of roughness (10.5), followed by vibrating toothbrushes (9.9) and manual toothbrushes (9.7). For cementum, manual toothbrush had the highest damage to cementum (9), while acoustic toothbrush (7.6) had the lowest damage to cementum.

In the previous literature, there has been a great deal of discussion about the safety of electric toothbrushes, and different techniques and designs have been extensively studied for plaque removal (Deacon et al., 2010; Grossman et al., 1995; Aass & Gjermo, 2000). However, few studies have looked at the damage that electric toothbrushes can do to teeth. They are widely regarded as safe (Robinson et al., 2005). The study of Loitongbam et al. (2020) fills in the gaps of previous literature. However, this study considers that the conclusions are questionable due to design flaws in this study. For one thing, the researchers weren't using living teeth, which have no internal nerve vessels or nutrient sources. As a result, human teeth are not as strong as normal teeth. Second, the environment of the experiment cannot truly simulate the situation of people brushing their teeth daily. For example, saliva can prevent tooth wear to some extent. For example, good bacteria may also protect teeth in some way.

4.4 Limitations and Conclusion

In summary, this chapter has made a critical analysis of the secondary literatures and compared them with the previous literatures. Firstly, different toothbrush brands have different cleaning effects on teeth due to their different technologies. At present, Oral-B toothbrush mainly adopts vibration technology, while Philips toothbrush mainly adopts acoustic technology. According to the research results, Oral-B toothbrush is superior to Philips toothbrush in terms of gingivitis, dental plaque and cleaning efficiency. Second, for children with disabilities, the use of electric toothbrush can achieve better cleaning effect than manual toothbrush, especially for children with hearing impairment, the advantages of electric toothbrush are more obvious. Unfortunately, electric toothbrushes do not help children with disabilities get the same cleaning results as ordinary people. Third, in terms of damage to teeth, vibrating toothbrush is more harmful to teeth than sonic toothbrush. Because this is secondary research, the reliability of the study depended on the quality of the present, although this study selected are periodical literature, however, this study found that for the relevant indicators (such as dental plaque and gingivitis) measurement, different scholars will adopt different standards, which brought difficulties to the comparison of the data. In addition, given the limited space of this study, only three journal articles were selected for this study, which exacerbated the difficulty of data comparison. To remedy this deficiency, this chapter has compared the three studies with the previous literature.

5. Conclusion

The purpose of this study is to explore the relationship between electric toothbrush and user experience. In terms of RQ1, this study compared Philips toothbrush with Oral-B toothbrush, and the results showed that Oral-B toothbrush was superior to Philips toothbrush in both the treatment of gingivitis and dental plaque. But even Philips toothbrush cleans better than manual toothbrush. In terms of RQ2, this study selected two kinds of

children with disabilities, namely children with visual impairment and children with hearing impairment. The study showed that both kinds of children with disabilities can benefit from electric toothbrush, because electric toothbrush can bring better dental plaque removal effect compared with manual toothbrush. However, electric toothbrushes do not give disabled children the same cleaning results as ordinary people. In terms of RQ3, this study also divided the damage to teeth into two parts, namely, the damage to enamel and the damage to cementum. In terms of enamel wear, sonic toothbrushes wear enamel more severely than vibrating toothbrushes. However, in terms of cementum, sonic toothbrush has less damage to cementum. Generally, sonic toothbrushes are less harmful than vibrating toothbrushes. Therefore, this study suggests that for general consumers, Oral-B toothbrush should be preferred over Philips toothbrush. Secondly, it is suggested that disabled children use electric toothbrushes to achieve better cleaning effect. However, as ordinary electric toothbrushes cannot make up for the defects of disabled children, it is suggested that relevant health institutions develop electric toothbrushes specially for disabled children. Thirdly, for those with sensitive and fragile teeth, the study recommends that they use a sonic toothbrush instead of a vibrating one. In view of the problems exposed in the process of this study, it is suggested that in future studies, subsequent scholars can use unified research parameters to measure relevant indicators. In addition, it is recommended that subsequent scholars conduct meta-analyses using more literature that may reveal more representative answers.

Reference

Aass, A. M., & Gjermo, P, (2000). Comparison of oral hygiene efficacy of one manual and two electric toothbrushes. *Acta Odontologica Scandinavica*, *58*(4), 166-170.

Adam, R, (2020). Introducing the Oral-B iO electric toothbrush: next generation oscillating-rotating technology. *International Dental Journal*, *70*, S1-S6.

Adam, R., Ram Goyal, C., Qaqish, J., & Grender, J, (2020). Evaluation of an oscillating-rotating toothbrush with micro-vibrations versus a sonic toothbrush for the reduction of plaque and gingivitis: results from a randomized controlled trial. *International Dental Journal*, *70*, S16-S21.

Azeem, M., Afzal, A., Jawa, S. A., Haq, A. U., Khan, M., & Akram, H, (2019). Effectiveness of electric toothbrush as vibration method on orthodontic tooth movement: a split-mouth study. *Dental Press Journal of Orthodontics*, *24*, 49-55.

Azeem, M., Afzal, A., Jawa, S. A., Haq, A. U., Khan, M., & Akram, H, (2019). Effectiveness of electric toothbrush as vibration method on orthodontic tooth movement: a split-mouth study. *Dental Press Journal of Orthodontics*, *24*, 49-55.

Belur, J., Tompson, L., Thornton, A., & Simon, M, (2021). Interrater reliability in systematic review methodology: exploring variation in coder decision-making. *Sociological methods & research*, *50*(2), 837-865.

Corbett-Davies, S., & Goel, S, (2018). The measure and mismeasure of fairness: A critical review of fair machine learning. *arXiv preprint arXiv:1808.00023*.

Cronin, M., Dembling, W., Warren, P. R., & King, D. W, (1998). A 3-month clinical investigation comparing the safety and efficacy of a novel electric toothbrush (Braun Oral-B 3D Plaque Remover) with a manual toothbrush. *American journal of dentistry*, *11*(Spec No), S17-21.

Deacon, S. A., Glenny, A. M., Deery, C., Robinson, P. G., Heanue, M., Walmsley, A. D., & Shaw, W. C, (2010). Different powered toothbrushes for plaque control and gingival health. *Cochrane Database of Systematic Reviews*, (12).

Deri, A., Kuzmanovic-Radman, I., Grabez, M., Bajic, Z., Prtina, A., Novakovic, B., & Zivkovic, S, (2013). Oral health in children with hearing and speech impairment in Banjaluka. *Stomatoloski glasnik Srbije*, *60*(3), 139-146.

Faria, M., Björnmalm, M., Thurecht, K. J., Kent, S. J., Parton, R. G., Kavallaris, M., ... & Caruso, F, (2018). Minimum information reporting in bio–nano experimental literature. *Nature nanotechnology*, *13*(9), 777-785

Grender, J., Adam, R., & Zou, Y, (2020). The effects of oscillating-rotating electric toothbrushes on plaque and gingival health: A meta-analysis. *Am J Dent*, *33*(1), 3-11.

Grender, J., Williams, K., Walters, P., Klukowska, M., & Reick, H, (2013). Plaque removal efficacy of oscillating-rotating power toothbrushes: review of six comparative clinical trials. *American Journal of Dentistry*, *26*(2), 68-74.

Grossman, E., Dembling, W., & Proskin, H. M, (1995). A comparative clinical investigation of the safety and efficacy of an oscillating/rotating electric toothbrush and a sonic toothbrush. *The Journal of clinical*

dentistry, *6*(1), 108-112.

Humm, V., Wiedemeier, D., Attin, T., Schmidlin, P., & Gartenmann, S, (2020). Treatment Success and User-Friendliness of An Electric Toothbrush App: A Pilot Study. *Dentistry Journal*, *8*(3), 97.

Humm, V., Wiedemeier, D., Attin, T., Schmidlin, P., & Gartenmann, S, (2020). Treatment Success and User-Friendliness of An Electric Toothbrush App: A Pilot Study. *Dentistry Journal*, *8*(3), 97.

Hutter, T., & Hutter, A. V, (2022). *Measurement of electric and magnetic radiation from an electric toothbrush*.

Jain, A., Gupta, J., Aggarwal, V., & Goyal, C, (2013). To evaluate the comparative status of oral health practices, oral hygiene and periodontal status amongst visually impaired and sighted students. *Special Care in Dentistry*, *33*(2), 78-84.

Jain, Y, (2013). A comparison of the efficacy of powered and manual toothbrushes in controlling plaque and gingivitis: a clinical study. *Clinical, cosmetic and investigational dentistry*, *5*, 3.

Katagiri, A., & Min, E, (2019). The credibility of public and private signals: A document-based approach. *American Political Science Review*, *113*(1), 156-172.

Loitongbam, M., Mohan, R., Chowdhary, Z., & Mehrotra, S, (2020). Comparative evaluation of tooth surface roughness caused by three different powered toothbrushes and a novel manual toothbrush — An SEM and AFM study. *Indian Journal of Dental Research*, *31*(5), 743.

Lyle, D. M., Qaqish, J. G., Goyal, C. R., & Schuller, R, (2020). Efficacy of the use of a water flosser in addition to an electric toothbrush on clinical signs of inflammation: 4-week randomized controlled trial. *Compendium*, *41*(3).

Nakai, K., Tanaka, H., Fukuzawa, K., Nakajima, J., Ozaki, M., Kato, N., & Kawato, T, (2022). Effects of Electric-Toothbrush Vibrations on the Expression of Collagen and Non-Collagen Proteins through the Focal Adhesion Kinase Signaling Pathway in Gingival Fibroblasts. *Biomolecules*, *12*(6), 771.

Neelima, M., Chandrashekar, B. R., Goel, S., Sushma, R., & Srilatha, Y, (2017). "Is powered toothbrush better than manual toothbrush in removing dental plaque?"—A crossover randomised double-blind study among differently abled, India. *Journal of Indian Society of Periodontology*, *21*(2), 138.

Ng, C., Tsoi, JKH, Lo, E., & Matinlinna, JP, (2020) Safety and design aspects of electric toothbrushes — Narrative commentary. *Dental Journal*, *8* (1), 15.

Nieri, M., Giuntini, V., Pagliaro, U., Giani, M., Franchi, L., & Franceschi, D, (2020). Efficacy of a U-shaped automatic electric toothbrush in dental plaque removal: A cross-over randomised controlled trial. *International Journal of Environmental Research and Public Health*, *17*(13), 4649.

Patel, N. G., Bargale, S., Shah, S., Ardeshana, A., Kariya, P. B., & Patel, H. N, (2021). Comparison of Plaque Removal Efficacy with Powered and Manual Toothbrushes in 10-14-year-old Visually and Auditory Impaired Children: A Randomized Controlled Study. *International Journal of Clinical Pediatric Dentistry*, *14*(3), 364.

Patel, N. G., Bargale, S., Shah, S., Ardeshana, A., Kariya, P. B., & Patel, H. N, (2021). Comparison of Plaque Removal Efficacy with Powered and Manual Toothbrushes in 10–14-year-old Visually and Auditory Impaired Children: A Randomised Controlled Study. *International Journal of Clinical Pediatric Dentistry*, *14*(3), 364.

Phadraig, C. M. G., Farag, M., McCallion, P., Waldron, C., & McCarron, M, (2020). The complexity of tooth brushing among older adults with intellectual disabilities: Findings from a nationally representative survey. *Disability and Health Journal*, *13*(4), 100935.

Rai, T., Rao, A., Natarajan, S., & Joseph, R. M, (2018). Evaluation of the effectiveness of a custom-made toothbrush in maintaining oral hygiene and gingival health in cerebral palsy patients. *Special care in dentistry*, *38*(6), 367-372.

Robinson, P., Deacon, S. A., Deery, C., Heanue, M., Walmsley, A. D., Worthington, H. V., ... & Shaw, B. C, (2005). Manual versus powered toothbrushing for oral health. *Cochrane Database of Systematic Reviews*, (2).

Sharma, A., Arora, R., Kenchappa, M., Bhayya, D. P., & Singh, D, (2012). Clinical evaluation of the plaque-removing ability of four different toothbrushes in visually impaired children. *Oral Health and Preventive Dentistry*, *10*(3), 219.

Sherif, V, (2018). Evaluating preexisting qualitative research data for secondary analysis. In *Forum: qualitative social research* (Vol. 19, No. 2, pp. 26-42). Freie Universität Berlin.

Silva, A. M., Miranda, L. F. B., Araújo, A. S. M., Prado Júnior, R. R., & Mendes, R. F, (2020). Electric toothbrush for biofilm control in individuals with Down syndrome: a crossover randomized clinical trial. *Brazilian oral research*, *34*.

Sutton, A., Clowes, M., Preston, L., & Booth, A, (2019). Meeting the review family: exploring review types and associated information retrieval requirements. *Health Information & Libraries Journal*, *36*(3), 202-222.

Tayal, M., Chavana, J., & Kariyat, R. R, (2020). Efficiency of using electric toothbrush as an alternative to a tuning fork for artificial buzz pollination is independent of instrument buzzing frequency. *BMC ecology*, *20*(1), 1-7.

Thurnay, S., Adam, R., & Meyners, M, (2022). A Global, In-Market Evaluation of Toothbrushing Behaviour and Self-assessed Gingival Bleeding with Use of App Data from an Interactive Electric Toothbrush. *Oral health & preventive dentistry*, *20*(1), 1-10.

Trombelli, L., Farina, R., Silva, C. O., & Tatakis, D. N, (2018). Plaque-induced gingivitis: Case definition and diagnostic considerations. *Journal of clinical periodontology*, *45*, S44-S67.

Van der Weijden, F. A., & Slot, D. E, (2015). Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis a meta review. *Journal of clinical periodontology*, *42*, S77-S91.

Weston, S. J., Ritchie, S. J., Rohrer, J. M., & Przybylski, A. K, (2019). Recommendations for increasing the transparency of analysis of preexisting data sets. *Advances in methods and practices in psychological science*, *2*(3), 214-227.

Xue, Y., & Fang, X, (2020). Research Design of Intelligent Toothbrush for Preschool Children Based on KANO Model. In *Journal of Physics: Conference Series* (Vol. 1631, No. 1, p. 012191). IOP Publishing.

Yamada, M., Hino, S., Nakamura, S., Iijima, Y., Kaneko, T., & Horie, N, (2020). Accidental oral injuries by electric toothbrush: a report of three cases. *Case reports in dentistry*, *2020*.