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**Exploring Psychological Correlates of Toothbrushing Behaviour -
A Systematic Review of Current Research and a Qualitative
Exploration of Real-Time Influences**

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Abstract

This thesis explores the psychological mechanisms of toothbrushing routines among younger adults. With individual attitudes and beliefs linked to toothbrushing engagement, an improved understanding of these mechanisms is expected to have benefits for preventive oral health efforts. Current limitations are that: a) there is little agreement regarding the psychological constructs that best correlate with toothbrushing, and b) there is little explanation around the dynamic, real-time influences that may influence toothbrushing on a daily basis. Two projects were designed: a systematic review of the current literature to determine the psychological constructs that best correlate with toothbrushing, and a qualitative exploration of how real-time variables may impact toothbrushing.

The systematic review screened 1117 articles. Analysis of the final sample ($N=13$) found that variables related to attitudes ($r=0.30$), self-efficacy ($r=0.48$), and intentions ($r=0.59$) had significant correlations with toothbrushing behaviour. However, findings were distorted by observations that methodology was poor/average, with the use of validated measures and reporting of statistics lacking across all studies.

The qualitative study consisted of in-depth interviews ($N=23$) that discussed toothbrushing routines, perceived attitudes and norms related to toothbrushing, and if toothbrushing routines ever changed from day-to-day. Individuals reported that routines were subject to change, with morning toothbrushing often skipped due to stress, and night-time due to exhaustion. Those who rarely neglected brushing reported being motivated by personal reasons rather than social pressures. Findings suggest the locus of motivations and ability to self-regulate during stress and/or feelings of tiredness may play a role in the experience of real-time barriers to toothbrushing.

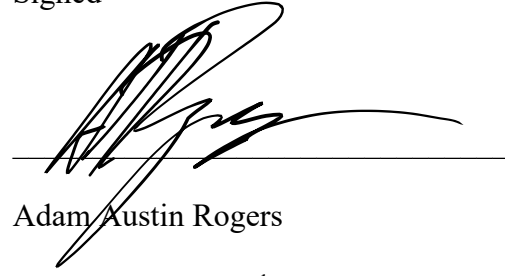
This thesis highlights the importance of exploring psychological mechanisms within the oral health field. Future research might attempt to quantify how self-regulation relates to toothbrushing engagement in terms of real-time decision making. Researchers are suggested to investigate the role of social pressures relative to more intrinsic motivations, and are advised to focus on study design, validated measures and the use of past literature. Clinicians are advised to be conscious of the role that situational barriers may have on toothbrushing behaviour, and should consider fostering intrinsic motivation within patients, rather than using fear or social norms to elicit improved toothbrushing. Limitations to the thesis and additional suggestions for research and further exploration within this field are discussed.

Declaration

This is to certify that:

- i) The thesis comprises only my original work towards the MPhil except where indicated
- ii) Due acknowledgement has been given in the text to all other material used
- iii) The thesis is less than 40,000 words in length, exclusive of tables, images, bibliographies and appendices

Signed

A handwritten signature in black ink, appearing to read 'A. Rogers', is written over a horizontal line.

Adam Austin Rogers

Submitted on the 8th August 2019

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Chapter 1 - An Introduction to the Preventive Capacity of Toothbrushing

1.1 - Introduction

The goal of this thesis and the contained research is to offer suggestions as to how dental professionals may better understand the cognitive and behavioural mechanisms that contribute to dental disease prevalence. Understanding disease incidence from a behavioural perspective can be challenging, with psychological constructs and cognitions both physically unobservable and intangible. To achieve this aim, the current project will specifically attempt to pinpoint the limitations of our understanding of these cognitive influences and will seek to offer suggestions for expanding this knowledge base in the effort of improving population oral health.

The thesis will begin by exploring dental disease at a biological level before demonstrating how individual behaviours may modify biological risk, and why behavioural tendencies may differ between individuals. Drawing on research from the field of psychology, the thesis will review the understanding of how modifiable psychological constructs (e.g. beliefs, attitudes, expectancies) may influence behaviour, and will illustrate how their continued exploration may increase the potential for preventive oral health interventions.

1.2 – The Biology of Oral Disease

Dental disease is typically associated with two specific pathological processes within the mouth: dental caries and periodontal disease. Together these two conditions account for damage to both the structure of the teeth themselves (caries) and to their supporting structures (periodontal disease).

1.2.1 - Dental caries. The process of dental caries is driven by the accumulation of bacterial plaque in the mouth, with plaque-levels linked to four key factors: the presence of oral bacteria (a prerequisite for the digestive system and found in the mouth of every human), the presence of tooth surfaces, fermentable sugars, and time (Gupta et al., 2013). With all factors present, bacteria gradually adhere to the outside of the teeth where the fermentation of sugars results in the proliferation of the plaque colony and the production of acidic by-products. Over time, acid drives a decrease in pH in the surrounding area that disrupts the mineral structure of the underlying tooth (Featherstone, 2008). This process slowly destroys the tooth via the complex ion exchange occurring between the mineral surface (i.e. the tooth) and the acidic environment (Abou Neel et al., 2016).

Dental caries can be hindered, though, by protective factors, with ions such as fluoride, calcium, and phosphate providing a buffer against acidic demineralisation (Gupta et al., 2013). With these protective ions naturally present within saliva, dental caries represents an ongoing struggle between factors that either drive or prevent the breakdown of the tooth, with the disease “dental caries” often referring the stage when visible changes to the tooth appear, such as a cavity on the tooth surface (Featherstone, 2008).

1.2.2 - Periodontal disease. Similar to dental caries, gingival disease is also related to the accumulation of bacterial plaque, and specifically bacteria that thrive within the gingival sulcus between the gum and tooth surface. Known as the periodontal pocket, chronic infection from plaque within the sulcus is termed periodontitis and represents a serious concern for the individual. Gingival disease can result in tissue necrosis and irreversible structural damage to the ligaments and bone that support the teeth, leading to severe dental complications and effects on general health (Reddy et al., 2000).

1.3 - The Impact of Dental Disease

In addition to localised effects, dental disease, dental pain, and tooth loss are also associated with negative consequences for quality of life. Systematic reviews of the oral health literature have revealed strong links between tooth loss and lower oral health quality of life (Gerritsen et al., 2010), between periodontitis and reduced general quality of life (Al Harthi et al., 2013) and between poor oral health status in general and reduced ratings of health-related quality of life (Naito et al., 2006). Self-rated oral health has also been linked to ratings of general health, self-esteem and life satisfaction (Benyamini et al., 2004).

1.3.1 - Dental disease within Australia. Within Australia, prevalence of dental disease is also cause for concern. Despite the above paragraphs linking dental disease to primary causative factors (i.e., bacteria, sugar, time), avoiding dental disease appears to be difficult based on statistics concerning the current disease burden. A report from the Australian Institute of Health and Welfare (AIHW) highlights that 16% of adults within Australia are likely to be affected by toothache (a severe level of dental pain, often indicating a chronic infection) in the course of an average year, with 27% also likely to report being uncomfortable with their dental appearance, and 20% already avoiding certain foods based on their dental problems (Chrisopoulos et al., 2016). In addition, 19% of adults over 65 are reported to have no teeth at all, and 53% are likely to have chronic periodontitis, representing a considerable pattern of depletion in oral health over the lifetime of Australian adults (Chrisopoulos et al., 2016).

While these statistics may indicate that dental problems simply compound and intensify with age, research illustrates that these serious disease patterns may show signs of beginning much earlier in life. A global report by Kassebaum et al. (2015) highlights that 25 years of age may be a peak-period for dental caries, with this claim further supported by Australian data that report 28.5% of younger Australians aged 25-44 have current active dental disease, and that 20.6% are likely to have experience some recent form of toothache (Chrisopoulos et al., 2016).

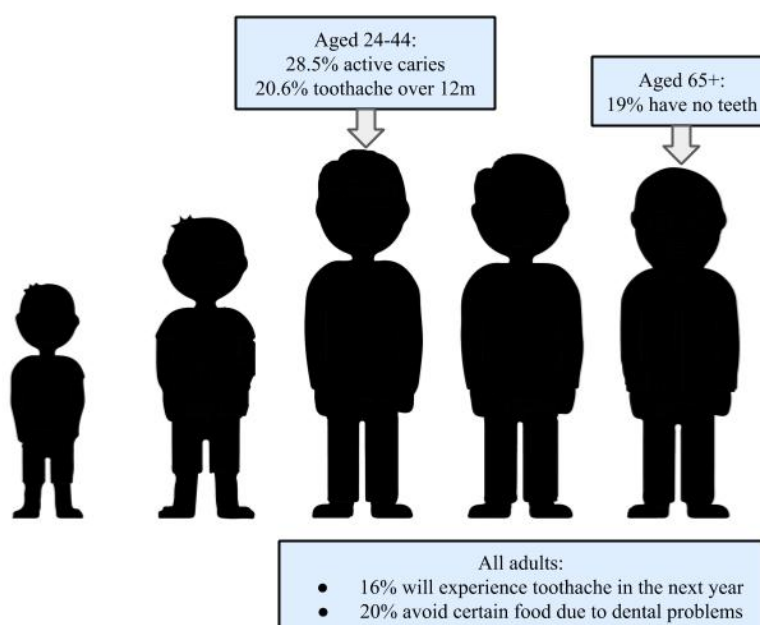


Figure 1. *Key concerns surrounding dental disease among Australian adults.*

1.3.2 - The looming crisis. Based on these statistics, summarized within Figure 1, the continuation of these patterns of dental disease is anticipated to have a sizeable effect on the quality of life of Australians, and could create a significant strain on future health systems (Gerritsen et al., 2010). In their systematic review of the effects of tooth loss, Gerritsen et al. (2010) pointed out that quality of life may also decrease further as additional teeth are lost, with each lost tooth representing a potentially preventable occurrence of dental disease. This finding indicates that while population-level efforts should aim to prevent initial dental caries and periodontitis, efforts should also aim to reduce the risk of subsequent tooth loss or dental disease amongst adults experiencing tooth loss or dental disease for the first time (Gerritsen et al., 2010).

1.4 - The Influence of Toothbrushing on Dental Disease

Looking at methods of preventing dental disease, and based on the biological knowledge of plaque-accumulation presented in Figure 2, the prevention of dental disease can be achieved through the advocacy of reducing sugar/carbohydrate consumption (Moynihan & Kelly, 2014) and by mechanically removing plaque (e.g. toothbrushing, flossing) on a timely basis (Hugoson et al., 1998).

Unfortunately, though, while the rate of sugar consumption is indeed related to dental caries incidence (Bernabe et al., 2014), research shows that no degree of sugar/carbohydrate reduction may affect the actual presence, or development, of plaque to the same degree as toothbrushing (L  e, 2000). Due to the inevitability of some carbohydrates in the diet, one cannot rely on diet-control alone to fight dental disease, necessitating mechanical plaque removal (L  e, 2000). While reducing sugars is certainly related to a reduced rate of plaque growth, mechanical cleaning is highlighted as the ideal means of reducing the total plaque burden in the mouth (L  e, 2000).

Mechanical removal via toothbrushing, in particular, can have a considerable impact on dental disease risk and require very little effort from an individual. Ideal toothbrushing routines consist of twice daily brushing (Kumar et al., 2016), with the recommended duration often 2-3 minutes for each brushing session (Wainwright & Sheiham, 2014).

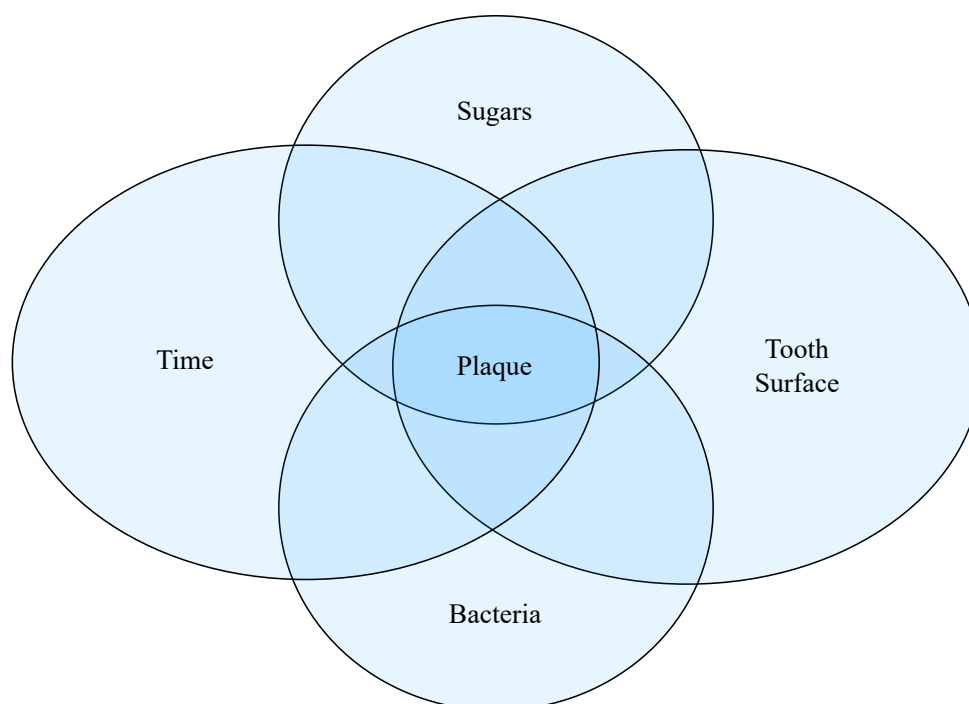


Figure 2. *A Venn-diagram of the four factors that drive plaque formation.*

1.4.1 - Flossing versus toothbrushing. Flossing, however, represents a supplementary method of removing plaque. As toothbrushing addresses plaque on visible tooth surfaces, flossing instead targets plaque that grows between the teeth and beneath the inter-dental gingivae. As these areas may be very difficult for a toothbrush to access, flossing is anticipated to provide an ideal means of support as a secondary oral hygiene behaviour. Despite this capacity, though, a systematic review of the effect of flossing on intra-oral plaque by Berchier et al. (2008) failed to provide any strong conclusions about the positive impact of flossing on plaque or gingivitis, highlighting difficulties in flossing technique as a potential reason for this result.

1.4.2 - A focus on toothbrushing. Without strong evidence supporting the independent effect of flossing on total plaque burden (Berchier et al., 2008), the primary focus of this thesis and research project will be toothbrushing twice daily. Toothbrushing is also an ideal target for behavioural change interventions as it represents a modifiable and accessible health behaviour (Gussy et al., 2008) with an established popularity among clinicians (Davies et al., 2003). Further, it is widely recognised by individuals (Löe, 2000), and has well documented effects on plaque levels (Hugoson et al., 1998), caries (Kumar et al., 2016), and periodontitis (Joshi et al., 2018). In a systematic review by Kumar, et al. (2016), meta-analysis confirmed that toothbrushing twice per day or more is significantly associated with a reduced caries risk compared to toothbrushing less frequently, and that the results were independent of the use of fluoride toothpaste. These findings highlight that the mechanical removal of plaque by toothbrushing, almost regardless of exposure to fluoride and protective factors, can be expected to significantly benefit dental health. The study also demonstrated that there may be a negligible effect from brushing more than twice daily (Kumar et al., 2016), supporting the idea that the advocacy of toothbrushing twice daily represents a clear, achievable, and well-defined goal for dental patients that is expected to have a real impact on dental disease incidence (Löe, 2000).

1.5 - Toothbrushing and General Health

Aiming to improve toothbrushing may also be worthwhile due to the anticipated benefits beyond improving oral health. Firstly, toothbrushing frequency has been shown to serve as a good indicator of general health risk (De Oliveira et al., 2010) and improvements to oral hygiene that may be expected as a result of toothbrushing are suggested to reduce individual risk of systemic disease (Fowler et al., 2001). Secondly, toothbrushing also appears to be linked to improvement in other behavioural areas (Tada & Matsukubo, 2003), with evidence highlighting potentially bi-directional relationships between increased toothbrushing

and both reduced rates of smoking and increased rates of exercise (Peltzer & Pengpid, 2014). Although not evidence of causation, these findings, plus additional associations such as that observed between dental health status and general physical activity (Rajala et al., 1980; Tada & Matsukubo, 2003), suggest that dental and general health behaviours, and individual attitudes towards maintaining both dental and general health, may be linked.

1.5.1 - Systemic effects of toothbrushing. The positive outcomes of toothbrushing appear to have an impact on chronic general health conditions. Infrequent toothbrushing, for example, is associated with an increased risk of a cardiovascular disease events, such as a stroke or heart attack (De Oliveira et al., 2010; Van Wormer et al., 2013). While this may potentially occur via the aforementioned links between toothbrushing and known correlates of heart disease such as exercise and smoking, it has been proposed that toothbrushing may influence the actual presence of systemic inflammatory markers through the removal of harmful bacteria (De Oliveira et al., 2010) with such systemic observations being independent of smoking, alcohol, and exercise habits (Kuwabara et al., 2016). Similarly, the presence of periodontitis has also been related to similar risk markers (Fowler et al., 2001), with periodontitis specifically linked to risks of birth complications and diabetes (Fowler et al., 2001; Nazir, 2017) as well as arthritis, cancer, kidney disease, and respiratory problems (Nazir, 2017).

1.6 – Current Rates of Toothbrushing Frequency

As indicated by evidence surrounding the burden of dental disease, toothbrushing twice every day is also not as common as may be perceived (Manton et al., 2018). Despite dental disease being preventable, it still constitutes a major public health burden (Jin et al., 2016) and, in line with the AIHW report (Chrisopoulos et al., 2016), global research highlights a need for better community-focused oral health promotion to address widespread neglected oral hygiene (Bourgeois & Llodra, 2014). On a global scale, this burden of dental disease translates to approximately 3.9 billion people being affected by problems with their oral health at any given time, with around 2.4 billion expected to be suffering from dental caries (Meier et al., 2017).

While global statistics may indicate major problems related to healthcare infrastructure among poorer nations, access to dental healthcare does not appear to be a panacea for this oral disease burden. Evidence shows that good self-care may be sufficient to adequately control dental plaque (Hugoson et al., 2007), and one study reported that 19% of adults would still delay their dental treatment based on associations with unnecessary anxiety and financial burden (Hill et al., 2013). This information indicates that the promotion of oral self-care may

be vital to population oral health in any case. Such a goal may be achieved through oral health promotion and health education that aims to empower individuals to achieve better oral hygiene and increase their toothbrushing compliance, especially younger adults.

Preventive focused solutions also address the need for long-term, sustainable solutions that focus on individual self-care (Jin et al., 2016), and fulfil goals related to increasing preventive efforts among adults who are already experiencing dental disease (Petersen & Yamamoto, 2005). With the above evidence highlighting the strengths of toothbrushing as an effective health behaviour, and the potential for interventions targeting self-care to have an influence on general health, improving the evidence that guides toothbrushing focused health-promotion among adult demographics represents a goal that is anticipated to have a population-level benefit, and constitutes the main aim of this thesis.

Chapter 2 - The Benefits of a Psychological Approach to Toothbrushing

2.1 - Psychology and Changing Human Behaviour

Understanding the individual determinants of self-care is illustrated as a means of achieving improved dental health (Tonetti et al., 2017). With the first chapter of this thesis outlining a biological perspective of dental disease and the role of toothbrushing behaviour in altering these biological disease processes, this chapter aims to adopt a behavioural science perspective to explain individual variations in oral hygiene self-care behaviour.

Completely understanding behaviour presents some challenges. Primarily, explaining one's own behaviour, disposition, and habits is a difficult task, let alone attempting to explain the behaviour of others. Further, changing behaviour based on our knowledge of why that behaviour occurs is rarely straightforward. Therefore, as health professionals, it may be difficult persuading patients to engage in behavioural change. Using an evidence-based approach is anticipated to help reduce uncertainty in this area of treatment, with behavioural science and psychology having the potential to provide such evidence and help guide health promotion in the dental clinic.

2.1.1 - The concept of behavioural science. The field of behavioural science is concerned with understanding the mechanisms through which behaviour is learned, remembered, and triggered during daily life. With these processes constituting part of an ongoing cycle of reciprocal influence between the person and their environment (Bandura, 1971), the sheer magnitude of influential factors involved can mean that pinpointing an exact mechanism of behaviour is a difficult task (Butz & Torrey, 2006). However, thanks to developments in technology, in monitoring capabilities, in statistical analyses, and in the biological science that underpins behavioural engagement, the ability to model and predict behaviour is constantly improving (Butz & Torrey, 2006). While early meta-theories of behavioural science were based around strict behaviourism or drive theories, more cognitive-affective theories have come to the fore since the second half of the 1900's (Bandura, 1971). Cognitive-affective theories suggest that humans are capable of storing and manipulating information, and assigning emotive (affective) values to these various cognitions. It is then suggested that humans are equally capable of deciding when and where information is used, with decision processes influenced by the environment, the encoding process, and emotive connotations (Bandura, 1971). This was opposed to behaviourist theories that perceived

behaviour as simple reactions to reward/punishment stimuli, or drive-theories that depicted behaviour as occurring solely to fulfil innate human needs (Bandura, 1971).

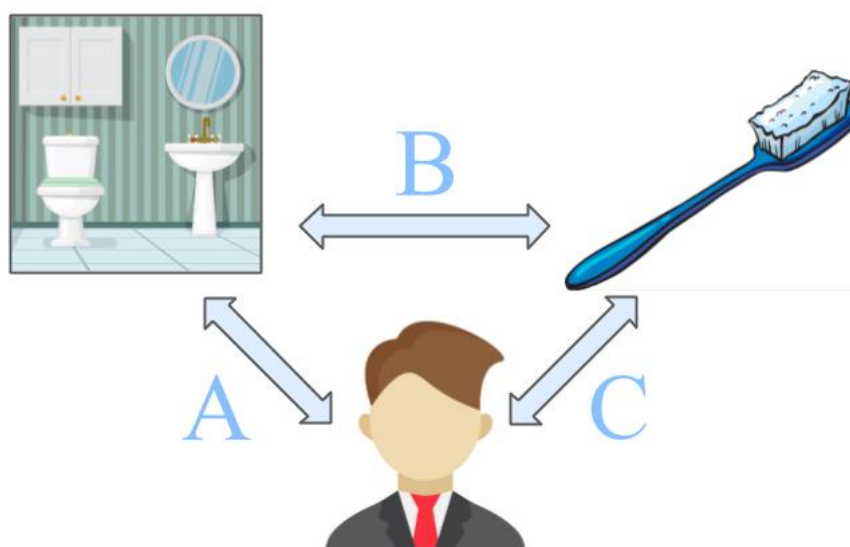


Figure 3. Example of reciprocal determinism in the toothbrushing context. Adapted from Bandura (1978).

As mentioned, though, behaviour events themselves constitute a small part of an ongoing cycle between the individual and their environment, as actions are continuously triggered by individual cognitions, and these cognitions are influenced by appraisals of behavioural engagement (Bandura, 1971). The theory that outlines this viewpoint most clearly is perhaps the Theory of Reciprocal Determinism (Bandura, 1978), depicted in Figure 3. Bandura's (1978) theory proposed that cognitions within the individual are influenced by their environment, but simultaneously influence the attention that given to particular environmental stimuli. In other words, if one suddenly thinks about brushing one's teeth, it could be attributed to a toothbrush being within the field of view in the bathroom. However, reciprocal determinism suggests that the only reason one would look at the toothbrush in the first place is because one was triggered to think about toothbrushing based on a previous interaction or experience, such as associating toothbrushing with the process of entering the bathroom.

Behavioural interactions between the individual and the environment, such as looking at a toothbrush, are proposed to be goal-directed and predetermined, rather than completely random (Ajzen, 1985). However, while some behaviours may seem easy, it is not uncommon that an individual can feel physically restricted based on their environment, or feel that the

environment does not lend itself to the cognitions that are required to induce behaviour (Ajzen, 1985).

For these reasons, approaches to psychology often study the processing and use of information based on experiences and interactions within the wider social environment (Ross et al., 2010). This social-psychology approach focuses on real-world applicability, and both the personal and environmental characteristics that are conducive to certain behavioural patterns. Social psychology has the underlying assumption that an explanation that can account for both individual-based and environmental-based elements may give the most realistic overview of why a behaviour exists (Mischel, 1973).

2.2 - Developing Theories of Behaviour

Adopting a social psychology approach to toothbrushing means that explaining toothbrushing may be achieved by defining the cognitions and circumstances that are most conducive to toothbrushing behaviour. Within the psychology field, such theoretical variables (i.e. beliefs, attitudes, etc.) are termed “constructs”, with each construct attempting to reflect an underlying measure of complex cognitive activity. Specific to toothbrushing behaviour, an example of a psychological construct may be “perceived benefits of toothbrushing” (Buglar et al., 2010). In this case, the construct is seeking to gauge where, on a continuum, the actual beliefs of the individual lie; ranging from little perceived benefits up to numerous perceived benefits in regard to toothbrushing. Constructs are essentially anticipated to provide reasonably reliable and accurate means of measuring an otherwise intangible and unobservable property.

In addition to defining which constructs potentially influence behaviour, understanding how these constructs relate to one another is equally important. Developing an explanation for why and how constructs relate to each other is known as the development of a theory, with an example of a theoretical path-model depicted in Figure 4. A theory is important to have in place prior to comparing constructs, as testing the relationship between constructs ultimately helps to either confirm or deny that the proposed theory may be correct.

2.2.1 - Transferability of behavioural theories. Behavioural theories account for a reasonable amount of variability in behaviour. For example, the Theory of Planned Behaviour (TPB) accounted for around 27% of behavioural variance when applied across a range of studies (Armitage & Connor, 2001). The only caveat is the suggestion that individual questionnaires and constructs be properly developed and validated within each community or culture (Oliver & Berger, 1979). Rosenstock (1966) further suggests that those most vulnerable may also be the hardest to observe, yet the most relevant when undertaking

research concerning community health. Research is encouraged to specifically seek input from people with lower levels of education and resources for living to ensure that those who need health interventions (i.e. those with the poorest health) are part of the validation process, and that findings are ultimately applicable to them (Rosenstock, 1966).

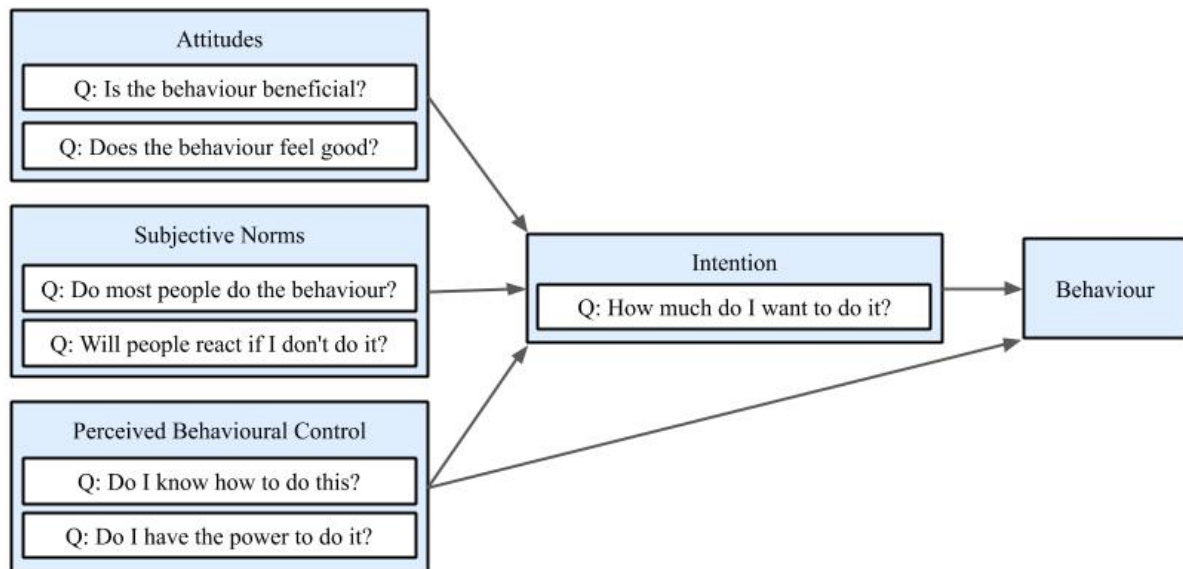


Figure 4. *An example of a behavioural theory - Theory of Planned Behaviour (Ajzen, 1985).*

2.3 – Applying Psychology and Health Behaviour

A review of the literature pertaining to behavioural-change theories by (Kwasnicka et al., 2016) suggests that models of human behaviour are numerous, focusing on a wide range of constructs that influence behavioural engagement, such as motivation, self-regulation abilities, physical and psychological resources, habituation, and environmental influences. Looking at the application of some of these theories to health-behaviour interventions, a systematic review by Hardeman et al. (2002) found that interventions based around the TPB were effective when used as the basis for interventions pertaining to cancer checking, building resilience during job seeking, and practicing safe sex. However, this review also observed limitations in the application of the theory to intervention design, making it difficult to attribute behavioural change to the strength of the theory alone (Hardeman et al., 2002).

The Health Action Process Approach (HAPA; Schwarzer et al., 2008), represents an alternative behavioural theory that focuses on individual capacities for developing coping and implementation plans. The HAPA has shown to be effective when used as the basis for interventions addressing beliefs and intentions regarding alcohol consumption (Irvine et al.,

2017) and flu vaccination, and interventions aimed at changing behaviour related to hookah smoking (Joveini et al., 2020) and exercise behaviour (Gaston & Prapavessis, 2014).

The Health Belief Model (HBM; Rosenstock, 1974), another popular theory, focuses on risk perception as a driver of positive health behaviour. A systematic review of the HBM illustrated effectiveness in 14 of 18 studies where it was used as the basis for a health behaviour intervention (Jones et al., 2014). More recent interventions based on the HPB have also been found to effectively change beliefs and behaviour related to smoking (Panahi et al., 2018), weight control (Nourian et al., 2017), exercise and diet (Noorbakhsh et al., 2017), cancer screening (Lee et al., 2019), and adherence to medical treatment plans (Wang et al., 2014).

2.4 – Applications of Psychology to Toothbrushing

Psychological behaviour frameworks have been applied to interventions aiming to improve toothbrushing frequency (Newton & Asimakopoulou, 2015). Understanding the psychological mechanisms behind oral hygiene behaviours is also advocated, and considered a necessity to guide oral hygiene education (Buunk-Werkhoven et al., 2011). Further, the general blending of health psychology into dental practice is anticipated to have positive influences on oral health promotion (Kay et al., 2016b), clinician-patient relationships, and oral health interventions (Freeman, 1999).

Hollister & Anema (2004) suggest that it may be unethical for a dental clinician to impart health counselling, or attempt behavioural change, without some understanding of behavioural theory. Additionally, Freeman (1999) suggests that it is crucial for clinicians to be able to understand why two similar people may behave differently, and respond to treatment differently, with clinicians ideally expected to have an appreciation for the attitudes, beliefs, and potential influences involved.

At the core, these opinions reflect a psychological view of health behaviours, where an understanding of the changeable constructs influencing an outcome is expected to enable a clinician to more systematically focus on addressing behaviour via such constructs.

2.4.1 - The best framework or theory for toothbrushing behaviour. Searching for evidence in support of one particular framework as a basis for understanding toothbrushing behaviour among young adults returns little high-level evidence. However, an article by Hollister and Anema (2004) qualitatively comparing a variety of psychological frameworks gives some insight. In their critical review, they discuss how models such as the Health Belief Model, Transtheoretical Model, Theory of Reasoned Action, and Social Cognitive Theory may all have a place in predicting oral health behaviours, and in guiding interventions or risk

assessment based on unique strengths and weaknesses. Overall, they conclude that understanding behavioural frameworks and the potential antecedents of behaviour, regardless of the model used, may at least offer guidance for clinicians in developing some form of systematic approach to education (Hollister & Anema, 2004). Psychological approaches are also expected to be largely dependent on the degree to which professionals are willing to embrace their use (Kay et al., 2016b). If a professional believes that their own intuition regarding patient behaviour (i.e. their own professional opinion) is more attuned or practical than any systematic assessment or use of theory, then it can be difficult to effectively implement behavioural modelling measures and interventions into real-life practice (Kay et al., 2016b).

2.4.2 - The best constructs that correlate with toothbrushing behaviour. Looking at individual constructs, rather than a particular theory, the evidence appears a little stronger. A systematic review by Scheerman et al. (2016) revealed that constructs such as intentions, self-efficacy, social influences, coping planning, and action planning all relate to toothbrushing behaviour among adolescents. As the only study that has reviewed psychological correlates with toothbrushing, as opposed to the effects of a particular intervention, Scheerman et al. (2016) offer insight into the constructs that may explain behavioural change within the dental field. The study notes, however, that investigating how such constructs actually influence behaviour, or behavioural change, is still to be determined, especially in relation to the effect that planning and coping abilities have on oral hygiene (Scheerman et al., 2016).

2.5 – The Potential for Behavioural Science within Preventive Dentistry

Based on these findings, there is exciting potential for the continued application of behavioural science knowledge within preventive dentistry. As identified by (Scheerman et al., 2016), psychological constructs may be very relevant to toothbrushing engagement, and there appears to be scope to explore these, and their overarching behavioural frameworks, among young adults. Further, based on the evidence regarding the application of theory to intervention practices, this exploration may be anticipated to have some influence on guiding interventions in the oral health field.

However, current psychological approaches to behavioural change have been shown to be quite beneficial (Kay et al., 2016a; Kay et al., 2016b; Yevlahova & Satur, 2009). It is suggested that counselling interventions may aim to adopt more replicable frameworks to allow for better cross-comparison (Newton & Asimakopoulou, 2015), and that the application of behavioural theory to intervention design may assist in targeting those specific beliefs that are conducive to behavioural change. Additionally, instead of focusing on disease-related

outcomes, researchers are encouraged to focus on behaviours and the psychological mechanisms of action, such as changes in self-efficacy or other beliefs (Gao et al., 2014).

Another point from the literature is that the investigation of how behaviour manifests within the context of daily life is anticipated to further help guide behavioural intervention (Kay et al., 2016b; Yevlahova & Satur, 2009). Looking at behaviour from a day-to-day perspective is anticipated to highlight the additional variables that potentially hinder or enable anticipated behavioural processes. Renz and Newton (2009) support this notion, highlighting the potential benefits of differentiating between the stable, motivational factors (beliefs that prepare an individual for action) and unstable, volitional factors (things that impact the ability to complete the action). By understanding these two separate components, a clinician may be able to identify when a person needs either an increase in their motivation or needs support regarding their capacity to carry out the behaviour in real-time. Establishing a more comprehensive account of behaviour is also expected to benefit the appreciation for a psychological perspective regarding oral hygiene (Brein et al., 2016).

Thus, the continued application of behavioural frameworks within dentistry is anticipated to increase both the understanding of oral hygiene behaviour and improve interventions that aim to elicit positive behavioural change. However, with suggestions that additional factors could influence real-time capacity to engage in behaviour, investigating these context-based influences is anticipated to also add to our overall explanation of oral hygiene behaviour among young adults.

2.6 - The Influence of the Behavioural Context

This exploration of the constructs involved in real-time behavioural engagement is described as a logical extension of any focus on general beliefs and attitudes (Armitage, 2015). Such a framework incorporates these beliefs and attitudes, and adds the supportive mechanisms which might help facilitate behaviour in a real-life scenario (Armitage, 2015). Although toothbrushing is sometimes depicted as a habitual behaviour, even a seemingly automatic behaviour is likely to be produced via a complex interaction between the stimuli, the response, and individual self-control (Gardner, 2015). Gardner (2015) suggests that teaching an individual how to overcome stimuli that trigger unwanted behaviour (e.g. thoughts that tell an individual they are too tired to brush their teeth) may also be more critical than teaching the individual the value of toothbrushing in the first place. As discussed by both Armitage (2015) and Renz and Newton (2009), this may mean shifting the view of oral health research towards a focus on reactive volitional control, and how real-time responses may ultimately account for actual oral health behaviour. In a body satisfaction study that followed

a sample of young adults over time, pre-held motivations and real-time emotions/reactions were found to operate independently of each other, interacting to predict behaviour frequency (Rogers et al., 2016), with potential that similar relationships may exist in the oral health field.

A study by Gwaltney et al. (2005) highlights how self-efficacy may act as one such mediator between pre-held motivations and the capacity to engage in a behaviour in real-time. In their study, they found that dynamic changes to the assessment of current self-efficacy, as opposed to stable self-efficacy beliefs, occurred over time and predicted real-time lapses in smoking cessation. Transferred into the dental setting, this indicates that there may be value in exploring the factors that contribute to individuals potentially suffering a decrease in real-time self-efficacy.

2.6.1 - Influences on real-time perception of capabilities. One explanation for changes in self-efficacy is related to our emotional state (Brosch et al., 2013). Emotions can influence the thoughts surrounding any given circumstance and may stir up a range of cognitions and reactions that correspond with the current emotional disposition. Not only are emotions and cognitions intertwined, but emotions can have a profound effect on beliefs about a task, such as perceptions of self-efficacy (Brosch et al., 2013). Within a stressed state, therefore, it may be common for an individual to report a lower level of self-efficacy, relative to times when they may be more relaxed and focused. These relationships have considerable potential to be explored within the dental setting.

2.6.2 – Emotional states and attention capacity. Understanding how the brain is triggered to act in both desired and undesired ways by emotions may also offer a useful guide for those seeking to alter health behaviour, be it a clinician or the patient themselves (Brosch et al., 2013). One class of emotion frequently linked to behaviour is negative affect. In this sense, “affect” refers to disposition or mood, with negative affect characterised by feelings that are generally unwanted, and typically the opposite of those associated with “happiness”. Negative affective states typically consist of depressive (sadness, worthlessness, lack of energy) or anxious (anger, stress, worry) feelings, and it is suggested that negative affect is often responsible for continued negative thought patterns and difficulties in controlling current cognitions (Seidel et al., 2016). Negative rumination (i.e. thinking about a negative topic continuously) is also thought to make it difficult to focus on desirable cognitions, despite strong intentions to do so, e.g. wanting to brush because it is beneficial (Brosch et al., 2013). In these circumstances negative mood can divert attention towards cognitions that are associated with the emotional state, rather than with pre-determined plans (Yiend, 2010). Due

to this, the predictors of behavioural success are suggested to be quite different from the predictors of behavioural motivation, with research into the impact of emotions expected to compliment what we know about the influence of motivations on behavioural outcomes (Vangeli et al., 2011).

2.6.3 - Regulating emotional influences. Self-regulation refers to the ability to monitor one's emotional state and overcome such emotive challenges from the environment. It is suggested that it is possible to focus on desired thoughts or stimuli, adhere to pre-held intentions, and resist emotional influence with the help of adequate self-regulatory abilities (Hagger, 2010). Self-regulation may account for the reasons that individuals think or react differently, despite similar experiences of stress, anxiety, or worry (Hagger, 2010). From a biological perspective, self-regulation is thought to be related to control over the working memory; the area of the brain concerned with what one thinks, feels, or gives attention to at any particular time (Gotlib & Joormann, 2010). With emotional states fundamentally having neurobiological origins and being triggered by changes in brain chemistry, the ability to self-regulate is even suggested to have biological origins rather than being a solely learned attribute (Gotlib & Joormann, 2010). In any case, it is suggested that theories of health behaviour should account for how an individual may respond to emotive changes, and their ability to exercise self-control in emotional circumstances (Hagger, 2010).

2.7 – Behavioural Circumstances related to Health Behaviour

Looking at health behaviours, Hoffman et al. (2014) found interesting results when examining how an individual may control and manipulate their urges or intentions to break away from a set diet plan. Rather than intentions predicting individual success, the best predictor was the degree to which the individual was able to control impulse behaviour and cognitions (Hofmann et al., 2014). In other words, no matter the difference in stated intentions regarding their actions, the differences in success were determined by actual control over their thoughts and behaviour in real-time. While it is still likely that a person with higher intentions will make more attempts at a behaviour, the degree of success may be determined by how often they can resist failing, rather than the frequency of attempts.

Brodbeck et al. (2014) further examined the role of self-efficacy in these affect-behaviour relationships, finding that negative affect had a positive relationship with more urge-based cognitions and an inverse relationship with real-time self-efficacy. The degree to which emotions may influence health behaviour may therefore rely on three things: the degree to which high self-efficacy is required to engage in the behaviour, the current experience of negative affect, and the degree to which one is able to self-regulate the influence of emotions

on self-efficacy (Brodbeck et al., 2014). A visual depiction of this relationship is portrayed in Figure 5.

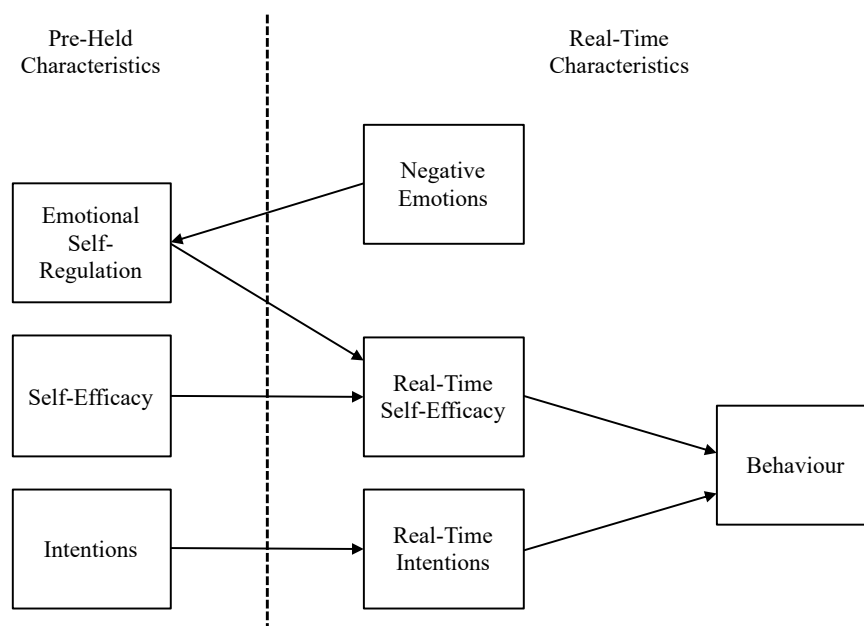


Figure 5. Flowchart illustrating the influence of negative affect on real-time efficacy, based on findings from Brodbeck et al. (2014)

In contrast, the role of positive emotional states has also been investigated, with this referring to mood states that may reflect satisfaction, joy, and excitement. However, in a study of positive affect and behaviour, Heckman et al. (2013) found that independent measures of positive emotions had little to do with cognitive patterns or behaviour. Instead, they found that positive emotions only have value when working to reduce excessive negative feelings (Heckman et al., 2013). Thus, positive emotions may buffer the threat of negative emotions, although if negative mood is not a concern then increasing an already positive emotional state may have a negligible effect. A summary of the means by which negative emotional states, self-regulation, and dynamic self-efficacy may influence behaviour is depicted in Figure 5. Figure 5 includes some examples of cognitions at each stage, representing the intentions to either engage in regular brushing, or avoid lapses in toothbrushing. In this figure, the cognition of “going to bed without brushing” may also represent a typical urge to break from a toothbrushing plan, similar to the urges to break from smoking cessation or diet plans, as explored by Brodbeck et al. (2014) and Heckman et al. (2013), respectively.

2.8 – Behavioural Circumstances and Toothbrushing

With a wealth of information regarding the potential mechanisms that may underpin the translation of intentions into real-time oral hygiene behaviour, the next step is understanding where similar constructs, relevant to these mechanisms, have been explored in the oral health field.

2.8.1 - Cross-sectional survey evidence. Looking at the correlates of toothbrushing amongst adolescents, evidence reveals that coping and action planning, as well as behavioural control (a construct similar to self-efficacy), influence rates of toothbrushing via direct effects and via an interaction between these variables (Pakpour et al., 2012). Similarly, when looking at barriers to toothbrushing, i.e. things that make the behaviour seem too difficult, Morowatisharifabad and Shiraz (2007) found that barriers were inversely related to self-efficacy and that they actually mediated the influence of self-efficacy on oral health behaviour outcomes (Morowatisharifabad & Shirazi, 2007). Vakili et al. (2011) also established that the perception of barriers at anticipated toothbrushing times was related to lower overall rates of toothbrushing, and that these effects could be countered by the perception of supportive influences (Vakili et al., 2011).

2.8.2 - Emotional influences on oral health. There is also support for the role of emotion in oral health behaviour. In a study of anxiety and depression symptoms amongst participants, Marques-Vidal and Milagre (2006) found that these negative emotional characteristics were associated with higher levels of gingivitis and poorer rates of preventive oral hygiene behaviour. Further, Antilla et al. (2001) found that anxiety and depression were both related to lower overall rates of toothbrushing frequency, and research has suggested that explaining how anxiety or depression may influence dental behaviours is important for the dental community (Marques-Vidal & Milagre, 2006).

This information not only conforms to our wider understanding of real-time influences and health behaviour, but also potentially explains the observed peaks in dental disease during young adulthood (Kassebaum et al., 2015). As young adulthood is a time for newfound independence, this may mean changes to the potentially supportive influence of parents who have had a role in triggering behaviour in the face of low self-efficacy or poor self-regulation. Among this demographic, scope exists to explore the mechanisms responsible for toothbrushing behaviour and explore reasons as to why young adults might find toothbrushing difficult within the behavioural context.

2.8.3 - Exploring the real-time influences on toothbrushing. As demonstrated, there may be considerable potential in continuing to explore both motivational beliefs and the

presence of real-time influences with relation to oral hygiene behaviours. Not only may a more comprehensive knowledge of these elements improve the collective understanding of oral hygiene behaviours, but such information is anticipated to boost the effectiveness of targeted counselling in the oral health field. The current thesis, therefore, will have two key aims: i) to review the literature and highlight which cognitions and frameworks may best explain motivations for toothbrushing among young adults, and ii) to explore the potential presence of real-time influences as explanations of the motivation-behaviour gap regarding toothbrushing.

Chapter 3 - Planning a Review of Toothbrushing Correlates

3.1 - The Aims of the Research Project

On the basis of the observed gaps in the literature concerning little conclusive evidence regarding the pre-held beliefs that relate to oral hygiene behaviour, and little exploration of the real-time factors that influence toothbrushing, the current thesis consisted of two goals:

- i) Provide a summary of the evidence related to relationships between pre-held cognitive attitudes/beliefs and toothbrushing frequency.
- ii) Undertake a qualitative investigation that explores the presence of lapses in toothbrushing frequency and the potential influence of real-time factors within this phenomenon.

3.1.1 - Providing a summary of current evidence. With these goals in mind, the first study within this thesis aimed to explore the evidence pertaining to psychological correlates with toothbrushing frequency among young adults. As motivating constructs (e.g. beliefs, attitudes) are likely to be relatively stable and explain general differences between participant behaviour, they should ideally be understood before attributing any variance to unstable real-time variables (e.g. mood). As the value of understanding unstable variables is dependent on how much they add to the variance already explained by stable traits (Rogers et al., 2016), understanding how much variance is explained by stable beliefs and attitudes was deemed important to establish first.

The ideal method to explore and compare common behavioural models is using a systematic review. A systematic review uses a detailed protocol to search and extract data from the literature. Through synthesising this data, reasonably valid answers to research questions that are related to the data are able to be generated. These research questions also inform the search process and are developed by setting criteria for the Population, Independent/Intervention variables, Comparison methods, and Outcomes of interest (PICO; Schardt et al., 2007). For the current topic, these variables were:

Population: Young adults, aged 18-40, who are capable of toothbrushing

Independent Variables: Any model of health behaviour that has well-defined constructs and has been validated in a previous study.

Comparisons: Any cross-sectional comparison between independent variables and outcomes.

Outcomes: Toothbrushing frequency.

The final research question was: which health behaviour model has the strongest correlation with toothbrushing outcomes for young adults aged 18-40?

The current research intended to highlight the strengths of both the individual constructs and also the behavioural models that have been correlated with toothbrushing frequency. It was anticipated this would result in certain constructs being identified as strong correlates with behaviour, helping to inform studies that might seek to explore the individual contributions of both stable between-person traits, and unstable within-person changes, to toothbrushing. The alternative option of just selecting a model without systematic consideration also raises the likelihood for bias, potentially leading to mistaken interpretations regarding the influence of real-time variables if evidence regarding baseline traits is weak.

The review also sought to highlight weaknesses in the current evidence and methodology. As the review aimed to highlight a good theoretical explanation of toothbrushing behaviour, it would also highlight where unusual methodology may inhibit accurate results and the implications on conclusions. Identifying weak constructs and highlighting where methodology may be improved was anticipated to be an equally valuable outcome from this systematic review.

3.2 - Preliminary Planning and Preparation

In order to plan the systematic searching of the literature, preliminary searching was identified as an appropriate method to collate literature that served as a good precedent for the current review and its search terms. Of the notable results was a systematic review by (Newton & Asimakopoulou, 2015) that investigated the variables related to adherence to an oral hygiene instruction intervention, concluding that perceived benefits of behaviour change and perceived seriousness of dental disease correlated with the likelihood of behavioural change. In addition, a study by Dumitrescu et al. (2014) compared five different health behaviour models, concluding that the Theory of Planned Behaviour predicted the most variance in toothbrushing behaviour (22.7%) and toothbrushing intentions (25.6%). Finally, a review by Scheerman et al. (2016) sought to highlight the variables that best correlated with oral health behaviours amongst adolescents, concluding that intentions, self-efficacy, social influences, coping planning and action planning were the best predictors of toothbrushing frequency.

3.2.1 - Framework for the review. Based on this information, it was deemed that the Scheerman et al. (2016) study offered a suitable framework for the current review, although it was anticipated that the methods of the review could be improved by restricting variables to those that were derived from, or related directly to, specific behavioural theories. With the

review by Scheerman et al. (2016) including a very inclusive range of psychological constructs, such as terms related to general health perception, and life-satisfaction, it was reasoned that it may be very difficult to compare individual operational definitions if any type of psychological attribute was investigated. Instead, as a good psychological theory or framework was suggested to have good nomological validity and provide reasonable explanations for relationships between constructs (Hagger et al., 2016), it was determined that selecting variables/constructs from validated behavioural models would allow for better cross-comparison and improve the transferability of results to future research.

3.2.2 - Determining the psychological components. With only health behaviour models and their variables to be included in the database searching and the review, the second stage of preliminary searching was undertaken to decide precisely which models of health behaviour to include in the search strategy. With research suggesting a high number of health behaviour models in existence (Kwasnicka et al., 2016), it was deemed both impractical, and likely impossible, to compare all theories - as the inclusion of modified models and grey literature would encompass an excessively large and potentially incomparable pool of data. Instead, it was considered more rational to choose health behaviour models for which there was already accessible literature relating to its use in the exploration of toothbrushing outcomes.

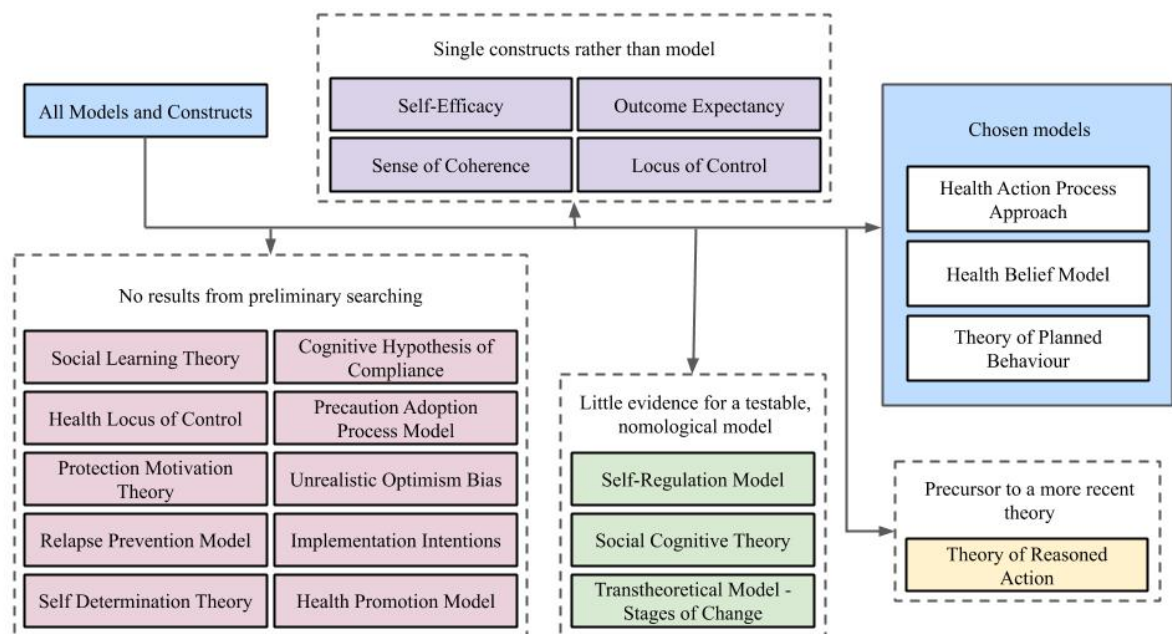


Figure 6. Flowchart of preliminary searching for relevant behaviour models

Identification of various frameworks. The key health behaviour models that were identified through preliminary searching included the Health Belief Model, Protection Motivation Theory/Model, Transtheoretical Model, Stages of Change, Self-Regulation/Self-Regulatory Model, Relapse Prevention Model, Social Learning Theory, Social Cognitive Theory, Self-Determination Theory, Theory of Planned Behaviour, Health Action Process Approach, Health Promotion Model, Theory of Reasoned Action, Locus of Control (construct), Self-Efficacy (construct), Sense of Coherence (construct), Health Locus of Control, Implementation Intentions, Unrealistic Optimism Bias, Precaution Adoption Process Model, Outcome Expectancy (construct), Cognitive Hypothesis Model of Compliance (Dumitrescu et al., 2014; Hollister & Anema, 2004; Newton & Asimakopoulou, 2015)

Preliminary results associated with topic. All the above models were searched within PubMed, PsycInfo, and MedLine databases in combination with the string “toothbrushing frequency”, to determine which models had readily available literature concerning this topic. A flowchart of the exclusion of models and constructs is presented in Figure 7.

Filtering the toothbrushing associated models. This searching returned seven health behaviour models that had been explored in relation to toothbrushing frequency: The Health Action Process Approach, the Health Belief Model, the Self-Regulatory Model, Social Cognitive Theory, the Theory of Planned Behaviour, the Theory of Reasoned Action, and the Trans-Theoretical Model. However, with further searching for meta-analysis literature concerning these models (to give information about previous testing of their nomological principles), not all of the theories agreed on shared definitions of the included constructs that underpin the model, or clear hypotheses about how they may predict rates of behaviour.

Self-Regulatory Model. The Self-Regulatory Model, for example, while offering perspective about the role of self-regulation in adhering to intended behaviour plans, explained little with regard to the additional constructs that would make this theory constitute a replicable model of health behaviour. For instance, Carver and Scheier (1982) highlight the importance and function of self-regulation in performing desired behaviour, with Rasmussen et al. (2006) elaborating on some potential processes involved, such as goal adjustment based on success/failure. Even further, a paper by Hagger (2010) discussed at length the benefits of including self-regulation in the modelling of health behaviour, however no study gave specific construct definitions regarding a comprehensive self-regulatory model that accounted for all the influences on behavioural variance - thus, the model was left out of future searching.

Social Cognitive Theory. Social Cognitive Theory had similar limitations to the Self-Regulatory Model. Both theories were linked to ideas put forward by Bandura that encompassed some fundamentally sound ideas regarding the cognitions that drive human behaviour (Bandura, 1971, 1978). However, again there was little agreement found in regard to shared operational definitions regarding the constructs that may be involved in a comprehensive, overarching model; or at least little evidence to suggest that any of the given definitions were widely accepted. For instance, while Dewar et al. (2012) recount an interesting and thorough exercise in the validation of a social-cognitive theory scale, a review by Lowry et al. (2017) conversely shows how, at the systematic review level, that these scales and definitions are not so clear cut, and that considerable effort is required to compare such constructs when authors seem to be at odds with precisely which constructs underpin Social Cognitive Theory. Thus, this theory was also removed from further searching.

Transtheoretical Model. The Transtheoretical Model was also a model removed from the search strategy. Rather than specifically accounting for the cognitive constructs that drive behavioural frequency, this theory primarily utilises its own assessment criteria to assign participants to theoretical stages of behavioural change. Behavioural change is thus explained as a process of progression through stages as opposed to changes in psychological constructs. This progress may be quite secondary to the mechanisms that are controlling behaviour in the first place. A critical review of theory by Romain et al. (2018) finds a lack of evidence to support the correlation of any particular variable with the transitions from one stage to another, citing insufficient explanation of how group assignment to each stage is carried out. Littell and Girvin (2002) also point out the inability to distinguish any sequential or discrete movement across stages, making reliable application of the theory difficult. These weaknesses regarding internal validity are also suggested to harm the ability to make any real predictions, with the theory drawing attention to conscious descriptions of perceptions of change, and away from any exploration of the cognitive processes that actually underpin and drive behaviour (West, 2005). For these reasons, the model was removed from further searching in favour of models that aim to explain cognitive mechanisms underpinning behavioural change instead.

Final behavioural model selection. Finally, the Theory of Reasoned Action represents a precursor to the Theory of Planned Behaviour and shares most of the same constructs (Ajzen, 1985). This theory was combined with its successor to leave three health behaviour models which dealt with toothbrushing behaviours for inclusion in the current review: the Theory of Planned Behaviour (TPB; Ajzen, 1985), the Health Belief Model (HBM;

Rosenstock, 1974), and the Health Action Process Approach (HAPA; Schwarzer et al., 2008). These three models also offered good face-value validity, with all three included in a comparison offered by Dumitrescu et al. (2014), and with constructs from these models being among the most significant correlates with toothbrushing identified in the review by Scheerman et al. (2016).

3.2.3 - Defining the outcomes. As previously mentioned, toothbrushing was the main concern of the thesis, and the primary outcome of the current systematic review. While a more comprehensive review may have sought to explore the relationships between the proposed health behaviour models and other dental behaviours (e.g. flossing, attending the dental clinic, etc.), the strong evidence that toothbrushing reduces dental caries risk (Kumar et al., 2016) meant that this systematic review aimed to address toothbrushing alone. Future studies may explore other behaviours, or even elements of toothbrushing such as duration and technique, if future evidence does suggest that they are independently relevant to disease risk.

Preliminary searching and toothbrushing. In order to define toothbrushing, previous literature was sought where a systematic review had examined toothbrushing frequency. However, initial searching returned broad results. Many reviewers simply searched for “oral health behaviours”, despite such behaviours including anything from a parent brushing the teeth of their child, to visiting a dentist or dental hygienist. Due to this, a more specific syntax for toothbrushing behaviour was introduced to restrict the pool of search results.

Keyword analysis. To achieve this systematically, the term “toothbrushing frequency” was entered into the Discovery search engine within the University of Melbourne online library portal. Discovery search is an EBSCO-host-powered database searching platform that scans literature from a wide range of databases and the library catalogue to return results. After searching toothbrushing frequency as both a keyword, and term within the title and abstract, the top 10 results (sorted by relevance) were screened in each case to find studies that actually measured and quantified toothbrushing frequency. Not all of the studies within the results actually related to toothbrushing frequency, and different keywords were used to refer to toothbrushing frequency within titles and abstracts. To analyse which terms did actually indicate toothbrushing frequency, nVivo software (QSR International, 2014) was used to conduct a textual analysis of the abstracts and titles from the relevant preliminary search results, and a search string was extracted that specifically targeted studies that measured toothbrushing frequency.

Articles that included a measure of toothbrushing frequency were deemed to refer to the following terms:

1. toothbrushing frequency OR toothbrushing behavior - in TITLE or ABSTRACT
2. oral health behavior OR oral hygiene behavior - in TITLE only
3. (dental OR oral) AND (brush*) AND (frequency) - across TITLE or ABSTRACT

With the outcome variable defined, the next steps were to decide the methodological approach for analysis and synthesis of results, as well as registration with a systematic review registry, before commencing the search itself.

3.3 - Proposed Analysis and Hypotheses for the Systematic Review

Based on the review question, the goal of the review was to conduct a quantitative synthesis of the effect sizes for the relationships between the psychological constructs (from the three health models) and toothbrushing frequency. As a secondary aim, the review also sought to offer a comparison of which psychological framework (the HBM, TPB, or HAPA) may offer the best explain variations in toothbrushing that were observed within the literature.

3.3.1 - Conducting a meta-analysis. In order to carry out a quantitative analysis for each psychological construct, a meta-analysis calculating the estimated population-level effect size based on multiple observations was required. To achieve this, zero-order correlations (i.e. the bivariate correlation between the psychological construct and toothbrushing frequency, irrespective of covariates or other variables) needs to be extracted from each of the included studies. Zero-order correlations are frequently reported using Pearson's r , with this being a widely accepted indicator of correlation strength in parametric statistical tests (i.e. when the data is assumed to be normally distributed). Pearson's r represents both the direction (positive or negative) of the relationship between two variables, and the degree to which changes in one variable relate to changes in the other. The magnitude of change is calculated by squaring the value of r . For example, a Pearson's r value of $r = 0.60$ indicates that for each degree of change in variable x , there will likely be a positive change in variable y , and changes to variable x will explain around 36% ($r^2 = 0.60^2 = 0.36 = 36\%$) of the observed positive changes in variable y .

3.3.2 - Value of correlation coefficients. It should be noted that Pearson's r does not indicate a causal change, but rather the strength of a relationship. Two variables (e.g. toothbrushing and exercise) may be very strongly correlated (e.g. $r = 0.80$), but this does not mean that a change in toothbrushing immediately influences exercise engagement, or that one must necessarily occur before the other. Instead, r squared (e.g. $r^2 = 0.64$, in this example) would indicate that 64% of the amount of variability in toothbrushing amongst the sample

seems to relate to observed differences in exercising - leaving 36% that is still explained by other factors, not to mention the real factors that may actually mediate the observed relationship - i.e. it is illogical to think that brushing more often will directly influence exercise, there must be other constructs that explain the observation. The real value of correlations is that they provide some information about relationship tendencies and highlight where the future exploration of the mechanisms behind such relationships may be worthwhile.

With an aim to synthesise current information regarding motivational/intention constructs, conducting a meta-analysis of Pearson's r values represents an ideal means of indicate where potentially strong relationships lie, and where potential exists for further exploration. A meta-analysis is achieved using an assumption of random effects (i.e. assuming population level effects are not fixed, and that error in estimates come from the expected variance in the population effect size and sampling error), and then calculating the average of a group of standardised r values. Standardised r values account for both the strength of the relationship and sample size, and are commonly calculated by transforming the correlations (i.e. the r values) into Fishers z values, and then transforming the overall average back to Pearson's r to give the estimate of the population-level effect size, and the 95% confidence intervals of this average (Quintana, 2015).

3.3.3 - Model suitability. In addition to the meta-analysis of effect sizes, a meta-analysis of the fit of the respective health behaviour models was also planned via the metaSEM software package for the R statistical software program (R Core Team, 2013), described in detail by Cheung (Cheung, 2015). With each model offering an independent prediction of how the variables may be interrelated, examining model suitability using Root Mean Square Error of Approximation (RMSEA; i.e. calculating the difference between the observed relationships between values, and what would be expected based on a matrix of all construct relationships contained in the model) values represents an accepted method of exploring which health behaviour framework may best match the observations of toothbrushing behaviour (Hooper et al., 2008).

3.3.4 - Publication bias and heterogeneity. The systematic review also aimed to check for publication bias and heterogeneity. These two measures indicate when there is little resemblance in the observed effect sizes for the same relationship, or when observations do not exhibit the sort of standard errors that one would expect from an unbiased range of studies. Publication bias is often used to describe the latter scenario, where anomalies exist in the reporting of standard errors and effect sizes. Within a population, it is estimated that if the standard error of an effect size (i.e. the standard error of a Pearson's r correlation) is low, it

will be closer to the population-level average. This is because lower error-rates logically indicate a more precise result, with higher error-rates anticipated to belong to results that are more spread out on either side of the average. However, if a correlation is observed between the standard error and the effect size it can indicate a bias to only report high-error findings when they either support or deny a certain hypothesis. As publishers are believed to favour low-standard errors (i.e. more precise results), publication bias is indicated when high-error studies only occupy one particular side of the observed population mean, indicating a willingness to publish high-error studies - but only if they confirm a particular viewpoint.

3.3.5 - Methodological quality. Finally, the study quality would be assessed using the Newcastle Ottawa Scale (NOS) for study quality. The NOS was chosen by the author based on studies by Elyasi et al. (2015) and Scheerman et al. (2016) that both examined toothbrushing and its relationship with psychological constructs. Both studies justified the use of the NOS and supported its use as a valid measure of methodological quality within studies that measured toothbrushing. The NOS gives studies a maximum score of 8, with higher scores indicating better study quality, and a better likelihood that the results are an accurate estimate of the real effect size. Using a methodological assessment instrument was anticipated to provide a systematic approach to the analysis of study methods, a key secondary objective within this systematic review.

Chapter 4 - Conducting the Systematic Review

4.1 - Eligibility Criteria and Registration

Based on the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines (PRISMA; Moher et al., 2009), the study was registered with the International Prospective Register of Ongoing Systematic Reviews (PROSPERO), a database developed by the University of York to encourage the registration of systematic review protocols prior to their undertaking to reduce the chance bias and of concurrent similar reviews (Booth et al., 2012). The registered protocol was based on the given rationale behind the systematic review, and the following methods that shall be discussed.

4.1.1 - Outline of the Protocol. Undertaken in accordance with the PRISMA statement for systematic review reporting (Moher et al., 2009), and based on evidence that psychological constructs may be correlated with toothbrushing frequency (Scheerman et al., 2016), the present study aimed to compare how variables from three psychological frameworks - the Theory of Planned Behaviour (Ajzen, 1985), the Health Belief Model (Rosenstock, 1974), and the Health Action Process Approach (Schwarzer et al., 2008) - may correlate with toothbrushing frequency outcomes. By restricting the review to common health behaviour models that employ discriminant and nomological construct definitions, more robust outcomes were anticipated when comparing i) the same construct across multiple observations, and ii) comparing the overarching frameworks to each other (Kimberlin & Winterstein, 2008). Psychological constructs were eligible if they pertained to toothbrushing (e.g. self-efficacy for toothbrushing), but studies that measured more global oral health attitudes or beliefs were excluded (e.g. attitude towards preventive dentistry). This is based on the assumption that the beliefs and attitudes that correlate best with a behaviour will be related to that specific behaviour (Francis et al., 2004).

The outcome variable of interest was limited to toothbrushing frequency. As a unique behaviour with evidence supporting its direct impact on dental disease risk (Kumar et al., 2016), excluding other oral health behaviours (e.g. flossing, visiting the dentist) was expected to increase the transferability of results to future research that also targets toothbrushing behaviour. Toothbrushing was defined as the act of using a toothbrush to clean one's own teeth, with all measures included as long as they were quantified and pertained to toothbrushing frequency alone. The key research questions within the review were 1) which variable(s) have the strongest correlation with toothbrushing frequency amongst young adults,

and 2) which behavioural frameworks have the best fit when applied to the modelling of toothbrushing frequency outcomes.

4.1.2 - Defining the eligibility criteria. Using these research questions, clear exclusion and inclusion criteria were developed. In order to compare the strength of correlates with toothbrushing frequency, the included articles had to contain the results of a quantitative hypothesis test between a psychological construct and toothbrushing frequency. Descriptive or qualitative studies were excluded, and the language of studies limited to English. Age limits were defined as an average age of the sample between 18-44, with this range corresponding with common definitions of young adulthood (Levinson, 1986) and age-limits employed when reporting dental disease incidence amongst younger adult populations (Chrisopoulos et al., 2016).

4.1.3 - Justification of the age limit. Limiting the age of samples to young adults was done to increase the transferability of results to this age group. It should be noted that this definition of young adulthood is based around definitions of psychological development, such as that by Erikson, that depict 18-40 as being the period of young adulthood, with 40-65 years constituting middle-age, and beyond this point representing elderly demographics. Levinson (1986) also shares this viewpoint, offering a suggestion that young adulthood may occur over four stages of development, but nonetheless within this timeframe between the ages of 17-40 years.

4.2 - Information Sources

Primary searches were conducted by the author across six databases: PubMed, CINAHL, EMBASE, MedLine, PsycInfo, and Web of Science. No limits were placed on date of publication, and searches encompassed all articles published from database inception up to May 2018. The databases were chosen based on systematic reviews that also examined psychological correlates with toothbrushing behaviour (Elyasi et al., 2015; Scheerman et al., 2016).

4.2.1 - Searching. The search strategy followed the same PICO model:

- 1) Population: Adult samples with a mean age between 18-44 years.
- 2) Independent variable(s): Any quantified psychological construct taken from the TPB, HBM or HAPA models.
- 3) Comparison: Any cross-sectional quantitative comparison. Multiple and logistic regressions were included, but zero-order correlations were specifically sought for the purpose of meta-analysis.

4) Outcome: Toothbrushing frequency. Any measure that used discrete counting or an ordinal scale to record how often participants engaged in the activity of brushing their teeth with a toothbrush.

The search terms referring to toothbrushing behaviour were developed using preliminary searching and the NVivo software package (QSR International, 2014) as described previously. The terms were searched in combination with keywords relevant to the three behavioural models. An excerpt of the strategy applied within PubMed is shown in Figure 9. The complete search strategy is included in Appendix A.

4.3 - Study Selection

Search results were first screened by the author. Articles had their title and abstract assessed and were excluded if they did not mention that the study assessed both toothbrushing frequency and one of the psychological constructs. Latitude was given where it was unclear whether the article measured a relevant construct or not. Abstracts that simply alluded to the inclusion of toothbrushing frequency (e.g. measuring “home care” behaviours) or alluded to the measurement of a relevant construct (e.g. reporting that “participant attitudes” were recorded) were only included in the instance that the abstract specifically stated that the corresponding prerequisite (i.e. toothbrushing or a psychological construct) was also measured. In cases where there were two vague descriptions of the study contents, or simply allusions to the possible measurement of relevant constructs, the article was rejected.

4.3.1 - Cross validation. The screening process was cross validated using a screening instrument, included in Appendix B. Cross validation was carried out by creating two different samples of 20 articles to be screened by two of the supervising authors (JS & MH). Using the author’s initial judgement of which articles required a full-text review, each sample deliberately contained between 5-10 articles which had been accepted by the first author. It was expected that a good instrument would result in the same the conclusions and the same articles being accepted in the two unique samples. After a minimal amount of discussion, primarily based on the interpretation of the age limits reported in some abstracts, the instrument was deemed valid and 100% agreement was reached.

Following this process, full-text screening took place. A sample of 10 full-text articles was cross-referenced with one co-author (MH) to check whether the full-text screening instrument was suitable for determining the studies to be included in the final review. Again, there was 100% consensus.

#1	((attitud*[tiab] OR norm*[tiab] OR control[tiab] OR intention*[tiab] OR planned behavi*[tiab] OR ajzen) OR (((benefit* [tiab] OR barrier*[tiab] OR threat*[tiab] OR seriousness[tiab] OR susceptibility[tiab] OR risk*[tiab]) AND (perceived [tiab] OR perception*[tiab])) OR self-efficacy[tiab] OR health belief model[tiab] OR hbm[tiab] OR rosenstock[tiab]) OR (((action[tiab] OR coping[tiab] OR task[tiab]) AND (planning[tiab] OR self-efficacy[tiab] OR control[tiab])) OR intention*[tiab] OR outcome expectanc*[tiab] OR risk perception[tiab] OR self efficacy[tiab]))
#2	((toothbrushing frequency[tiab] OR toothbrushing behavio*[tiab]) OR (oral health behavio*[ti] OR oral hygiene behavio* [ti]) OR ((dental[tiab] OR oral[tiab]) AND (brush*[tiab]) AND (frequency[tiab])))
#3	(infant*[tiab] OR newborn*[tiab] OR child*[tiab] OR preschool*[tiab] OR kinder*[tiab] OR adolescen*[tiab] OR elder* [tiab] OR geriatric[tiab] OR pensioner[tiab] OR frail[tiab] OR rats[tiab])
#4	#1 AND #2
#5	#4 NOT #3

Figure 7. Search strategy used in PubMed database.

4.3.2 - Data collection process. Data extraction was performed by one researcher (AR) and is presented in Table 1. Authors were contacted where variables were reported, but where comparisons or bivariate correlations were missing. However, there were few responses to these emails, and an absence of responses to requests for raw data or bivariate correlations from studies where the variables were recorded but not compared. For example, a study by Chan and Chin (2015) clearly reports measurements of toothbrushing self-efficacy and toothbrushing frequency but offers no comparison between these variables or any zero-order bivariate correlations. Thus, attempts were made to contact such authors to obtain this data (via the use of contact details within the papers and researcher portals), but with little success.

4.3.3 - Data items. The items used to measure the psychological constructs were identified within each study, along with the results of their comparison with toothbrushing frequency. This was defined as a quantitative relationship between toothbrushing frequency and any of the following constructs: cognitive and affective attitudes, subjective norms, intentions, perceived behavioural control, self-efficacy, action planning, coping (planning), outcome expectancies, and perceptions of benefits, barriers, seriousness, threat, susceptibility and risk (Ajzen, 1985; Rosenstock, 1974; Schwarzer et al., 2008). Data items further included frequency of toothbrushing, methods used to measure toothbrushing, information about the author, country, and year of publication, as well as details about the sample itself. Conceptual path-models of the included models, and the links between these constructs are included in Figures 9-11.

4.3.3 - Risk of bias in individual studies. Methodological quality was evaluated by the author using a modified version of the Newcastle-Ottawa Scale (NOS), adapted from Herzog et al. (2013) and Modesti et al. (2016), to assess the quality of cross-sectional studies (Luchini et al., 2017). This version of the NOS evaluates key influences on methodological quality across 6 factors, with a maximum score of 8. A description of the items is presented in Figure 13.

4.3.4 - Synthesis of results. Only zero-order correlations were used in the quantitative synthesis due to the inability to isolate raw effect-sizes from multiple regression models (i.e. one cannot interpret the raw correlation value between two variables if they are included in a model that controls for the effect of other variables). Meta-analysis was performed when more than one set of zero-order correlations, reported in all cases as Pearson's r , was available per construct.

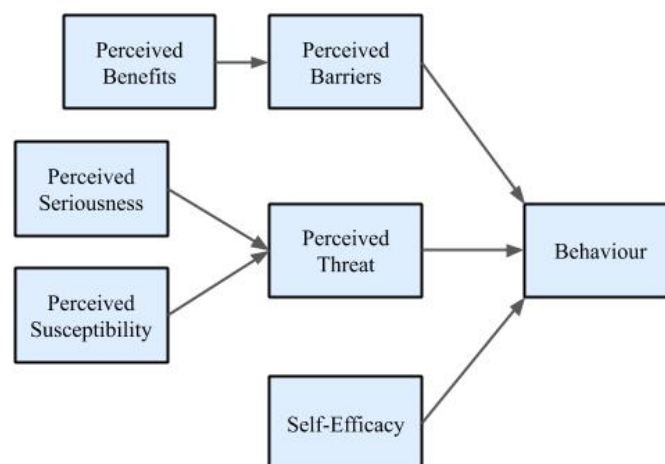


Figure 8. *The Health Belief Model.*

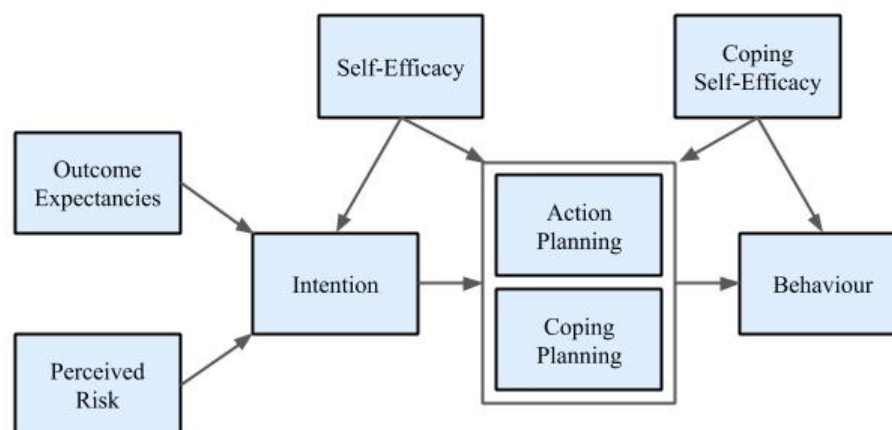


Figure 9. *The Health Action Process Approach.*

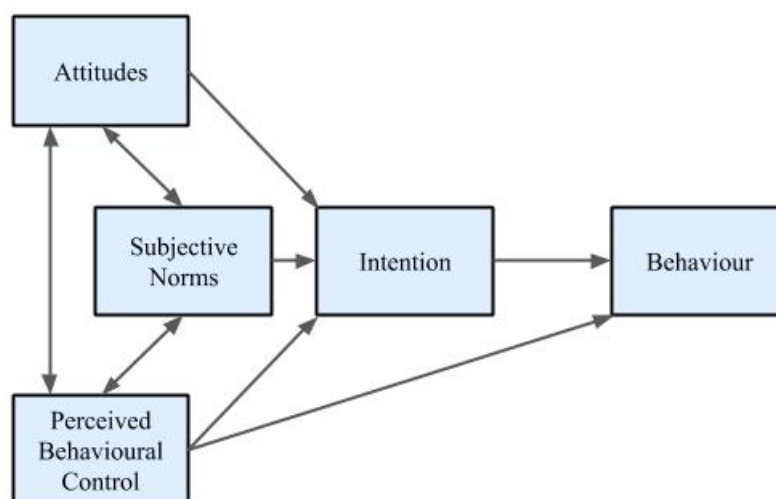


Figure 10. *The Theory of Planned Behaviour.*

To calculate pooled effect sizes, Cohen's d was calculated to reflect the standardised effect size within each sample (Cohen, 1988), and pooled using Fisher's method (Fisher, 2006), to give the population-level approximate. The meta-analysis was carried out according to methods described by Quintana (2015), and the software packages R and XQuartz (to view data output) were used for the synthesis of the results (R Core Team, 2013).

4.3.5 - Risk of bias across studies. Risk of bias was assessed using the I^2 statistic to test study heterogeneity (Higgins et al., 2003), with publication bias assessed using Egger's regression test (Egger et al., 1997) and Kendall's rank-correlation (Kendall, 1955). Significant heterogeneity, when results are very different from each other, can indicate undisclosed confounding variables (i.e. a third factor is interfering with the outcome measurement), and publication bias, as discussed, refers to anomalies in the distribution of effect sizes and standard errors.

4.4 - Results of the Review

The process of inclusion in the review is presented in the PRISMA flowchart in Figure 13. A total of 1117 records were identified after initial searching and 711 duplicates removed. The remaining 406 records were screened based on title and abstract, and 349 studies removed. The final 57 records were given full-text analysis, with 44 records excluded: 18 contained psychological constructs not associated with toothbrushing behaviour, eight contained demographics outside the inclusion criteria, seven had quantitative

Selection	<i>Quality measure (points allocated) - (max. 5)</i>
Representativeness	Truly representative or random (1) Somewhat representative, non-random (1) Selected users (0) No description (0)
Sample size	Justified and satisfactory (1) Not justified (0)
Non-respondents	Comparison with respondents offered and good response rate (1) Unsatisfactory response rate or comparison (0) Not described (0)
Independent variable tool	Validated measurement tool (2) Non-validated, but described well (1) No description (0)
Outcome	<i>(max 3.)</i>
Outcome assessment	Independent blind assessment (2) Record linkage (2) Self-report (1) No description (0)
Statistical test	Test is described and reported comprehensively (1) Test is not appropriate or reported/described fully (0)

Figure 11. *The modified version of the Newcastle-Ottawa Scale (Modesti et al. 2016).*

comparisons or other key data comparisons missing (Blinkhorn, 2010; Chan & Chin, 2015; Neves et al., 2015; Ronis et al., 1996; Soutome et al., 2012; Tedesco et al., 1992; Zetu et al., 2014), six did not quantify TBF, four articles did not have a full-text available in English, and one was a conference report based on a study that was already included in the final analysis. The remaining 13 articles were included in the qualitative synthesis.

This final sample included 11 unique samples and one subset of a larger sample. One sample was used across two studies (Syrjälä et al., 1999; Syrjälä et al., 2002), and one sample ($N = 131$) underwent initial analysis, before having a subset ($N = 77$) split off for separate analysis within the same article (McCaul et al., 1985), and another publication (McCaul et al., 1988).

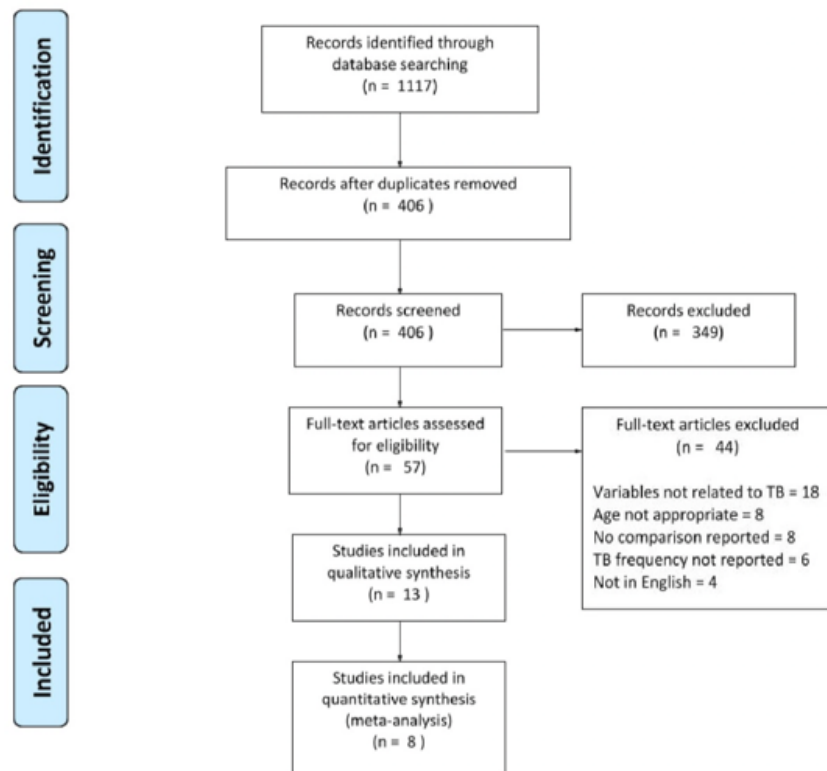


Figure 12. PRISMA flowchart of the systematic review process.

4.4.1 - Study Characteristics. All studies employed cross-sectional designs except one that measured TBF using a daily diary after the initial survey of psychological variables (McCaul et al., 1988). Bivariate correlations were reported in nine instances across eight studies, and multiple regression used for 11 unique models across six samples. There were two studies that used logistic regression and studied the same sample. Four studies were conducted in Romania, three in the USA, two in Finland, and one in each of Australia, Belgium, Japan, and South Africa. Seven studies examined students from either medicine or psychology courses, five studies examined patients in hospital and dental settings, and the remaining examined healthcare workers and members of a local community. The size of the 11 samples (excluding the subset sample) ranged from 39 to 2011 with a median size of 172 participants.

Toothbrushing instrument characteristics. Of the 12 unique samples, eight used Likert scales ranging from 3-points to 6-points to measure TBF. The smallest scales included the items: *less than once per day, once per day, more than once per day* (Dumitrescu et al., 2011), and *once, twice, three times or more* (Mizutani et al., 2012), whilst the largest included *less than twice a month or never, twice per month, once per month, 2-3 times per week, once per day, twice or more per day* (Chapman, 2015b).

Table 1. Results from Individual Studies.

Author, year, country	Year	Type of study	Participants	Toothbrushing Measure	TBB M (SD)	Psychological measure	Pearson's r	β coefficients	OR (95% CI)
Buglar et al. 2010 Australia	2010	Cross section	Dental patients N = 92 Age: 41.20 (17.00)	5-pt Likert scale: Not at all, once a week, every second day, once per day, twice per day. Source: None. Validated: No.	4.54 (0.64)	Health Belief Model Validated: No	SUS: -0.12 SEV: -0.02 BEN: 0.22* BAR: -0.40** SE: 0.57**	R ² : 0.36 AT: -0.01 PT: 0.04 AGE: 0.23* GEN: 0.17 OHK: -0.07 SUS: 0.24 SEV: -0.04 BEN: 0.17 BAR: -0.56***	NR
Chapman, 2013 South Africa	2013	Cross section	Various participants N = 257 Age: 28.77 (14.35)	6-pt Likert scale: Less often or never, twice per month, once a week, two to three times per week, once a day, two or more times a day. Source: Waddington (2000). Validated: No.	5.62 (0.78)	Oral Health Belief Scale (OHBS) Validated: No	BEN: 0.25*** SEV: 0.11* SUS: -0.04	R ² : 0.43 AT: 0.01 PT: -0.03 AGE: 0.20* GEN: 0.11 OHK: -0.02 SUS: 0.21 SEV: -0.07 BEN: 0.15 BAR: -0.41** SE: 0.32**	NR
Defranc et al. 2008 Belgium	2008	Cross section	Healthcare Workers N = 201 Age: 41.47 (9.79)	NR	NR	Questionnaire based on TPB. Validated: Yes (Defranc et al. 2008)	NR	R ² : 0.60 INT: 0.29*** PBC: 0.55***	NR
Dumitrescu et al. 2011a Romania	2011	Cross section	Medical Students N = 198 Age: 19.75 (1.35)	3-pt Likert scale: more than once per day, once per day, less than once per day. Source: Honkala & Al-Ansari, 2005 Validated: No.	NR	Proactive Coping Inventory (Greenglass et al. 1999) Validated: Yes (Greenglass et al. 1999).	NR	R ² : 0.08 AGE: 0.03 GEN: 0.13 AEL: 0.01 SEL: 0.15 DEL: 0.01 SRE: -0.11 P-COP: 0.298* PRO: 0.02 P- ATT: -0.12	NR
Dumitrescu et al. 2011b Romania	2011	Cross section	Medical Students N = 153 Age: 20.16	4-pt Likert scale: less than once a day, once a day or less, twice a day, more than twice a day. Source: None. Validated: No.	NR	Questionnaire based on TPB. Validated: No	INT: 0.33*** ATT: 0.37*** SN: -0.06 PBC: 0.16* (ATT-A: 0.38***) (ATT-C: 0.29***)	NSR	NR

Table 1. Results from Individual Studies (continued).

Dumitrescu et al. 2013 Romania	2013 Cross section	Medical Students N = 179 Age: 19.68	5-pt Likert scale: "during the last month how [often] have you [brushed]?" Source: None. Validated: No.	4.17 (0.72)	Questionnaire based on TPB. Validated: Yes (Dumitrescu et al. 2013)	SN: 0.02 PBC: -0.02 (ATT-A: 0.25**) (ATT-C: 0.28**)	R ² : NR (SEM) SN: -0.01 PBC: -0.09 (ATT-A: 0.16*) (ATT-C: 0.24**)	NR
Dumitrescu et al. 2014 Romania	2014 Cross section	Medical Students N = 172 Age: 19.58 (2.78)	5-pt Likert scale: "during the last month how often have you brushed your teeth?" not at all, less than once a day, once a day, twice a day, more than twice a day. Source: None. Validated: No.	NR	Questionnaire based on TPB. Validated: Yes (Dumitrescu et al. 2014)	NR	R ² : 0.10** ATT: 0.29*** SN: -0.03 (C: GEN, AGE)	NR
						NR	R ² : 0.10*** ATT: 0.29*** SN: -0.03 PBC: 0.03 (C: GEN, AGE)	NR
						NR	R ² : 0.13*** SUS: -0.03 SEV: 0.02 BEN: 0.32*** BAR: 0.02 (C: GEN, AGE)	NR
						NR	R ² : 0.13** SUS: -0.03 SEV: 0.01 BEN: 0.31*** BAR: 0.03 SE: 0.06 (C: GEN, AGE)	NR
						NR	R ² : 0.13*** SUS: -0.03 SEV: 0.01 OEX: 0.30*** (C: GEN, AGE)	NR
McCaul et al. 1985 USA	1985 Cross section	Psychology Students N = 131 Age: NR	1 item: How often did you brush your teeth in the last week? Source: None. Validated: No.	NR	Self-Efficacy Expectations (14 items) and Outcome Expectation (10 items) questionnaire. Validated: No	SE: 0.48** OEX: 0.15	NR	NR
		Psychology Students N = 77 Age: NR	Daily diary. Brushing recorded every day for two weeks. Average per day. Source: None. Validated: No.	NR	Self-Efficacy Expectations (14 items) and Outcome Expectation (10 items) questionnaire. Validated: No	SE: 0.43** OEX: 0.33**	NR	NR
McCaul et al. 1988 USA	1988 Split cross section t-1: TPB variables t-2: TBB variables	Psychology Students N = 77 Age: 24	Daily diary. Brushing recorded every day for two non-consecutive 7-day periods. Average per day. Source: None. Validated: No.	2.2 (no SD)	Questionnaire based on TPB. Validated: No	SE: 0.39** INT: 0.52**	NSR	NR

Table 1. *Results from Individual Studies (continued)*

Mizutani et al. 2012 Japan	2012	Cross section	Hospital patients N = 2011 Age: 18 or 19	3-pt Likert scale: daily frequency of tooth brushing. Once, twice, three or more times. Source: Furuta et al. 2012 Validated: No.	NR	Self-Efficacy Scale for Self-care (Kakutani et al. 2008) Validated: Yes (Kakutani et al. 2008)	SE: 0.10***	R ² : NR (SEM) SE: 0.13*** CHK: 0.11**	NR
Syrjälä et al. 1999 Finland	1999	Cross section	Hospital patients N = 149 Age: 34	Dichotomous: Brushing twice per day, or less. Source: None. Validated: No.	NA	Toothbrushing self-efficacy Validated: Yes (Syrjälä et al. 1999)	NR	NR	SE: 1.51*** (1.30 - 1.77)
Syrjälä et al. 2002 Finland	2002	Cross section	Hospital patients N = 149 Age: 34	Dichotomous: Brushing twice per day, or less. Source: None. Validated: No.	NA	Questionnaire based on TRA (Tedesco et al. 1991) Validated: No	NR	NR	INT: 179.06*** (38.30 - 837.06) ATT: 2.12** (1.41 - 3.20) SN: 3.03*** (1.45 - 6.37)
Tedesco et al. 1991 USA	1991	Cross section	Dental patients N = 39 Age: 36.66	5-pt Likert scale: how often do you forget to brush your teeth at least twice a day - never, rarely, once, twice a week. [reverse scored] Source: None. Validated: No.	3.13 (1.55) [rarely - once/twice weekly]	Questionnaire based on TRA and SCT. Validated: No	SE: 0.75*** INT: 0.68***	NSR	NR

AEL = anxiety in everyday life; AGE = age in years; AT = appointment type; ATT = attitude; ATT-A = affective attitudes; ATT-C = cognitive attitudes; BAR = perceived barriers; BEN = perceived benefits; C = controlled covariates; CHK = dental checkup in past year; DEL = depression in everyday life; GEN = gender; INT = intention; NSR = not reported; NR = not reported; OEX = outcome expectancies; OHK = oral health knowledge; P-ATT = proactive attitude; P-COP = proactive coping; PBC = perceived behavioural control; PRO = procrastination; PT = patient type; R² = variance explained by model; SE = self-efficacy; SEL = stress in everyday life; SEM = structural equation model used; SEV = perceived severity; SN = subjective norms; SRE = self regulation; SUS = perceived susceptibility; * = p < 0.05; ** = p < 0.01; *** = p < 0.001

Of the remaining four samples, one asked for an answer to the question: “*how often did you brush your teeth last week?*” (McCaul et al., 1985); one had participants fill out a brushing diary for two non-consecutive weeks (McCaul et al., 1985; McCaul et al., 1988); one asked participants to report how often they brushed, then dichotomised this to twice or more per day, or less (Syrjälä et al., 1999; Syrjälä et al., 2002); and one study reported TBF but did not elaborate on the reporting methods (Defranc et al., 2008).

Standard deviations in TBF were minimal amongst seven of the Likert scales (ranging from 0.64 - 0.78). However, a reverse-coded measure based on forgetting to brush resulted in much more variance ($SD = 1.55$) across a 5-pt scale (Tedesco et al., 1991). It was noted that only one publication used past literature as a reference for their TBF measure (Chapman, 2015a).

Psychological instrument characteristics. Across the studies, 13 questionnaires regarding psychological correlates were used. Nine were questionnaires based on the chosen health-behaviour model, and of the remaining studies two measured self-efficacy (Mizutani et al., 2012; Syrjälä et al., 1999), one measured self-efficacy in combination with outcome expectancies (McCaul et al., 1985) and one measured proactive coping abilities amongst participants (Dumitrescu et al., 2011). Three studies employed psychological measures that had been used previously, with two validated (Dumitrescu et al., 2011; Mizutani et al., 2012) and one simply used previously (Syrjälä et al., 2002). Only four studies demonstrated the validity of their instruments via principal components analysis to ensure the discriminate validity of the separate factors and the suitability of the question items (Defranc et al., 2008; Dumitrescu et al., 2014; Dumitrescu et al., 2013; Syrjälä et al., 1999), meaning a total of six of the 13 studies used validated psychological measures, whilst seven did not.

4.5 - Methodological quality within studies

The quality of each individual study was measured using the NOS, with results included in Table 2 below. Overall, the mode of study scores was a 3 out of 8, which represents relatively poor quality. Most studies suffered limitations in justifying their sample size, recording non-respondent rates, using an objective measure of toothbrushing frequency, and reporting the statistical tests in a satisfactory manner.

4.5.1 - Extraction of Results. The extracted results are included in Table 1. Overall, nine of the included studies had available zero-order correlations available. However, once sorted based on each variable and health behaviour framework, this was not enough data to complete a quantitative comparison of the models.

<i>Author, Year</i>	<i>REP</i>	<i>SAM</i>	<i>RES</i>	<i>IND</i>	<i>OUT</i>	<i>STA</i>	<i>TOT</i>
Buglar et al. 2010	1	0	0	1	1	0	3
Chapman 2013	1	0	0	1	1	0	3
Defranc et al. 2008	1	0	0	2	0	0	3
Dumitrescu et al. 2011a	0	0	0	2	1	0	3
Dumitrescu et al. 2011b	0	0	0	1	1	0	2
Dumitrescu et al. 2013	0	0	0	2	1	0	3
Dumitrescu et al. 2014	0	1	0	2	1	0	4
McCaul et al. 1985	0	0	0	1	1	0	2
McCaul et al. 1988	0	0	0	1	1	0	2
Mizutani et al. 2012	1	0	0	2	1	0	4
Syrjälä et al. 1999	1	0	0	2	1	1	5
Syrjälä et al. 2002	1	0	0	1	1	1	4
Tedesco et al. 1991	1	0	1	1	1	0	4

REP = representativeness, SAM = sample justification, RES = recording of non-respondents, IND = independent variable measure, OUT = outcome variable measure, STA = reporting of statistical data, TOT = total NOS quality score

Table 2. *Quality of studies based on a modified version of the Newcastle-Ottawa Scale.*

4.5.2 - Quality of studies. The mean NOS score was 3.23 ($SD = 0.93$) out of a possible 8.00, indicating low-medium methodological quality. In terms of sample representativeness, seven studies recruited broadly, whilst 6 studies used convenience samples from university cohorts. While university students may constitute a young adult demographic, sampling specifically from the same class may not give an ideal representation of the general young adult population. Other studies may consider university cohorts to be a good representation of their target demographic and may thus change this rating on the quality scale accordingly. In terms of sample calculations, only two studies performed power analyses prior to recruiting (Chapman, 2015a; Dumitrescu et al., 2014), with only one actually using this as a guide (Dumitrescu et al., 2014). Regarding non-respondents, only one reported the rates of non-respondents (Tedesco et al., 1991), only two reported confidence intervals for statistical testing (Syrjälä et al., 1999; Syrjälä et al., 2002), and in terms of toothbrushing measures, all used self-reporting except for one (Defranc et al., 2008) that did not mention the methodology. Considerable potential was identified to improve study methodology.

Author, year	Theory of Planned Behaviour				Health Belief Model						Health Action Process Approach						
	ATT	SN	PBC	INT	BAR	BEN	SEV	SUS	THR	SE	OE	RISK	COP	ACT	INT	COP-E	SE
Buglar et al. 2010					*	-	-	-		*							*
Chapman 2013						*	*	-									
Defranc et al. 2008			*	*											*		
Dumitrescu et al. 2011a													*				
Dumitrescu et al. 2011b	*	-	*	*											*		
Dumitrescu et al. 2013	*	-	-														
Dumitrescu et al. 2014	*	-	-		-	*	-	-		-	*						-
McCaul et al. 1985										*	- / *						*
McCaul et al. 1988				*						*					*		*
Mizutani et al. 2012										*							*
Syrjälä et al. 1999										*							*
Syrjälä et al. 2002	*	*		*											*		*
Tedesco et al. 1991				*						*					*		*
% $p < 0.05$	100%	25%	50%	100%	50%	67%	33%	0%	0%	86%	75%	0%	100%	0%	100%	0%	86%

* = construct tested and $p < 0.05$, - = construct tested and $p > 0.05$, - / * = construct tested twice in same sample with differing results

Table 3. Frequency analysis of significant correlations across studies.

4.6 - Results of the Systematic Review and Meta-Analysis

The Theory of Planned Behaviour (TPB) was the most observed model within the review, with seven studies exploring constructs related to the TPB and its predecessor, the Theory of Reasoned Action. Of the individual constructs, self-efficacy was the most tested with nine out of 13 studies exploring self-efficacy.

Model fit was not quantified due to the scarcity of correlation data. Instead, it was measured using face-value approximations, made by summing the observed significant correlations between individual constructs and toothbrushing frequency. Theoretically, all the constructs were directly or indirectly associated with toothbrushing frequency. Therefore, the presence of a greater number of significant relationships gives some indication of model suitability, with higher frequencies of significant pathways indicating a higher likelihood that the theoretical model may fit the data, should confirmative factors analysis be applied in the future (Schmitt, 2011). On face-value, this method showed that TPB constructs generated significant relationships in 71% of tested cases, with all constructs tested multiple times (4.25 times on average). Although constructs from the HAPA correlated significantly in nearly all (90%) cases, the absence of three variables being tested within the literature made it difficult to draw any conclusions about the strength of the theory as a whole. Results from this frequency analysis are presented in Table 3.

4.6.1 - Predictive ability of individual variables. Attitudes and intentions were significant predictors across all studies in which they were employed. The meta-analysis in Table 4 confirms the strength of intentions and attitudes, and suggests that self-efficacy (SE), perceived benefits, and outcome expectancies also have a sufficient level of evidence to

Variable	<i>k</i>	<i>r</i>	<i>p</i>	95% CI		Heterogeneity			Publication Bias	
				Lower	Upper	<i>I</i> ²	<i>Q</i>	<i>p</i>	<i>z</i>	<i>τ</i>
Intentions	3	0.50***	<0.001	0.28	0.68	75.32%	7.89*	0.02	2.80**	1
Intentions†	2	0.59***	<0.001	0.41	0.72	35.38%	1.55	0.21	NA	NA
Self-efficacy	6	0.46***	<0.001	0.26	0.62	90.81%	79.64***	<0.001	5.14***	0.41
Self-efficacy†	4	0.48***	<0.001	0.39	0.55	0.00%	2.58	0.46	-0.56	-0.55
Attitudes	4	0.30***	<0.001	0.23	0.37	0.00%	1.84	0.61	0.99	0.82
Benefits	2	0.24***	<0.001	0.14	0.34	0.00%	0.07	0.8	NA	NA
Outcome expectancies	2	0.23*	0.01	0.05	0.4	41.96%	1.72	0.19	NA	NA
Perceived Severity	2	0.07	0.21	-0.04	0.19	10.84%	1.12	0.29	NA	NA
Perceived Behavioural Control	2	0.07	0.45	-0.11	0.24	62.47%	2.66	0.1	NA	NA
Perceived Susceptibility	2	-0.06	0.26	-0.17	0.05	0.00%	0.43	0.51	NA	NA
Subjective Norms	2	-0.02	0.76	-0.13	0.09	0.00%	0.52	0.47	NA	NA

* = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$; † = Model adjusted for heterogeneity and publication bias; *k* = studies included in synthesis; *r* = sample weighted model coefficient, reported as Pearson's *r*; 95% CI = lower and upper 95% confidence intervals; *I*² = percentage of heterogeneity explained by variability between studies; *Q* = test for model heterogeneity; *z* = Egger's regression test for

Table 4. *Meta-analysis of psychological correlates with toothbrushing frequency.*

support their correlation with toothbrushing frequency. Variables that were not good predictors of TBF included Perceived Severity (SEV), Perceived Susceptibility (SUS), and Subjective Norms (SN). Of the six samples in which SEV and SUS were tested, and the five examining SN, these constructs were significant on one occasion each (Chapman, 2015a; Syrjälä et al., 2002), with findings echoed in the meta-analysis.

Interestingly, perceived behavioural control (PBC) was not supported at a meta-analytic level, although evidence did show significant contributions within half of the analyses, as shown in Table 3.

4.6.2 - Risk of bias across studies. Risk of bias was found within meta-analytic models of intention and self-efficacy, although both models remained significant after the removal of studies contributing most to heterogeneity.

Chapter 5 - Discussion of the Systematic Review

5.1 - Discussing the Findings of the Review

This review sought to compare three behavioural frameworks and synthesise the evidence regarding which constructs may best correlate with toothbrushing frequency. To the author's knowledge, this was the first study to review such correlates among younger adult samples. As revealed, variables related to cognitive beliefs about toothbrushing (i.e. attitudes, outcome expectancies, and perceived benefits), intentions to engage in toothbrushing, and self-efficacy served as the strongest correlates. However, an equally important finding, and one that potentially skews the validity of these outcomes, was the low methodological quality observed among the included studies. With the current review limiting its scope to validated frameworks in order to increase the comparability of similar research, the lack of rigour and limited use of valid question items and prior research presents a concern that should be addressed within this research field.

5.2 - Issues with Methodology

5.2.1 - Lack of past literature use. As clinical guidelines and recommendations should be based around strong, cumulative evidence from multiple sources, it is vital that researchers aim to ensure their methods and results can be integrated into the wider evidence base. Observation from the review that contradicted this goal included a lack of validated measures, failing to properly validate constructs, and a series of shortcomings regarding the reporting of basic statistics. In particular, it should be noted that assessing the Cronbach's alpha is a measure of scale reliability, not construct validity, and one needs to conduct a principal components analysis to first determine whether the questions in a survey impact each other prior to using such scale reliability tests (Field, 2018). This is to ensure that constructs are adequately divergent and that question items related to one construct are not inadvertently correlated with one of the other constructs. This was overlooked by many of the studies, and it is suggested that the methods used in applying psychological theory to oral health could be improved. Even if there is a lack of past evidence to guide studies, using research from the broader health field may be a solution to guiding question development and validation.

5.2.2 - Under-reporting concerns. Under-reporting of response frequency and the use convenience sampling can present a methodological concern (Peterson & Merunka, 2014). Power statistics and results were also under-reported, a-priori calculations were largely absent, and bivariate correlations and standard errors were missing in many cases.

Considering that standard error estimates are useful for a-priori calculations (Jones et al., 2003), reporting margins of error should be addressed; and the inclusion of zero-order correlations should be strongly advocated to increase the usability of results in future research. It is suggested that authors aim to let the reader draw their own conclusions from the study, rather than only report the conclusions that they believe to be important.

5.2.3 - Bias in reporting methods. Reliance on self-reported toothbrushing also presented a common downfall, which is surprising given that the technology exists (e.g. a computer sensor that detects when a toothbrush is picked up, or a sensor in a toothbrush holder to report when a toothbrush is removed) to objectively record toothbrushing, or even help validate one of the many items that are used for self-report. In addition, the inherent non-normality of the ordinal measures used (i.e. *brush twice per day, once per day, less than once*) was only addressed twice using dichotomisation and logistic regression (Syrjälä et al., 1999; Syrjälä et al., 2002). Statistical limitations exist in treating ordinal measures as continuous (Field, 2018), and authors are suggested to use discrete continuous measures, such as a count of how many times the event has occurred, to measure frequency. Measures may also aim to be sensitive enough to capture a spread of data that adheres to the central limit theorem, that data that will begin to resemble a normal distribution as more is collected (Field, 2018).

5.2.4 - Definitions of toothbrushing. Despite definitions of toothbrushing measures constituting one limitation, it should be noted that limitations regarding the classification of toothbrushing as a unique behaviour was identified during data screening. While not discussed earlier due to its insignificance in relation to the current data, it is worth observing that many studies were rejected from this review because they explored “oral health behaviours” as a composite measure, rather than splitting behaviours into separate entities (i.e. toothbrushing + flossing + dental visits = total oral hygiene behaviour).

When correlates are measured in relation to a composite behaviour, it makes the interpretation and transferability of the results difficult, as one would be assuming that self-efficacy for flossing and self-efficacy for toothbrushing, for example, are the same thing. Although the composite behaviours may address an ideal scenario, it may be much more practical to research the individual behaviours alone rather than treat them as the same thing as it leaves considerably more room for error. Brein et al. (2016) found that composite oral hygiene behaviours exhibited poor internal consistency when compared to treating them as discriminant variables. Further, if one was to create a risk assessment related to a composite behaviour it may offer little practical information about which element of the behaviour is lacking, again leading to the potential for error in interpreting the results. While it makes

sense that the individual behaviours and beliefs associated with each are correlated, it does not make sense to treat them as the same construct, with future studies suggested to focus on understanding the specific elements of oral hygiene self-care.

5.3 - Comparing the Psychological Frameworks and Correlates

While the current review did not compare model-fit due to sparsity of data, examining the sum of significant relationships between constructs and toothbrushing showed the Theory of Planned Behaviour (TPB) to be the most applied and most supported framework. The TPB was not perfect, as subjective norms did not have a strong relationship with outcomes, but it did have strong supporting evidence for the majority of its included constructs. Considering that constructs relating to perceived threat, severity and susceptibility within the HBM failed to demonstrate any value, and that many of the HAPA constructs (perceived risk, action planning ability, self-efficacy for coping) were untested, the conclusion may be drawn that the TPB is the strongest model while still having some weaknesses.

5.3.1 – Comparing the models. Support for the TPB does reflect evidence that the model is a comparably good predictor of health behaviour (Taylor et al., 2006) with wide applicability (Cooke et al., 2016; McDermott et al., 2015; Rich et al., 2015; Starfelt Sutton & White, 2016) and validity (González et al., 2012; Kasper et al., 2012) across behavioural domains. Although, the average R^2 value of 26.7% across the three studies that explored the TPB is very similar to the 27% of variance explained in a review of all behavioural applications (Armitage & Conner, 2001), this is short of the 34% of variance explained when examining health-specific behaviour (Godin & Kok, 1996). In terms of average variance explained, the HBM explained around 26.2% of variance, and the HAPA around 13%, with all multiple regression models significant. However, models of the HBM did tend to control for many covariates (i.e. used extra constructs that add to the explained variance), and the single model of the HAPA left many variables out, so the numbers may not be accurate.

One reason for the Theory of Planned Behaviour not explaining more variance, despite its strengths, may be due to evidence failing to support subjective norms as a strong correlate with toothbrushing frequency. While not clear why this variable alone failed to correlate significantly, it may be due to the unspoken nature of oral hygiene norms. While the discussion of health-behaviours (e.g. alcohol consumption, exercise, diet) is perhaps common within daily activity or among peers, a possible lack of discussion concerning toothbrushing may mean that similar norms regarding toothbrushing standards are not salient as often during daily life. The strong correlation between subjective norms and toothbrushing within adolescent demographics (Scheerman et al., 2016) also supports this hypothesis, as the

influence from parents or guardians is likely more common and direct than what may be experienced by independent adults.

Also, some authors added extra variables, such as gender and age (Buglar et al., 2010), to their psychological frameworks without much elaboration on why these decisions were made. While controlling for confounding variables is warranted, the addition of variables without any theoretical basis may lead to bias through unnecessary adjustment (Schisterman et al., 2009). Pourhoseingholi et al. (2012) suggest that any variable being added to a model should have a theoretical basis somewhere within the hypothetical causative model that is guiding the study. This means that age may be included if there is a theoretical relationship between age and toothbrushing frequency, but should be left out if this is not the case.

5.3.2 - Comparing individual variables. As the construct of attitudes concerns the appraisal of benefits and detriments of a behaviour, it is logical that more positive attitudes, and higher perceived benefits, correlated with higher reported frequencies of toothbrushing behaviour. With toothbrushing relatively accessible, it was also logical that stronger intentions correlated with rates of engagement. If an individual intends to do something frequently, they will likely attempt or accomplish it more often than a person with lower intentions, especially if the behaviour is accessible. Thus, attitudes and intentions were the most robust correlates with toothbrushing outcomes according to the current review.

Alternatively, though, variables related to severity, susceptibility, and social norms were less than ideal correlates. This aligns with the findings of Carpenter (2010), who suggested that benefits and barriers may be best predictors of behaviours within the Health Belief Model, rather than variables associated with perceived threats, risk or susceptibility. However, the findings may also be due to the detached nature of these constructs from toothbrushing itself. In this sense, *detached* means that while attitudes and intentions relate directly to behaviour (e.g. perceived benefits of *toothbrushing*, intention to use a *toothbrush*, etc.), environmental norms and risk assessments are instead associated with the eventual outcomes of poor hygiene (e.g. dental caries, halitosis, gingivitis). Also, with dental disease being an ongoing process, and with little immediate noticeability of dental caries or periodontitis in the early stages, it is understandable that the interpretation of risk is largely subjective, and potentially based on dental disease knowledge and the assessment of one's own hygiene routines. Therefore, asking an individual to define their current risk of dental disease may be reliant on a large number of unfounded assumptions about their own oral health. It is also tenable that two separate people may brush at different frequencies but perceive a similar risk of dental decay. A qualitative study of attitudes among young adults in

the USA found that many respondents viewed oral hygiene standards as excessive and had a fatalistic view of their own oral health (Savage et al., 2018), meaning that they would likely rate their oral health as sub-par, despite potentially having reasonable oral hygiene habits. Based on this example, it is possible that one individual may brush often because they are worried about their high risk of disease, while another brushes infrequently and perceives a similarly high risk-status. Such a hypothesis could certainly explain the results observed across the current studies, and the lack of relationship between subjective assessments and actual toothbrushing behaviour.

The review by Scheerman et al. (2016) showed opposing results with regards to attitudes, as well as subjective norms. Within their review, it was suggested that subjective norms were good correlates with toothbrushing behaviour, while attitudes were not (Scheerman et al., 2016). Thus, as their study only examined adolescent demographics, this may support the theory that the influence of norms changes when the direct influence of the parents is reduced. Once this happens, it may be that the influence of subjective pressures is replaced by more intrinsically driven attitudes. In other words, rather than doing something because one is pressured to do it, one must engage because one wants to do it. Such findings are of particular interest and examining how attitudes and subjective norms may change during the transition away from the home-environment may certainly be worthy of future exploration.

5.4 - Limitations of the Review

The review itself faced primary limitations related to data availability. This was quite interesting considering the degree to which toothbrushing is associated with plaque and dental disease risk (Kumar et al., 2016; L  e, 2000), and the range of publications that have explored the influence of psychological constructs on oral hygiene behaviours. While this limitation could be explained by the limited scope of frameworks included in the review, the implication that psychological predictors have been explored extensively, but with little use of validated (and common) theoretical models; little focus on individual behaviours such as toothbrushing frequency; and with little exploration amongst young adult demographics,. As the review aimed to offer suggestions for future research, the validity of the conclusions was affected by concerns over methodology.

5.4.1 - Sampling limitations. Authors should also be mindful of limitations that exist when using narrow or convenience sampling methods. The finding that many samples came from limited university cohorts, and especially that there was no attempt at random sampling, compromises validity. With strong links between education and health outcomes (Costa et al.,

2012), this raises questions as to why one may focus on exploring the opinions of university students over actual risk demographics. With this approach most likely related to the accessibility of student samples, especially for university-based researchers, it compromises the value of the findings.

5.5 - Future Recommendations

Following this review, future studies should aim for increased rigour when exploring relationships between psychological constructs and toothbrushing behaviour. If the global aim of research in this field is to enhance the effectiveness and efficiency of risk assessments and health behaviour interventions, then ensuring methodological rigour is a vital step towards creating the evidence-base required to achieve this goal. Future research may also aim to align more with behavioural science research in general, as a means of guidance and of ensuring relevance. It may even seek collaboration with psychology-specific-researchers to assist the construction of questionnaires and other assessment items (Francis et al., 2004). Combining psychology-specific researchers with those from a dental background should also potentially be an aim for any dental research team looking to explore the influence of beliefs and attitudes on behaviour. Especially since dental schools are often located within specific dental facilities and hospitals, potentially far removed from faculties concerned with the behavioural sciences, it is important that such physical limitations do not inhibit important cross-collaboration in this field. Such cross-disciplinary relationships are not only anticipated to help guide research, but to give dental-focused findings an increased value within the psychology field itself and assist the integration of oral health research within the scope of general health research, a key aim within the Australian National Oral Health Plan (McAuliffe et al., 2015).

In any case, the recommendation may be noted that constructs related to intention, attitudes, and self-efficacy have reasonably strong correlations with toothbrushing frequency, and that these variables are likely to belong within a framework that best explains toothbrushing behaviour. However, prospective study designs are required to track the observed changes in these constructs and behaviour over time to thresh out causative links and either strengthen or weaken this conclusion. Further, the replication of such studies across multiple populations would also be encouraged to help strengthen such evidence, with the current studies focusing unique questionnaires on unique populations in each circumstance, making cross-comparison difficult.

Finally, the current review may also point to the potential for exploring the HAPA amongst young adults. Whilst the actual evidence is scarce in support of the HAPA among

this demographic, it should be noted that the constructs contained within this model actually resemble those that were found to be significant (i.e. outcome expectancies, intentions, and self-efficacy), while coping and action-planning abilities were simply not explored often. However, as coping and action-planning abilities were both shown to be good predictors of toothbrushing among adolescents (Scheerman et al., 2016), it may be suggested that it is worth exploring these variables among young adults. Especially since the literature review demonstrated considerable support for coping and self-regulation as likely correlates with health behaviour, it was disappointing to find that a framework including such variables has not been explored more often with regards to toothbrushing. Thus, the exploration of the HAPA may present a means of testing these variables, with precedent for such research despite the scarcity of relevant findings within the current review.

5.5.1 - Summary and applications. Overall, the findings from the current review, while somewhat negative in relation to methodology and total observations, are nonetheless positive in that they offer assistance in guiding future research in this field. As a general observation, it should be noted that significant R^2 values (the total variance explained by the current framework) were observed for all multiple regression models of toothbrushing frequency, reinforcing the potential for psychological frameworks to explain variability in toothbrushing behaviour (Kay et al., 2016b). However, as mentioned, it can be broadly suggested that authors aim to better apply more scientific rigor to when attempting to explain toothbrushing behaviour in this manner.

With younger independent demographics in need of affordable and effective intervention solutions to promote oral health and prevent dental disease, this review makes the suggestion that strategies targeting individual attitudes, intentions and self-efficacy could be expected to correlate with improved toothbrushing behaviour. However, with significant shortcomings related to study design and validity, improved methodology is required to strengthen the evidence base for such recommendations. Building upon the current findings is expected to contribute further to the understanding of toothbrushing behaviour, and this review hopefully plays some part in guiding the continued improvement of evidence and care within the preventive dentistry field.

Chapter 6 - Planning an Exploration of Within-Person Variability

6.1 - Exploring Real-Time Influences and Within-Person Variability

With evidence that attitudes, intentions and self-efficacy drive toothbrushing behaviour, and that the Theory of Planned Behaviour represents, perhaps, the most ideal psychological framework to explain variability in toothbrushing behaviour amongst young adults, the next step within the thesis was to use this information as a base for the exploration of real-time influences. As mentioned, the systematic review aimed to synthesise our understanding of stable personality constructs, with these assumed to be relatively unchanging, so that the exploration of unstable, real-time constructs (i.e. context-based enablers/barriers, dynamic self-efficacy, behavioural lapses, etc.) may be more accurately explored. As each event outcome is anticipated to result from an interaction between stable traits and unstable states (Mischel & Shoda, 1995), understanding stable personality-based elements first can assist in conceptualising where unstable real-time elements may fit in a model that includes both dimensions. With such investigation relatively untested among young adults and toothbrushing routines, though, more information regarding the phenomenon of unstable real-time influences may have to be gathered before attempting to immediately quantify these unknown variables.

6.1.1 - The existence of toothbrushing lapses. Despite the high likelihood that lapses in toothbrushing behaviour exist (i.e. individuals break from their routines from time to time), and evidence that young adults may not brush routinely based self-report data (Manton et al., 2018), toothbrushing research frequently focuses on toothbrushing as a fixed rate, such as once or twice per day. This is evidenced within a review of toothbrushing frequency where the measurement of this variable was split into *less than once* and *twice or more* categories, based on these being the only commonalities in toothbrushing measures across a range of studies (Kumar et al., 2016). Treating self-reported toothbrushing as a fixed rate presents a considerable gap in the literature in terms of measuring the potential difference between pre-held intentions to engage in toothbrushing at an intended rate and actual behaviour. Looking at the systematic review, this may have been hinted at by Tedesco et al. (1991), who showed that considerable variance existed ($SD = 1.55$ on a 5-point Likert scale) between participants when measuring toothbrushing in a reverse manner – i.e. how often participants forgot to engage in toothbrushing twice daily. Employing the term “forget” in their account of toothbrushing lapses implies that respondents may have intended to engage in toothbrushing

more than what they actually accomplished. If true, the implications are that individuals may experience unanticipated barriers to toothbrushing, independent of pre-held intentions and motivation, and that these could have a bearing on toothbrushing outcomes.

6.1.2 - The phenomenon of the toothbrushing lapse. Searching for explanations of variance in behaviour beyond the level of intentions and attitudes also fits with our understanding of these constructs themselves. According to the definition provided by Ajzen (1985), intentions and attitudes are assumed to be quite stable. Therefore, when thinking about a lapse in toothbrushing, it is unlikely that an individual may believe toothbrushing is beneficial one evening, then drastically change their intentions and decide it is not beneficial the next evening, only to wake up feeling like it may be beneficial the day after. Instead, it is assumed that attitudes (i.e. if we think toothbrushing is beneficial) and intentions (how strongly we want to engage in this behaviour, based on beliefs that it is beneficial) are relatively stable (Ajzen, 1985). Due to this, inabilities to perform the behaviour are therefore likely to arise from difficulties with control during the behavioural context. This hypothesis fits with the literature review, and suggestions that constructs such as self-efficacy, planning, coping, and self-regulation may all play a part in enabling behaviour engagement in real-time.

6.1.3 - Exploring a real-time phenomenon. Hence, the next stage of this thesis aimed to explore the phenomenon of toothbrushing lapses in a qualitative way and answer complex questions about real-time reactions and why pre-held intentions regarding toothbrushing may not be otherwise fulfilled. Using personal in-depth accounts of behaviour, one may examine where barriers exist within the behavioural context and seek to determine whether it is a simple case of forgetfulness, or perhaps the presence of particular antecedents or circumstances, that influences engagement in toothbrushing.

Research reveals that the experience of barriers to health behaviour may be due to the emotional or cognitive mindset at a given time (Brodbeck et al., 2014) or the focus of attention (Brosch et al., 2013). To explore their impact on toothbrushing, this study aimed to explore the antecedents (the events that happen before an incident) for instances of both engaging and disengaging in this behaviour. This study aimed to observe whether lapses were attributed to the perception of real-time barriers and, if so, explore how these might manifest and be influenced by pre-held beliefs such as cognitive attitudes, subjective norms, or self-efficacy.

This qualitative study would ultimately attempt to determine if, on face value, the potential for real-time factors to explain meaningful changes in oral hygiene behaviour does exist. While primarily an exploratory study of a phenomenon, the study aimed to also report

how prevalent such lapse-behaviour may be within a representative young adult population. The null hypothesis was that individuals would not experience any changes in behaviour based on real-time factors, but rather possess pre-meditated intentions to deliberately avoid toothbrushing at particular intervals that would explain changes in behaviour.

Investigating the toothbrushing phenomenon in this way may also give an indication about the ideal method for measuring toothbrushing outcomes. For example, either using a discrete counting measure of all toothbrushing events over a week/month, or using a measure based on average daily frequency, e.g. once or twice per day. Such findings have the potential to address suggestions from the systematic review as to whether traditional reports of toothbrushing are the ideal way to quantify this behaviour.

6.2 - Planning the Study

A group of younger adults aged 18-40 was sought to explore toothbrushing routines and personal accounts of both the environment in which toothbrushing takes place and the potential influences therein. Planning the project required the development of interview questions, the recruiting of young adults, and a decision about how to analyse the responses.

With the semi-structured interviews also seeking to explore pre-held beliefs and attitudes towards toothbrushing, question stems (initial questions and statements that prompt topics of discussion during the interview) were developed using the Theory of Planned Behaviour as a guide. This was based on evidence from the systematic review that the beliefs and attitudes described within this theory may have a strong relationship with toothbrushing frequency. Using construct definitions of attitudes, subjective norms, and perceived behavioural control as a guide (Francis et al., 2004), questions were developed to entice discussion of these factors and give insight into the cognitions that drive intention to engage in toothbrushing. All question stems were developed by the author, and used question guides such as that compiled by (Francis et al., 2004) as support for development. Overall, the questions aimed to be open-ended, to encourage open discussion and lend themselves to a conversational flow.

Questions were also developed to address phenomenological aspects of individual experiences with toothbrushing and toothbrushing lapses, i.e. how they felt at the time, what they were thinking, what they were focused on, etc. These were deliberately open-ended and aimed to primarily get the participant talking about their experiences within the context of a planned toothbrushing event; opening up about their feelings, thoughts, and other memories during these events. The key aim was to construct a model of how the various constructs and events, reported by participants, may have a bearing on subsequent toothbrushing behaviour,

and if there were common threads within the responses. It was anticipated, based on the literature review, that results would potentially highlight emotional variables and the experience of maladaptive cognitions as playing a role in toothbrushing lapses. In any case, findings were anticipated to help illuminate which real-time variables might have some impact toothbrushing, with this information being potentially valuable to those seeking to further investigate or quantify such constructs in the future.

6.2.1 - Question development. As per Figure 17, questions were developed using guidelines for Theory of Planned Behaviour scale construction (Francis et al., 2004) in conjunction with literature from the original theory (Ajzen, 1985). Through reading this literature, general themes and overarching definitions were used to ultimately develop simplified and open-ended question stems to elicit discussion around the central topic. For example, “attitudes” represents the degree to which individuals value the behaviour, and how strong these beliefs are in their mind, i.e. what are the perceived benefits, and do they think about them often. Participants were not simply asked if they thought toothbrushing was “good”, but rather what they perceived will happen if they didn't brush. This was expected to disclose whether they listed more serious, long-term detriments (or even detriments to self-image), or whether they simply perceived less serious, temporary concerns. Other question stems were developed in a similar manner and all question stems were read and discussed among the research group for suitability. A convenience sample of three young adults, aged between 20-30 years, with a university-education background were used to pilot the questions, test the length of the interview, and to help the interviewer to prepare before the real interviews.

6.2.2 - Recruiting participants. The study was registered with the Human Ethics Administration Group (HEAG) within the University of Melbourne prior to recruiting (HREC Num: 1648439.1). Advertisement of the study took place within the Royal Dental Hospital of Melbourne, and the University of Melbourne, to obtain a mixed sample of demographic and socio-economic backgrounds. As the Royal Dental Hospital of Melbourne provides public waiting-list dental services to those with a low-income, based on a government-determined income threshold, this was anticipated to offer a spectrum of socio-economic status in comparison to students at the University of Melbourne, a highly ranked university within Australia (Times Higher Education, 2019). Recruiting brochures were distributed within the dental hospital and were distributed by student practitioners to suitable patients within the clinics. These brochures contained information about the study, and also the email addresses

of the research team. Brochures instructed individuals to simply send a keyword via email (i.e. “TOOTHBRUSH”), and that they would receive further information about the study and

<i>Questions from Francis et al. (2004)</i>	<i>Theory of Planned Behaviour construct</i>	<i>Broad theme</i>	<i>Potential current question stem</i>
"Referring patients is easy"	Self-efficacy	Do they feel in control, do they feel that they are the one making decisions, or is it others/external forces?	"How much control do you have over the toothbrushing barriers you reported?"
"The decision to refer patients is beyond my control"			"What role do your motivations play in determining your oral hygiene?"
"I Could refer patients if I wanted to"			"Is it external barriers that hinder you?"
"Whether I refer patients or not is up to me"			
"Giving a patient a blood test is worthless"	Attitudes	What is the value of the behaviour, do they think about the consequences, or ever worry about the behaviour?	"What do you perceive are the consequences of not brushing your teeth?"
"I get worried if I send a patient for a test"			"How often do you think about toothbrushing?"
"When I refer a patient I am doing something good"			"How often do you think about the consequences of not brushing?"
"I care what patients, doctors, or specialists think about me"	Subjective norms	Where is pressure coming from, is there the threat of a reaction? Is the pressure a reasonable standard, or above what is likely expected of the person?	"Where do you feel that you learned most of the oral hygiene habits you engage in?"
"I feel social pressure to refer patients for tests"			"What would people who taught you about oral hygiene do if you did not follow their advice?"
"Most people like me refer their patients for tests"			"How often do people like yourself usually brush their teeth?"
"I expect that I will refer my patients for tests"	Intentions	Do they comply with their intentions, or are actual intention weak compared to ideal intentions, are there future intentions and are they strong?	"How well do you comply with your oral hygiene aims?"
"How often do you usually refer patients for tests"			"What would you change to help your oral hygiene?"
"I want to refer my patients for tests more often"			"Do you have any planned changes with regards to your oral hygiene?"

Figure 13. Development of question stems from guidelines published by Francis et al. (2004).

a list of available times to partake in the 15-20-minute interview. Participants were advised that they would receive a toothbrushing package as compensation for their time. Packages consisted of dental floss, toothpaste, a toothbrush, and a sample-size mouthwash, with a total value of approximately \$10 AUD. This incentive was deemed appropriate based on research showing that \$10 USD (approximately \$14-16 AUD) can have a positive influence on participation without effecting results (Yu et al., 2017), and evidence that non-monetary incentives may be particularly effective for recruiting (Edwards et al., 2009). After participants contacted the research team, they were emailed a consent form and plain language statement, in addition to the schedule of available times over the upcoming week. Timeslots were deliberately blocked by the interviewer to allow for interviews anywhere from 8am - 10pm, with earlier or later times available on irregular days. Participants were advised that if no suitable times were available, that they could make a request for a particular day and time, and it would be arranged the following week. Once a time was agreed upon, participants were phoned using Skype VOIP (Voice Over Internet Protocol) software, with interviews audio recorded. In all cases, verbal consent was obtained by reading the consent form aloud, having the participant verbally indicate their agreement, and by ensuring that the participant had received a physical copy of the consent form to keep.

6.3 - Analysis Methods and Hypotheses.

With an aim to thoroughly explore the toothbrushing behaviour phenomenon as a means of addressing the research questions, a grounded theory approach, using literature by Charmaz (2014), was employed to guide the qualitative analysis. Grounded theory is useful for exploring areas of research where there is little data, such as exploring the real-time barriers to toothbrushing and coping strategies used (Charmaz, 2014). The process of applying grounded theory involves systematic coding and grouping of the data into concepts and categories, with this method aiming to increase the objectivity of an otherwise subjective and qualitative approach (Charmaz, 2014). Primary coding and grouping of response themes was performed by the author, with some guidance from the research team.

6.3.1 - Coding the data. As a first step, transcripts were tagged and marked, based on the line of questioning being answered within the response. Using NVivo software, this process is considerably streamlined, with users able to highlight passages in the transcript and simply select the line of questioning to which the response applies. Transcripts were coded into question themes systematically until all passages had been accounted for, in terms of having their meaningful text extracted. As this process occurred concurrently with the interview process, the database of extracted passages and the range of responses slowly grew

with each new interview. The process of continuously analysing the transcripts and grouping the data followed the grounded theory approach to qualitative analysis outlined by Charmaz (2014).

The second step was to deconstruct and compare the responses within each response to each question theme. To accomplish this, for each question theme a database of the keywords and phrases contained in each passage was created, with one passage able to contain many different keywords or phrases. For example, responses to the question theme regarding reasons given for skipping toothbrushing in the morning generated phrases such as “I slept in”, “I woke up late”, “I am running late”, “I did not get much sleep the night before”. Once coded, multiple correspondence analysis (MCA) could be used to determine whether response answers may best fit under one theme, or several themes, based on the patterns of those who reported them and the semantically similar words used in their answers. The use of MCA is common where binary response patterns are observed - i.e. in this case where the participant either did (score of 1) or did not (score of 0) report the particular keyword or phrase (Akturk et al., 2007). Using MCA, response keywords are able to be grouped under more universal headings with these groupings potentially helpful in comparing responses and in assisting any attempts to quantify the constructs in the future. If MCA results are concise, and account for the majority of keywords and phrases, they can also offer a good indication of thematic saturation within the interviews. In other words, if keywords and phrases keep being the same, or new responses are semantically similar to the established response themes, it indicates the data is reaching saturation. On the other hand, if many keywords are left without being grouped (i.e. they don't seem to belong to any of the themes), then this would indicate that such themes may need to be explored further, possibly by conducting more interviews. If we use the previous example of question responses, multiple correspondence analysis may, for example, reduce these phrases into the single response theme of “Oversleeping and running late”.

Once all response themes were extracted, transcripts were re-read, and response themes compared. Participants were deliberately compared across a few domains to answer the primary research questions. First, participants were examined to explore potential response differences between those reported the most frequent lapse behaviour, and those who reported the least. Second, the methods that individuals used to prevent lapse behaviour was also of interest and comparisons looked for which themes tended to differentiate different coping approaches, and approaches to toothbrushing and oral health in general.

Overall, based on a desire to explore influences within the behavioural context, the analysis sought to identify themes related to: i) the main reasons attributed to skipping toothbrushing, ii) the main reasons that individuals gave for overcoming an urge to skip toothbrushing, iii) the beliefs, attitudes and real-time reactions reported by those who skip toothbrushing frequently and infrequently, iv) any potential relationship between certain pre-held beliefs or attitudes and their subsequent experiences with real-time barriers or challenges.

By exploring these four topics, it was anticipated to illuminate why individuals may either succumb to toothbrushing lapses or be equipped to resist them. Plus, the data was expected to give an indication about how reactions within the behavioural context may relate to pre-held beliefs, and potentially point to means of quantifying and studying them within future research.

Chapter 7 - Conducting a Qualitative Analysis of Toothbrushing Lapses

7.1 - Response Rates and Data Coding

Younger adults, aged 18 to 40, were recruited from the University of Melbourne, the Royal Dental Hospital of Melbourne (RDHM), and via snowball sampling (Morgan, 2008) from participants themselves.

Patients at the RDHM were initially invited to participate in the study using a brochure distributed by clinicians to their patients to promote the study; dental clinicians asked their patients and handed them the brochure inviting them to contact the research team by email. Participants were offered a toothbrushing gift pack (containing a toothbrush, toothpaste, floss, and mouthwash, valued at AUD \$10) for their time, and after indicating interest by contacting the research team via email, they were sent an introductory letter containing a plain language statement, an informed consent form, and a list of suitable interview times for the upcoming week. Participants were asked to reply with their ideal interview time and would then be called for a telephone interview. Despite approximately 300 brochures being distributed either directly to patients, or being available within the waiting rooms, only one person agreed to take part in the study through this method of recruiting. Although clinicians reported that patients indicated an interest in participating in the study, they failed to follow up with the research team to arrange an interview time.

University of Melbourne students were recruited through digital means by advertising the study within a portal on the Faculty of Medicine, Dentistry and Health Sciences homepage. This advertisement was the same image as the brochure given to patients within the RDHM and included the same offer of an incentive pack for participation. Responses to the online advertisement were good, with 13 participants recruited via this method.

Whilst not an original part of the planned recruiting, snowball sampling was introduced mid-way through the project to account for difficulties experienced in recruiting participants for the study. Snowball sampling was introduced after 12 interviews, primarily due to little variance in educational background, low response rates from RDHM patients, and a desire to access these potentially more high-risk populations.

7.1.1 - Contingency measures to recruiting. Given the difficulties in recruiting sufficient participants, snowball sampling took place to help initiate contact with potential participants who were potentially at a higher risk of dental disease. This involves asking initial respondents to nominate potential participants who they know to fit the eligibility, or

desired, criteria (Morgan, 2008). To recruit in this manner, individuals who had taken part in the study were asked to refer a friend who did not have a university background and who might be interested in taking part in the study. Several participants provided contact information for a friend or relative and this person was subsequently sent the standard introductory email (or text-message in many cases) to offer a chance to participate in the study. This sampling method worked quite well, yielding a further nine participants.

Non-probability sampling methods such as this may be justified when attempting to explore the characteristics of a group who fail to respond to other methods, and where research aims to explore a particular issue in a qualitative manner without necessarily attempting to draw conclusions about the population as a whole (Saumure & Given, 2008).

7.1.2 - Study approval. The study had ethics approval from the Human Ethics Approval Group of the University of Melbourne (HREC Num: 1648439.1). Each phase of the sampling process and its development was subject to an ethics amendment and approval prior to further recruitment.

7.1.3 - Data collection. As interviews were conducted via telephone, consent forms were read aloud by the interviewer prior to commencing, and verbal consent obtained in every case. Interviews lasted 15-20 minutes, with audio data collected and transcribed for every participant. The interviews followed a semi-structured interview design, and question stems were developed using the methods set out Figure 17. Theory of Planned Behaviour guides, such as (Francis et al., 2004), were used to develop stems that aimed to elicit answers relating to pre-held beliefs. Stems that explored the behavioural context were more phenomenological in nature and aimed to incur rich responses related to reasons for toothbrushing lapses, thoughts and feelings during these times, and differentiation between events in which one either engages, or fail to engage, in toothbrushing. Question stems are included in Figure 18.

7.1.4 - Extraction of themes. Transcripts were monitored and coded following each interview, with themes relating to toothbrushing variability, self-reported reasons for variability, and motivations for toothbrushing monitored specifically for the purpose of addressing the primary research questions. After approximately 18 interviews, these themes reached saturation, with no new reasons given as to why toothbrushing might lapse, and no new motivations or beliefs being reported to drive toothbrushing in the behavioural context. However, with an aim to observe more variability in educational background, and potentially participants with an even lower reported rate of toothbrushing frequency, recruiting continued until the final sample of 23 was decided upon. While no participants at this stage had reported

- Demographic and education information
- Describe your oral health/toothbrushing routine
- Describe how your toothbrushing routine may change from time to time
- Describe the main barriers to toothbrushing you may experience
- Describe how you feel after you skip toothbrushing
- How much control do you have over these barriers?
- What do you perceive are the consequences of not brushing?
- How often do you think about these consequences?
- Where do you feel that you learned the majority of your oral hygiene routine?
- What would significant people think if you brushed less?
- How often do you believe that people like yourself brush, in general?
- How well do you feel you comply with your idea of an optimal OH routine?
- What would you change to improve your satisfaction with your OH routine?
- What role do personal motivations have in determining your ability to improve your OH routine?
- What role to external barriers have in improving routines?

Figure 14. *List of question stems for semi-structured interview.*

particularly low rates of toothbrushing, it was deemed that thematic saturation was reasonable grounds to conclude recruitment and that the difficulties in recruiting individuals with poor habits may be related to individual reluctance to discuss poor habits (i.e. those with poor toothbrushing habits may not be willing to discuss their poor habits), rather than the recruiting methods themselves.

Following the interviews, audio transcripts were imported into NVivo (QSR International, 2014) and coded by the author to identify keywords and phrases used when answering certain lines of questioning. Multiple correspondence analysis was then used via IBM SPSS v25.0 (IBM Corporation, 2017) to identify the response themes within each question category, based on the common use of similar keywords (Abdi & Valentin, 2007). This means of data reduction was performed concurrently with the qualitative analysis of each transcript, and the sample as a whole, to ensure the validity of the emerging themes. A comprehensive list of all 60 response themes across the 18 identified question themes is included in Appendix C. As mentioned in Chapter 6, these themes were compared between participants to search for emerging meta-themes that could answer the key research questions regarding the reasons for lapses, the means of preventing lapses, and any relationship between lapse-related themes and themes related to pre-held beliefs or attitudes.

7.2 - Results of the Interviews

While 32 individuals expressed interest in participating in the study, only 23 ultimately participated in the interview process ($N = 23$). Mean age amongst the sample was 25.09 ($SD =$

4.25) years, with 87.0% coming from Australia, 43.5% from metropolitan Melbourne, and 60.9% possessing a bachelor's degree education or higher. Taking reported lapses into account, average toothbrushing was 11.87 ($SD = 2.30$) times per week. Most participants ($n = 19$) reported a degree of differentiation from their routine toothbrushing at times, with all reporting that changes were influenced by real-time, context-based variables, rather than any deliberate changes to behaviour (i.e. they did not plan to brush twice on one given day, and just once the day after).

Although education background did not tend to relate to any differences in toothbrushing frequency, it did relate to themes regarding perceived outcomes and social norms. Participants with non-university backgrounds reported more often that reduced toothbrushing led primarily to aesthetic consequences (i.e. bad odour, discoloured teeth), and that there were strong social pressures regarding clean teeth, fresh breath, and a possibility that peers would react to poor oral hygiene.

The broader analysis of the responses returned four themes that differentiated participants and answered the research questions regarding when and why participants would experience real-time barriers to toothbrushing. These themes related to i) differentiation in the frequency of toothbrushing lapses (i.e. frequently, sometimes, not at all), ii) differentiation in the timing of barriers to toothbrushing (i.e. morning or night), iii) differentiation in internal or external triggers for overcoming barriers, and iv) differentiated general approaches to toothbrushing routines.

7.3 - Frequency of Toothbrushing Lapses

Answering questions about toothbrushing routines evoked a range of responses with regard to lapses. While some individuals reported that their routines were stable and would never change on a day-to-day basis, others reported that lapses during the week did happen on occasion, with some reporting they were a regular occurrence. The degree of lapses in toothbrushing thus emerged as a theme between respondents.

7.3.1 - High frequency of lapses. Looking at those who lapsed frequently ($n = 3$), avoiding toothbrushing approximately four times per week, there was a salient theme that they reported their main drive for engaging in toothbrushing was to prevent pain and avoid any social-related consequences. This was opposed to individuals who reported that they brushed for the sake of their own good health and hygiene. The main perceived outcomes of not brushing in this group were a mix of aesthetic and long-term consequences.

“[If I didn’t brush] I would start to get cavities or gum pain. And, if you do that, it will get to the point where, I think it there would [also] be an unpleasant smell for other people.. you would also get to the point where you could smell it on yourself, and that’s a sign that it’s really bad.”

– Undergraduate student, 21, Male

“Every time I flossed, I would have bleeding gums, and I think that was because I had plaques formed in my teeth already, and they were very sensitive... When I flossed before, my gums used to be really inflamed, and they hurt, but now they’re much better. I think the dentist took care of most of it... [I’m most concerned about] bleeding gums again, I think that will happen if I don’t [brush]”

- Undergraduate student, 21, Male

"I'd be more inclined to brush if I knew I was going out to see other people. If I was going to stay home all day I probably wouldn't brush, but if I'm leaving I definitely would."

- Tradesperson, Male, 32

This group also reported that they were most likely to avoid toothbrushing in the mornings because of events the night before and reported occasionally sleeping-in and running late a few times each week. These events were associated with feeling tired, rushed, and stressed during these mornings. Individuals were also prone to skipping toothbrushing of a night-time, reporting that they would often go out and consume alcohol, and would come home feeling sleepy and go straight to bed without brushing their teeth. They reported that night-times were difficult because of being in a relaxed mood or distracted by things like TV or movies.

“[It’s] usually [after] a few beers... it’s kind of easy to forget because all you want to do is get home from work, relax, then go to bed, so you forget to brush I guess.”

- Tradesperson, 22, Male

This group reflected that their routines could likely be controlled better, but they also reported that there was just no significant reward for toothbrushing, so they often didn’t care about it. They reported that it was difficult to prioritise toothbrushing, but that if they felt food or plaque it became easier to trigger toothbrushing thoughts.

"I used to get myself out of bed to brush my teeth, even if I was really tired, but I think living alone got me into bad habits... I [feel that] I'm waking in 6 hours so it won't matter...I think my laziness overcomes my guilt many times. I don't think that [calculus is] something you see immediately [either]. I didn't realise I even had it until I went to the dentist."

- Undergraduate student, 21, Male

"You get into bed and you are getting ready to sleep and you can feel [stuff] on your teeth, like mossy [stuff] on your teeth, and it makes you want to just get up and brush. But, getting out of bed, it is pretty hard... after a few beers you forget a lot of things, and you are definitely not thinking about, you know, brushing your teeth."

- Tradesperson, 22, Male

7.3.2 - Low frequency of lapses. Looking at responses from the participants who reported always brushing twice per day ($n = 4$), and rarely lapsing in their behaviour, there were two key themes that were salient among this group. First, when asked what the outcome of failing to brush might be, these individuals were more likely to perceive that long-term damage was their prime concern. Such consequences included cavities, gum disease, and a feeling that failing to brush could lead to "worse" teeth overall and potential problems with function.

"I hear that people my age get root canals and stuff like that, and I have worked at a dental clinic and saw all that happen first hand... to me this kind of stuff is very important."

- Undergraduate, Female, 20

"Plaque build-up, tartar, holes in your teeth, potentially sensitive teeth as well... gum bleeding, gingivitis... and cavities would be the main [consequences]."

- Undergraduate student, Male, 26

"Over time you'd get dental caries and a build-up of plaque, and... I know that there's also links between poor gum health and cardiovascular disease, and obviously tooth decay and tooth ache, or gums bleeding, which would be costly in the long run. If, over a chronic period of time, you didn't look after it, it would be a real financial burden to fix up."

- Undergraduate student, Male, 20

Second, this group of individuals who lapsed least often were actually quite likely to be forgiving of themselves in times that they did lapse. Although they reported that they would never lapse themselves, they were quite critical of the internalised standards that they had formed and were sceptical as to whether there really was an expectation that people brush twice and floss every day. Instead, they suggested that the average person is likely to struggle with these things, and that if something did hinder their toothbrushing, that this would be okay – although they reported this never happened to them.

“[I] brush twice a day, and floss twice a day, and mouthwash... I’m very consistent with the routine... I have spoken to a few people and I don’t think it’s that common, especially the flossing component. It’s like a zero for most people. And, the brushing component gets overlooked in the morning or overlooked when they are studying late at night.”

- Undergraduate student, Female, 20

“I brush my teeth twice a day. I floss with dental floss, or like an interdental brush, probably once a day... I’m pretty fastidious, I don’t really miss brushing my teeth... I think I’m probably a bit of an exception in that I’ve thought pretty carefully about my oral health. I brush for two or three minutes, always ask my dentist questions about how to brush, floss, use interdental brushes, and I think maybe I have a heightened awareness about my oral health... In general, I’d say students are probably more aware than most people about the consequence of poor oral health, [but] I think I probably [brush and floss] more than my colleagues. I don’t think that [they] would notice anything [if I didn’t brush], and maybe that’s half the problem. Maybe if it was noticeable, we would all brush more!”

- Undergraduate, Male, 23

7.4 – Timing of Barriers to Toothbrushing Compliance

With twice-a-day brushing reported as the norm among the majority of participants, lapses most commonly occurred during typical toothbrushing sessions scheduled prior to work/university, or before going to bed of an evening. Due to this, the time at which an individual felt that they encountered barriers to toothbrushing was a theme that differentiated participants.

7.4.1 - Failing to toothbrush in the morning. Several participants responded that they did not brush their in the morning, having otherwise planned to brush their teeth at this time. A salient theme among this group was that they nearly all reported a similar mindset during

the mornings when they tended to skip brushing. During these times, they reported being distracted by other tasks, feeling tired and sleepy from either a late night or poor sleep prior to waking up, or that they were generally rushed or stressed and pressed for time in the morning.

“If I’m really running late, or something is happening, occasionally I will just rinse my mouth out with water and put a little bit of toothpaste on my finger, and just swish it around and then wash my mouth out again... if I have slept in, woken up late, and I’ve got classes I need to get to and I can’t miss my train, sometimes that will cause it, or if I’m running late for work or something... usually [it happens when] I’m running really late for classes or an appointment or something.”

- Undergraduate, Female, 21

“I’m usually pretty slow in the mornings... if I don’t wake up early enough to have time after breakfast to brush, or even have breakfast, then I often grab fruit or something on the way out... I think when I was living at home, there was such a routine and I would brush morning and night... but moving out of home, there are so many more stressors and things you have to deal with, and something like getting up quick to go to university means everything is busy... [brushing] just falls off the radar.”

- Undergraduate, Female, 21

7.4.2 - Failing to brush of an evening. Of those who said that the main time they struggled was during the evening, they tended to also report salient themes regarding the reasons for difficulty at this time. Primarily, the reasons for lapsing were attributed to feelings of tiredness and exhaustion. Respondents reported that if brushing was left until a very late period of the evening that this late-ness changed their approach to toothbrushing. Additional salient feelings concerned feelings of laziness and lacking the energy to engage in brushing during some evenings.

“I’ll be too tired and forget by the time I’m already in bed... my teeth don’t feel desperately dirty if I run my tongue over them, so I think that I’ll be fine, it’s only 8 hours until I brush them... I would put it down to laziness or tiredness. I’m in bed, reading my book, and I’ll think - I’ve forgotten to brush my teeth, I’m not going to get up, I’ll do it in the morning.”

- Tradesperson, 29, Male

"I will miss some of the night-time ones, if it's too late, like it's 1:00am or 2:00am and I'm still not asleep. If I'm on my bed, and I'm tired, then I'll probably miss it... Sometimes it helps if I brush immediately after dinner - when I'm still awake and when I still have energy... but the thing is, I don't do that sometimes, and it's because I'm still hungry after dinner... I think [it is best to] brush your teeth right after your meals, because I often think I want to drink some tea, or eat some nuts afterwards, so I don't brush. Then, as a result, [it gets to] 1:00am and I don't want to brush anymore because now I'm too tired."

- Undergraduate student, 21, Male

"I jump into bed and put the TV on, then fall asleep without getting up and doing it... there's a second where it pops into my head, but it's me being lazy I think, not getting out and doing it, but I don't know if it really matters if you miss one brush, I don't know what the damage [would be]... I'm just going to do it in the morning... I don't know what the consequences are of missing, or say if you brush 11 [times a week] compared to 14, what's the difference in that?"

- Tradesperson, 27, Male

7.5 - Common Triggers for Overcoming Barriers

The most common triggers for coping with real-time adversity, such as a rushed morning or a late night, were either i) a focus on intrinsic personal responsibilities and "being an adult", or ii) through extrinsic triggers such as physically feeling plaque on the teeth. With participants tending to favour one over the other, this again differentiated their approach to toothbrushing within the behavioural context.

7.5.1 - Intrinsic motivations helped them cope. Individuals seemed to be split regarding the events or cognitions that triggered their coping mechanisms, with these coming from either intrinsic or extrinsic sources. Intrinsic sources were related to feelings of responsibility, thoughts about one's own health status, and a desire to avoid laziness and to be proactive. This theme was common among some individuals and reflected a view that their motivation for overcoming toothbrushing lapses was an intrinsic urge to persist with behaviour for the sake of the individual themselves. These individuals expressed other salient themes, such as feelings of guilt, worry, or frustration after letting their toothbrushing lapse. Individuals with an intrinsic motivation were likely to report thinking about a need for fillings, and regret that they had skipped brushing, after having done so.

“On Saturday I was at my local pub... 1:00am I got home, then I brushed my teeth, then went to bed... I sort of focus, I guess. When I was younger, I wasn't so responsible with it. But the last sort of 3-4 years I've been a lot more strict on it myself, because obviously if I didn't I'd probably start to get into trouble with my teeth, and I like to chew on some steak, so I don't want to be losing them or getting fakes - which might happen if I didn't do anything about it.”

- Tradesperson, Male, 31

“I think that thinking about [toothbrushing] as a positive feeling, rather than [something you have to do], can help... I always feel better afterwards, it just sort of feels like I'm being responsible and being a good adult - although that sounds lame! But, you know, it feels like I'm being organized and it makes me feel better and so if I'm stressed about particular study things or have a test, I guess brushing my teeth or responding to emails can feel good because it's like ticking things off a to-do list and gives me a bit of confidence.”

- Postgraduate student, Female, 24

Individuals who reported intrinsic motivations to persist with toothbrushing were also more introspective about the difficulties faced in controlling their actions. Among this group, individuals reported that toothbrushing was harder than it seems at times, but that they themselves were aware that being overly relaxed, under the influence of late nights, or even overly rushed made them more susceptible to lapsing. This susceptibility seemed to trigger thoughts that they should strive to overcome this adversity for their own personal reasons.

“[It is rare that I need to] exert some kind of will-power to [brush my teeth] ... on the rare occasions [I do], it's probably because I'm super tired, or have been out and had a really late night. When that happens, I guess I just think that I will wake up in the morning with this disgusting taste in my mouth, and so on those occasions I just remember to do it! I just do it because I know it's good for you, and I'm aware that it's easy to break good habits as well. If you start missing it a couple of times here and there, it can then be easier to miss in the future... it's also just the idea that if I don't brush, then it's going to be 24 hours between brushes... and I just think that's kind of gross.”

- Undergraduate student, 26, Male

“If I’m in a rush, I might not brush in the morning... [but] I like the feeling of having clean teeth. It makes me happier... finishing my routine in the morning [also] makes me feel better. Everyone likes routine, so brushing is part of your routine, and when you complete your routine in the morning, you feel better... [but] the power of the mind is a massive thing, you know, if you feel that you can’t complete something in your mind, it will feel impossible... and it can be hard to even begin a task, whatever it may be.

- Undergraduate student, 25, Female

7.5.2 - Extrinsic motivations. Extrinsic motivations to brush, on the other hand, were characterised by individuals who reported that the sudden sensation of plaque in the mouth, the consumption of sweet food or drinks, or the presence of others, served as triggers to remind them to brush. This differed from the intrinsically motivated group, as these individuals tended not be triggered by omnipresent desires to focus on health or behaviour, but rather specific triggers from plaque, food, or people.

A salient theme among this group was that failing to brush would likely lead to more aesthetic consequences. Respondents reported that skipping toothbrushing will result in dentures, in stained and discoloured teeth, and losses to self-confidence. If these outcomes were not being threatened by a lapse in toothbrushing, it seemed that the individual was less likely to persist with their toothbrushing behaviour.

“[If I didn’t brush my teeth], I think they’d go yellow and probably discoloured... If I’m going somewhere where I know someone is going to be quite close to my face, I’ll definitely [brush]... for appointments I tend to be really careful - even if I’m running late, I have to brush my teeth.”

- Undergraduate student, 21, Female

“If they don’t feel too dirty, [sometimes] I won’t [brush my teeth]. But, if I notice that I haven’t done them and they feel really dirty, I’ll do it... it depends on what [I’ve eaten], if I can feel stuff between my teeth... it [also depends on] your breath, the way your mouth feels and if your teeth feel smooth, and maybe what other people’s impressions might be... These make me [brush] a bit more than any fear of me losing my teeth or getting a root canal or something.”

- Tradesperson, 29, Male

7.6 - Meta-themes within the Responses

Last of all, examining the overall tendencies regarding toothbrushing within the sample highlighted three general approaches. These approaches again tended to differentiate the participants from each other and consisted of a combination of individual tendencies regarding beliefs and reactions, potentially hinting at the presence of stable and unstable dimensions within the toothbrushing context.

The first approach was favoured by six participants, and was defined by behaviour being driven by responsibility, rather than any fear of pain or social consequences. Those aligning with this self-driven approach reported that although real and unexpected barriers can indeed occur, they were not susceptible to skipping toothbrushing due to any feelings of relaxation or distraction. They instead tended to anticipate these barriers and were determined to persevere in these conditions. This group also felt little pressure from their peers if they did skip brushing and were more concerned with their own lapse in control. Overall, they tended to focus on their own willpower, and seemed to strive to exert control over their behaviour for more internal, rather than external, reasons.

The second approach was favoured by a majority of participants ($n = 11$) and was characterised by feeling quite concerned after not brushing. These individuals were not so worried about health consequences or dental treatment, but were more worried by social consequences, and that others might express disappointment or comment on their poor oral hygiene if they had not brushed. They tended to report the existence of general pressures to brush more often, regardless of how often they actually brushed at the moment. The reasons that they felt these pressures to brush more often were usually linked to an understanding that they were prone to not brushing if they were particularly relaxed or comfortable in the evening.

The third approach was favoured by six participants and was characterised by feeling general social pressures to spend more time and money on dental health, and a tendency to believe that most people in society would typically toothbrush twice daily and use mouth-rinse frequently. However, at the same time, this group reported little reaction to instances of failing to meet these standards. They were hesitant to blame their own self-efficacy or feel any strong disappointment in themselves for failing to comply with social pressures. Instead, they were more likely to justify lapses in behaviour and claim that their teeth felt okay, and that toothbrushing is sometimes just not worth the effort.

Although no obvious differences were observed between these approaches to toothbrushing and actual toothbrushing frequency, those who reported that they never skipped

brushing were most likely to favour the first approach, and those who lapsed the most tended to favour the third.

Chapter 8 - Discussion of the Qualitative Study

8.1 - Discussing the Findings of the Interviews.

The present study sought to explore the toothbrushing routines of young adults and offer a phenomenological account of the real-time factors that influenced changes to toothbrushing behaviour. Overall, the interviews highlighted that real-time emotions and pre-held motivations may have some influence on toothbrushing frequency via their observed impact on self-reports of individual barriers to brushing. The findings illustrate that the continued exploration of real-time variables (i.e. mood, location, stress, etc.) may have value in the oral health field. As most participants reported aiming towards toothbrushing twice daily (with homogeneity in this regard being a limitation), the observation that they encountered various levels of difficulty in achieving this goal means that there may be scope for real-time circumstances to help explain the apparent intention-behaviour gap. Being one of the first studies to explore toothbrushing lapses among young adults, the findings point to the potential for exploring how social norms, emotional antecedents and cognitive attitudes can influence individual oral hygiene behaviour events.

8.2 – Real-Time Influences on Oral Hygiene Behaviour

One of the most important findings, too, was that behaviour was subject to some fluctuation, with these fluctuations attributed to the context or situation in which the behaviour occurred – i.e. morning, night, during stress, during tiredness, etc. While focusing on these fluctuations could potentially represent an overly reductionist view of behaviour, the alternative is that this variability may account for some real variability in disease risk. With results observed in fields of drug use (Buckner et al., 2012), binge eating (Goldschmidt et al., 2019), and alcohol consumption (Simons et al., 2014), the use of similar longitudinal and momentary-assessment designs may be of value in exploring these variables within the oral hygiene field.

Further, it might be noted that there were no reports of deliberate alterations to toothbrushing plans. Considering the responses, toothbrushing was never really forgotten in the sense that toothbrushing it vanished from memory. Instead, it appeared that intrusive thoughts or emotions, and potentially deviations in attention, hindered any ability to focus on toothbrushing. The influence of emotions is suggested to be considerably important when explaining information processing and cognitive decision-making regarding health behaviour (Ferrer & Mendes, 2018). This is also supported by evidence that emotions such as stress can

influence actual abilities related to the retrieval information (Kuhlmann et al., 2005). Further, this aligns with research from the health behaviour field, where smoking (Brodbeck et al., 2014; Brodbeck et al., 2013) and diet (Hofmann et al., 2014) research has suggested that a calm mind may have a better capacity to focus and engage in a behavioural plan. In any case, the findings highlight that the presence of external and emotive stimuli, rather than a lack of motivation, may influence abilities related to the recall of behavioural plans and adherence to pre-held motivations.

8.2.1 - Mixed messages. Another point of interest was the perspective of participants with regards to their own toothbrushing lapses. Although most clearly stated that their goal was to brush their teeth twice per day and were able to give clear reasons as to why they may lapse, participants were generally uncertain about how well they were meeting their oral hygiene goals. If participants reported occasional lapses or not, they still stated that they could do more with regards to their dental care, indicating a general lack of confidence in assessing personal oral health, and a lack of confidence that oral hygiene self-care is being performed adequately. This general dissatisfaction is less than ideal and draws attention to possible limitations with currently advocated oral hygiene goals. Current goals are based on evidence regarding their influence on dental caries incidence (Kumar et al., 2016), however creating goals that are achievable, above all else, may have benefits with regards to the self-efficacy felt by individuals when they successfully fulfil their health aims (Bailey, 2017). Achievable goals could potentially be adapted through identifying the extent to which lapsing may actually influence caries incidence, or through investigating the influence of contingency plans – such as brushing longer, avoiding sugar, rinsing with water, or using topical products – as a means of accounting for a lapse. Adjusting goals in this way might increase the likelihood that young adults agree that they meet their own personal standards of oral hygiene, despite incurring occasional lapses in toothbrushing that might prevent them from complying 100% with their understanding of current recommendations.

8.3 - Patterns in Approaches to Brushing

It was also interesting to note the overall differences in the general approaches of participants towards toothbrushing. These seemingly personality-level differences gave some insight into three hypothetical personality-types that may dictate individual approaches to toothbrushing and the experience of barriers in different ways.

In terms of applying theory to these observed approaches, there are perhaps many theories that can offer at least some degree of explanation. The themes themselves tended to represent individuals who were either self-driven to engage in toothbrushing behaviour, who

were driven by external pressures and social expectations, and who perceived external norms but were reluctant to state that they felt any social pressure regarding their oral health. Based on these categories, Self-Determination Theory (SDT; Ryan & Deci, 2017), is one theory that could offer a parallel. This theory suggests that individuals exhibit personalities that display either autonomous motivation (self-driven), external motivation (driven by others), or amotivation (lacking any motivation), with the observed approach styles tending to align with such concepts to a degree. SDT has been shown to correlate with self-reports of toothbrushing among younger demographics (Halvari et al., 2012; Halvari et al., 2017). However, it should be noted that the reported personality differences arose during individual accounts of real-time barriers, rather than being stable observations. With this in mind, it might be suggested that the locus of motivations, from autonomous to external, may have differing effects based on different behavioural circumstances.

Looking at Figure 17, one can see how potential constructs of locus of motivation, self-regulation, and even strength of attitudes and norms may fit with the three approach styles. While purely hypothetical, the definitions within the Figure 17 are based on the reports of individuals who appeared to conform to each approach style. By observing these patterns as a whole, it may be reasoned that there exists a continuum whereby an individual may be placed somewhere between approach three and approach one, based on their own individual levels of these attributes.

However, no discrepancy is made between constructs such as attitudes and norms, and self-control and locus of motivations, with future research required to explore these relationships in detail. Future research might explore how attitudes and norms relate to each other, such as the effect of increasing cognitive attitudes (e.g. benefits of toothbrushing) on perceived social norms. In the current sample, individuals who reported seemingly strong attitudes towards toothbrushing weakened their viewpoint in the light of their perceptions of social norms. For example, an individual who reported that toothbrushing was important would also report that toothbrushing perhaps was not so important after comparing their toothbrushing habits to others. Similarly, those who possessed more extrinsic motivations were less likely to report self-driven regulation or control mechanisms. While perhaps logical that those driven by external forces were less likely to report real-time self-regulation, as they potentially relied more on triggers from external sources, it may be interesting to explore the directionality of such qualities and how intrinsic values relate to intrinsic-focused coping within future studies.

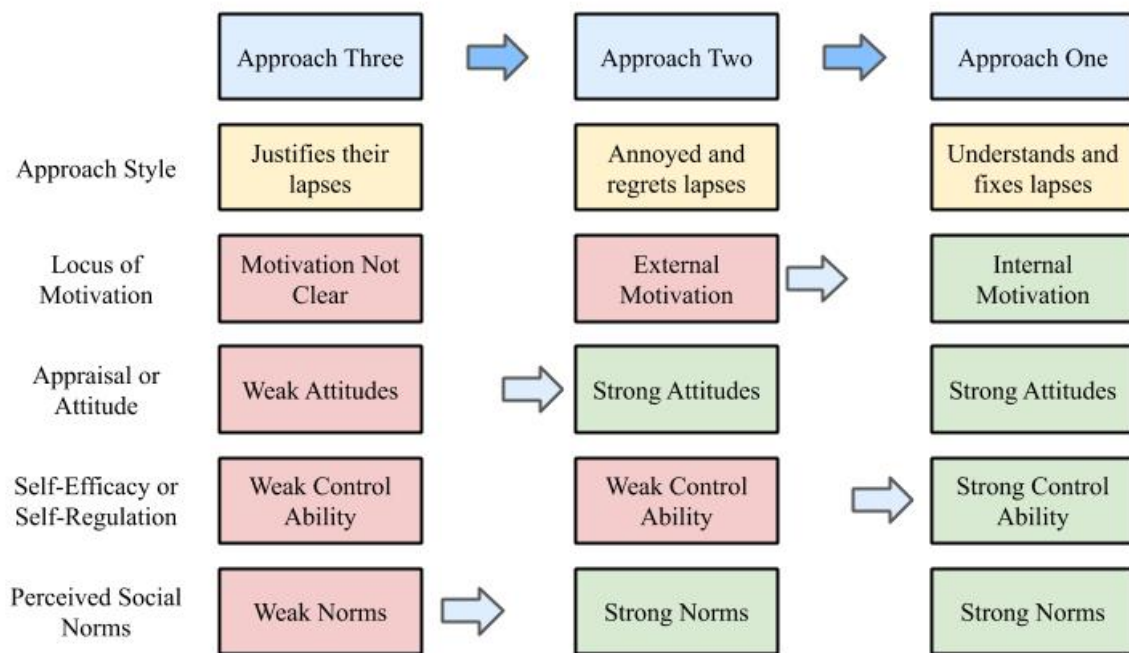


Figure 15. Key differences in approach styles towards toothbrushing.

In a similar way, Figure 18 takes these potential relationships and places them within a path-model, based on the Theory of Planned Behaviour; with this framework highlighted within the systematic review as a potentially good explanation of toothbrushing behaviour. Within the path model, locus of motivation may be linked to those attitudes and subjective norms that are salient and drive real-time intentions. At the same time, self-regulation abilities may dictate the degree to which real-time barriers, such as stress or tiredness, influence actual behavioural self-control and the ability to fulfil salient motivations. This theory fits somewhat with the Trans-Contextual Model, proposed by Hagger and Chatzisarantis (2012), based on research that sought to combine the Theory of Planned Behaviour and Self-Determination Theory (Hagger & Chatzisarantis, 2009). This model suggests that the intrinsic/extrinsic nature of motivations may influence the actual intentions within the context, with engagement moderated by perceptions of behavioural control in the same time-space. While the model doesn't account for challenges presented by negative mood (represented by stress or exhaustion), research examining smoking behaviour (Brodbeck et al., 2014) suggests that these mood-related barriers might determine the degree to which self-control is able to be exerted. Empirical studies may therefore test the degree to which toothbrushing behaviour may be dependent on both the locus of motivations before/during an event, and the presence of mood-based barriers as a means of exploring Figure 17.

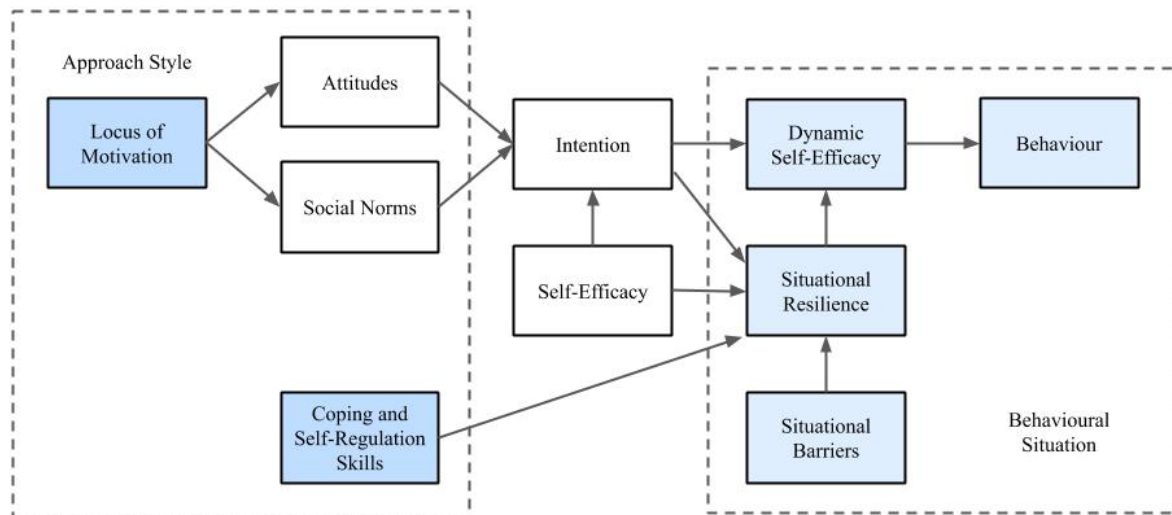


Figure 16. *A possible path-model of toothbrushing behaviour.*

8.3.1 - Influence on current oral health messages. In addition to exploring the above path model, future research is also suggested to examine how common messages, such as social pressure (that one should brush their teeth otherwise other people will notice), may actually impact subsequent toothbrushing routines. Coercing oral hygiene through increasing attention to social norms may have a potentially undesirable effect on intrinsic motivations. Research by Slep et al. (2018) examines this link between coercion and intrinsic motivations and attitudes towards health behaviours among children. In their findings, they highlight that coercion can have detrimental effects when considering later habits and intrinsic drives for children to comply with behaviour in the absence of coercive forces (Slep et al., 2018). Although they examine younger children, and the direct influence of parental coercion to engage in health behaviours such as toothbrushing, the effect of social coercion could be a valuable area of research among younger adults. While the threat of a social consequence, on one hand, served as a motivator for many respondents, it should be noted that toothbrushing due to social circumstances may be linked to weaker intrinsic motivations in the long term.

In addition, while there was no split in terms of overall toothbrushing frequency based on education level among the current respondents, the slightly higher prevalence of external motivations among non-university participants was of interest. One hypothesis may be that university education lends itself towards autonomous motivation and less motivation from social circumstances, with intrinsic motivation related to academic success at a university level (Bailey & Phillips, 2015). As success at a tertiary level is driven by independent learning, it could be reasoned that studying in an environment where one is treated like an

‘adult’ fosters the capacity for intrinsic motivation and potentially greater self-regulation. As universities do not employ the same discipline as high-school environments (e.g. detention, punishment, contacting parents), students must develop an ability to self-regulate their own behaviour and motivate themselves in the absence of being coerced by others. While the current sample exhibited a high level of heterogeneity with regards to toothbrushing, future studies may examine education and intrinsic pressures as a means of explaining common links between socio-economic factors, such as education, and dental disease (Mejia et al., 2018).

Further, extrinsic norms may also be explored for their influence over time. Beyond any research that focuses on younger adults, it may be of interest to monitor the resilience of extrinsic oral hygiene norms over time and in the face of dental disease. In theory, losing a tooth could potentially cause an individual to change the way they view their compliance with social norms, or even their perception of current social norms altogether. This potential for extrinsic norms to degrade may account for observations regarding the rates of edentulousness (losing all the teeth), as one may expect that extrinsic pressures, once dissipated, might result in little remaining motivation to care for the rest of the teeth.

8.4 - Limitations of the Study

Although rich data were extracted from the interviews, and themes tended to align with prior research, the current project was subject to a number of limitations, as discussed below.

8.4.1 - Limitations due to participant variability. As mentioned in the results section, a significant limitation was experienced regarding the recruiting of participants at high-risk of dental disease. Due to this, toothbrushing variability was more homogenous than anticipated. Further, due to difficulties in recruiting high-risk participants from the outset, what was expected to be a representative sample of young adults from within the local community ended up being a convenience sample from a university combined with a snowball sample of people who were not university students. With this bias present, the generalisability of results is limited, and it is likely that the reported frequency of twice per day toothbrushing is an overrepresentation of the true population of young adults (Manton et al., 2018). However, a reasonable amount of lapse-based variability was observed among individuals who brushed twice per day, giving some indication that there may be even more variability when accounting for those who brush less often.

8.4.2 - Limitations due to the use of non-probability sampling. The use of snowball sampling was also a limitation itself, despite attempting to correct limitations with sample composition. Non-probability sampling methods such as this can be justified when attempting

to explore the characteristics of a group who fail to respond to other methods, and where research aims to explore a particular issue in a qualitative manner without necessarily attempting to draw conclusions about the population as a whole (Saumure & Given, 2008). As this was the case within the current study, snowball sampling was employed. Snowball sampling methods are nonetheless highlighted as having considerable issues relating to bias in sample selection (Morgan, 2008), although referred participants in the current study were clearly advised that participation was voluntary, despite being referred. Future studies may, in any case, be encouraged to find alternative methods of overcoming recruiting difficulties, and plan for these prior to the recruiting phase.

8.4.3 - Limitations due to recruiting difficulties. As mentioned, recruiting difficulties were a limitation, contributing to a student-heavy sample composition, and unideal contingency measures being used to try and capture an overview of young Australian adults. While saturation was nonetheless reached in terms of emerging themes, and there was valuable variability among the data, there was nonetheless a relationship between public-dental-patient status and participation in the current project. One explanation may be that those with sub-optimal oral hygiene habits felt less inclined to willingly discuss oral hygiene shortcomings with a researcher when recruitment is undertaken in a dental school setting, as this may have had little benefit from the patient's perspective (Patel et al., 2003). To combat this, it is suggested that research promotes some benefit in order to attract patients who do not participate for purely altruistic reasons (Patel et al., 2003), although the toothbrushing package used in the current study did not seem to provide much incentive. One solution, therefore, may be to increase the value of the incentive package. Another suggested solution is also to repeatedly contact potential participants (Patel et al., 2003), although the effect and ethics of this, especially the presence of coercion, would need to be explored. A stronger approach instead may be to increase collaboration with primary care clinicians, with this highlighted as a means of utilising strong client-patient relationships to increase likelihood of participation (Newington & Metcalfe, 2014). In these cases, it is anticipated that the potential participant will be more likely to take part in the study if the person giving them the study information is a trusted individual (Newington & Metcalfe, 2014). This may have been a barrier within the current study as it relied on teaching-clinics for recruitment, where patients switch between student clinicians across the course of months or years, potentially diminishing any strong relationships. With high-risk patients expected to always present some degree of difficulty regarding accessibility (Rosenstock, 1966), future studies are encouraged to conduct interviews as an adjunct to a treatment visit, or at least utilise clinicians who have

an established degree of trust among their patients during the recruiting process. Additionally, studies may seek to use alternate contact methods. It should be noted that the current study relied heavily on email as a means of contact, which appeared not to be the preferred method of contact for all individuals. Such decisions may be alienating for those who do not have access to a computer or the internet, which may include people in low-socioeconomic groups, with this being an oversight in the current study.

8.4.4 - Limitations due to research methods. The study also experienced limitations due to the use of one interviewer, and the use of the author as the primary analyst of the results. As there is always a potential for bias based on the person asking the questions during a qualitative study (Gravetter & Forzano, 2012), the use of one single interviewer could have led to certain themes either being hidden or coming to the fore. Further, with the author providing the primary analysis, this could have been improved by having all transcripts and themes triangulated among multiple researchers. While the whole research team was certainly involved in the current project, and contributed to confirmation of the findings, future designs may seek to have multiple parties equally involved in data capture and analysis throughout the entire process.

Chapter 9 - Discussion and Recommendations based on the Thesis

9.1 - Recommendations and Benefits for Future Studies

Overall, the current study and current thesis highlight how toothbrushing rates may be considerably complex, and that there may be real benefits from further exploration in this field. While sometimes dismissed as a simple habit, current findings suggest that toothbrushing may be more related to individual abilities, such as self-regulation, and the context-based capacity of an individual to carry out behaviour in trying circumstances. For these reasons, future studies are encouraged to explore such mechanisms of engagement further, with suggestions for such research, and the benefits from a research and clinical perspective, outlined below.

9.2 - Benefits within this Research Field.

The current thesis is anticipated to first have some benefits related to the continued exploration of psychological constructs within the oral health field. Current findings demonstrate how small changes in stress, self-regulation, or perceptions of social consequences, for example, may potentially result in changes to oral hygiene habits and perhaps oral health. The findings from the systematic review also demonstrated that intentions, attitudes, and perceptions of self-efficacy may be related to the frequency of engagement in oral hygiene behaviours.

Findings from the systematic review, as mentioned, echo findings within the wider health-behaviour field that demonstrate the applicability of the TPB to health behaviour (Cooke et al., 2016; McDermott et al., 2015; Rich et al., 2015; Starfelt Sutton & White, 2016). However, with little evidence within the review suggesting that these variables have been studied at multiple time-points, future research might consider employing prospective designs to monitor associations with toothbrushing practices and dental disease over time. Research might also be encouraged to explore extended models of the TPB, such as that proposed by Hagger and Chatzisarantis (2009), which includes measures of intrinsic/extrinsic motivation as distal moderators of attitudes and intentions. Further, it may also seek to apply research regarding the effect of mood on real-time changes in self-efficacy (Tak et al., 2017), with this potentially having real-time applications to dental behaviours.

Simultaneously, the systematic review also pointed to the need for increased rigour among future studies that choose to explore these themes. Improving methods of measurement and reporting are anticipated to improve the transparency, cross-comparability,

and validity of future findings. In particular, it might be suggested that future studies attempt either random sampling or objectively measuring toothbrushing frequency, with these being two key limitations across all studies. The systematic review also pointed to difficulties in defining young adult risk groups, and hopefully future dental research is drawn towards this limitation and works to address a definition of the age at which younger adults are at the biggest risk of dental caries due to socio-economic hardships and independent living.

The thesis also pointed to the potential benefits of exploring real time variability in oral hygiene behaviours. While participants in the qualitative study exhibited somewhat homogenous toothbrushing routines than what was expected among an Australian sample (Manton et al., 2018), the evidence that real-time barriers occasionally contributed to lapses in behaviour may be worth exploring. Although not explored in this thesis, increasing oral hygiene behaviours is likely to either necessitate a) the removal of barriers to increased brushing, or b) require an increase in the motivation to brush more often. Therefore, exploring real-time barriers, and methods of coping with these, could be anticipated to have some value, regardless of whether these barriers explain more or less behavioural variability than that explained by pre-held motivations. Using this reasoning, a two-pronged approach that addresses both an increase in motivation and also a reduction in barriers may also serve as a suggestion for future intervention practice. Overall, it is hoped that the current findings might serve as an impetus to continue looking more closely at real-time barriers and the mechanisms behind real-time toothbrushing engagement.

Finally, the benefits of the findings may be that they point towards the exploration of self-regulation and locus of motivations as potential moderators of how intentions are formed and carried out in the context of toothbrushing. Research that seeks to explore real-time incidences of toothbrushing may further seek to examine the intrinsic/extrinsic nature of real-time motivations and how self-regulation and current mood may ultimately influence self-efficacy and behaviour engagement within the behavioural context itself.

9.3 - Benefits within the Dental Clinic

Although little direct transferability is possible from the current findings, based on the heterogeneity of the qualitative sample and the quality of studies within the systematic review, findings do support suggestions that the continued targeting of psychological variables may be worthwhile (Hollister & Anema, 2004; Kay et al., 2016b; Newton & Asimakopoulou, 2015; Werner et al., 2016). Similarly, the observation that toothbrushing behaviour appeared to have both motivational and volitional components, reflecting suggestions made regarding health behaviours in general (Hagger & Luszczynska, 2014),

suggests that the application of general health behaviour principles to dental behaviour may be warranted. This could also have benefits beyond the ability to apply behavioural science knowledge to the development of knowledge in the dental field. Alternatively, if such general attributes such as self-regulation and intrinsic motivations play a role across a number of health behaviours, as shown in the literature concerning health behaviour and physical activity (Hagger & Chatzisarantis, 2009) and chronic health conditions (Tougas et al., 2015), this could indicate the potential for developing and delivering such messages as part of a collaborative and multi-disciplined health approach. If messages regarding self-regulation, for example, were developed in a way that facilitated delivery from a physician, dental hygienist, personal trainer, etc., one can see how such messages might be strengthened and increase the likelihood of benefits for the person receiving the message. Thus, finding that the hypotheses derived from behavioural science research appeared to fit the data gives some promise that future applications may also adhere to such principles, and that an approach to dental disease might even attempt to target broad correlates of general health behaviour as a means of enhancing overall patient benefits.

In any case, clinicians may be encouraged to discuss behavioural lapses with their patients and discuss potential triggers or circumstances that necessitate strong self-regulatory skills. While prospective studies are required to inform how specific self-regulation-focused interventions may be delivered, clinicians might nevertheless guide patients to identify and attend to personal triggers of toothbrushing barriers, with this being anticipated to help avert such triggers and difficult circumstances in the first place.

Further, findings among the literature suggest that self-regulation interventions in particular might be targeted via electronic means (Song et al., 2019; Van Dyck et al., 2016), with potential to explore similar approaches in the dental setting. Developing non-clinical means of providing oral health promotion and education represents an area of need for young adult populations. With financial barriers cited as a common reason for avoiding dental care among young adults in Australia (Manton et al., 2018), the provision of evidence-based digital care may have a positive effect on the accessibility of these preventive strategies.

Finally, while not a strict clinical benefit, the study also sheds some light on the need to explore the influence of external social pressures within the dental field. As external norms tended to be associated with a slightly increased tendency to report occasional toothbrushing lapses, the effect of norms on toothbrushing should be explored further. Especially since the systematic review found that subjective norms and perceptions do not relate directly to toothbrushing frequency, the methods of quantifying these norms and understanding their

mechanism of influence may require some attention. The internalisation of cultural aesthetic norms has been shown to influence behaviours during exposures to mood states, such as body checking behaviours among young adults (Rogers et al., 2016). Therefore, the similar internalisation of oral hygiene norms associated with cultural aesthetics may play some role in real-time reactions among young adults. The exploration of the internalization of such norms, and especially aesthetic versus health norms, may constitute an interesting area for future study.

9.4 - Benefits for the Oral Health Therapist

This thesis was, last of all, also hoped to have some benefits for individuals practicing oral health therapy, or who may have a particular focus on preventive dentistry as part of their everyday research or practice. Continued research in the preventive field that draws on the behavioural science field is hoped to increase the general understanding of psychological principles, raise the curiosity about such topics among clinicians, and lead to stronger evidence to guide preventive practice. Thus, the current findings are hoped to stir some curiosity regarding the exploration of real-time toothbrushing events, as well as demonstrate the benefits that may be realised by aiming to be somewhat convergent and cross-comparable, focusing on appropriate validity and the use of past research as a guide for future research.

The systematic review, in particular, highlighted a need for this increased rigour in methodology. With potential for oral health therapists to continue similar lines of research that concern oral hygiene behaviours and or other elements of the profession, it may be important that research aims to encourage higher degrees of rigour and collaboration to strengthen future findings. Looking at research bodies such as the PEARL group (Practitioners Engaged in Applied Research and Learning), a research network that was established to conduct practitioner-based dental research at New York University in 2005 (Curro et al., 2013), one can observe how a single group can bring together multiple professionals with the aim of creating transferrable evidence in a particular field. The PEARL group demonstrated how a united vision translated into clear and applicable research agendas, strong evidence, and ultimately an influential impact on the working environment with findings being generated by a group of practitioners who ultimately played a role in their implementation (Curro et al., 2013). Similar groups may therefore be sought in relation to oral health therapy. While national and international committees already exist, ensuring that adequate collaboration is used to create cooperative, rather than competitive, research pursuits may be of real value to the development of research in this profession with few academics.

Further, while the thesis is hoped to constitute a platform for future research examining real-time influences on oral hygiene, the limitations on the current study illustrate the equal importance of continuing to focus such research at a community level and review the emerging themes and norms. The rich qualitative data highlighted that behavioural patterns were quite complex, that they were subject to a variety of current social pressures, and that high-risk individuals may be particularly difficult to assess and understand. Therefore, future research is suggested to continually aim to capture such high-risk individuals and to maintain a phenomenological approach to this area of research that accounts for changing social pressures and norms. Just as Sischo and Broder (2011) promoted the importance of transferability and community involvement in measuring and refining outcomes such as oral health quality of life, similar sentiments may be applied to the continued exploration and definition of psychological determinants of oral hygiene behaviours.

9.5 - Conclusions

The current thesis aimed to explore the psychological correlates of dental behaviours. It aimed to review the literature surrounding the application of these correlates to the behaviour of young adults and explore relationships with individual reactions in the behavioural context.

Overall, while it was found via systematic review that the research around behavioural correlates was quite weak, the evidence nonetheless suggested that variables relating to attitudes, self-efficacy and intentions may correlate well with toothbrushing outcomes, with this finding agreeing with previous literature. With this in mind, these constructs may be used to help guide future research, be it through targeting these variables within an intervention, or through their inclusion in research that continues to explore relationships with toothbrushing. In any case, with clear limitations among the reviewed studies in relation to research design, definitions of normative pressures, and measures of toothbrushing, future research is encouraged to continue exploration in this field with a focus towards improving methodological rigour.

This thesis also reviewed a series of interviews that explored contextual influences on toothbrushing. Toothbrushing behaviour seemed to be influenced by pre-held beliefs, the perceptions of social pressures, the locus of primary motivations, and the way these interacted with experiences of tiredness or stress within the behavioural context. Those who were motivated by extrinsic parties seemed to report more lapses in toothbrushing than those who brushed their teeth for more intrinsic reasons. Many participants also reported that toothbrushing was “too difficult” when tired/stressed emotions were present, offering a conclusion that self-regulation, the ability to moderate the influence of emotion on self-

efficacy, could play a role in toothbrushing behaviour. Overall, as toothbrushing lapses were also rather prevalent, the study showed that exploring real-time barriers and the mechanisms of toothbrushing engagement that occur within the behavioural context is warranted.

Future research might seek to explore these mechanisms in a quantitative way, and determine how attitudes, intentions, and self-efficacy may actually be manipulated by emotions, self-regulation, and changes to self-efficacy in real-time. By continuing this research among younger demographics, such findings are expected benefit the understanding of the mechanisms of toothbrushing engagement, inform clinician interventions, and raise the appreciation of oral health mechanisms within the wider community.

In conclusion, this thesis aimed to explore oral health behaviours in a manner that addressed limitations in the current literature and attempted to open new doors for useful research in the preventive dentistry field. At the same time, the thesis attempted to further align oral health research with pathways being employed within the behavioural science field. It is hoped that this thesis opens new perspectives of dental behaviours, with the findings demonstrating how preventive dentistry may benefit from the application of behavioural science to the measurement and modelling of patient behaviour in real-time

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Appendices

Appendix A. Complete search strategy

PubMed

- #1 ((attitud*[tiab] OR norm*[tiab] OR control[tiab] OR intention*[tiab] OR planned behavi*[tiab] OR ajzen) OR (((benefit*[tiab] OR barrier*[tiab] OR threat*[tiab] OR seriousness[tiab] OR susceptibility[tiab] OR risk*[tiab]) AND (perceived [tiab] OR perception*[tiab])) OR self-efficacy[tiab] OR health belief model[tiab] OR hbm[tiab] OR rosenstock[tiab]) OR (((action[tiab] OR coping[tiab] OR task[tiab]) AND (planning[tiab] OR self-efficacy[tiab] OR control[tiab])) OR intention*[tiab] OR outcome expectanc*[tiab] OR risk perception[tiab] OR self efficacy[tiab]))
- #2 ((toothbrushing frequency[tiab] OR toothbrushing behavio*[tiab]) OR (oral health behavio*[ti] OR oral hygiene behavio*[ti] OR ((dental[tiab] OR oral[tiab]) AND (brush*[tiab]) AND (frequency[tiab])))
- #3 (infant*[tiab] OR newborn*[tiab] OR child*[tiab] OR preschool*[tiab] OR kinder*[tiab] OR adolescen*[tiab] OR elder*[tiab] OR geriatric[tiab] OR pensioner[tiab] OR frail[tiab] OR rats[tiab])
- #4 #1 AND #2
- #5 #4 NOT #5

Ovid

- #1 (attitud* OR norm* OR control OR intention* OR planned behavio* OR ajzen).ti.
- #2 (attitud* OR norm* OR control OR intention* OR planned behavio* OR ajzen).ab.
- #3 #1 OR #2
- #4 (((benefit* OR barrier* OR threat* OR seriousness OR susceptibility OR risk*) AND (perceived OR perception*)) OR self-efficacy OR health belief model OR hbm OR rosenstock).ti.
- #5 (((benefit* OR barrier* OR threat* OR seriousness OR susceptibility OR risk*) AND (perceived OR perception*)) OR self-efficacy OR health belief model OR hbm OR rosenstock).ab.
- #6 #4 OR #5
- #7 (((action OR coping OR task) AND (planning OR self-efficacy OR control)) OR intention* OR outcome expectanc* OR risk perception OR self efficacy).ti.
- #8 (((action OR coping OR task) AND (planning OR self-efficacy OR control)) OR intention* OR outcome expectanc* OR risk perception OR self efficacy).ab.
- #9 #7 OR #8
- #10 #3 OR #6 OR #9
- #11 (toothbrushing frequency OR toothbrushing behavio*).ti.
- #12 (toothbrushing frequency OR toothbrushing behavio*).ab.
- #13 #11 OR #12
- #14 (oral health behavio* OR oral hygiene behavio*).ti
- #15 (dental OR oral).ti.
- #16 (dental OR oral).ab.
- #17 #15 OR #16
- #18 brush*.ti.
- #19 brush*.ab.
- #20 #18 OR #19
- #21 frequency.ti.
- #22 frequency.ab.
- #23 #21 OR 22
- #24 #17 AND #20 AND #23
- #25 #13 OR #14 OR #24

- #26 (infant* OR newborn* OR child* OR preschool* OR kinder* OR adolescen* OR elder* OR geriatric OR pensioner OR frail OR rats).ti.
- #27 (infant* OR newborn* OR child* OR preschool* OR kinder* OR adolescen* OR elder* OR geriatric OR pensioner OR frail OR rats).ab.
- #28 #26 OR #27
- #29 #10 AND #25
- #30 #29 NOT #28

EBSCO

- #1 (TI (attitud* OR norm* OR control OR intention* OR "planned behavior*" OR ajzen))
- #2 (AB (attitud* OR norm* OR control OR intention* OR "planned behavior*" OR ajzen))
- #3 #2 OR #3
- #4 (TI (((benefit* OR barrier* OR threat* OR seriousness OR susceptibility OR risk*) AND (perceived OR perception*)) OR "self-efficacy" OR "health belief model" OR hbm OR rosenstock))
- #5 (AB (((benefit* OR barrier* OR threat* OR seriousness OR susceptibility OR risk*) AND (perceived OR perception*)) OR "self-efficacy" OR "health belief model" OR hbm OR rosenstock))
- #6 #4 OR #5
- #7 (TI (((action OR coping OR task) AND (planning OR self-efficacy OR control)) OR intention* OR "outcome expectanc*" OR "risk perception" OR "self efficacy"))
- #8 (AB (((action OR coping OR task) AND (planning OR self-efficacy OR control)) OR intention* OR "outcome expectanc*" OR "risk perception" OR "self efficacy"))
- #9 #7 OR #8
- #10 #3 OR #6 OR #9
- #11 (TI ("toothbrushing frequency" OR "toothbrushing behavior*"))
- #12 (AB ("toothbrushing frequency" OR "toothbrushing behavior*"))
- #13 #11 OR #12
- #14 (TI ("oral health behavior*" OR "oral hygiene behavior*"))
- #15 (TI (dental OR oral))
- #16 (AB (dental OR oral))
- #17 #15 OR #16
- #18 ((TI brush*) OR (AB brush*))
- #19 ((TI frequency) OR (AB frequency))
- #20 #17 AND #18 AND #19
- #21 #13 OR #14 OR #20
- #22 (TI (infant* OR newborn* OR child* OR preschool* OR kinder* OR adolescen* OR elder* OR geriatric OR pensioner OR frail OR rats))
- #23 (AB (infant* OR newborn* OR child* OR preschool* OR kinder* OR adolescen* OR elder* OR geriatric OR pensioner OR frail OR rats))
- #24 #22 OR #23
- #25 #10 AND #21
- #26 #25 NOT #24

Web of Knowledge

- #1 TS=(attitud* OR norm* OR control OR intention* OR "planned behavior*" OR ajzen)
- #2 TS=((benefit* OR barrier* OR threat* OR seriousness OR susceptibility OR risk*) AND (perceived OR perception*)) OR "self-efficacy" OR "health belief model" OR hbm OR rosenstock)

#3 TS=((action OR coping OR task) AND (planning OR self-efficacy OR control)) OR intention* OR "outcome expectanc*" OR "risk perception" OR "self efficacy")

#4 #1 OR #2 OR #3

#5 TS=("toothbrushing frequency" OR "toothbrushing behavio*")

#6 TI=("oral health behavio*" OR "oral hygiene behavio*")

#7 TS=((dental OR oral) AND brush* AND frequency)

#8 #5 OR #6 OR #7

#9 TS=(infant* OR newborn* OR child* OR preschool* OR kinder* OR adolescen* OR elder* OR geriatric OR pensioner OR frail OR rats)

#10 #4 AND #8

#11 #10 NOT #9

Appendix B. Screening instrument for the systematic review.

Screening Tool

A systematic review comparing the ability of three health behaviour models to predict tooth brushing frequency amongst young adults.

Exclude

- Mean age of sample under 18 years, or over 44.
- Reviews, commentaries, or qualitative data articles

Abstract screening

Read *methods* (a YES for toothbrushing **and** psychological constructs = FULL TEXT SCREEN)

- Does it measure **toothbrushing** or self-care oral hygiene behaviour?
- AND
- Does it measure **at least** one of the **psychological** constructs in Figure 1?

If unsure, read *results* section of the abstract.

- Does it clearly state one construct, but the other is a *little* unclear or could be interpreted multiple ways? **FULL TEXT.**
- Is it unclear about *both*? **REJECT.**

Full text (needs to pass all 5 criteria)

- Check the age of the sample - mean age between 18-44.
- Is the psychological construct **defined** and measured **continuously**?
- If using a one question, is it stated the question will deliberately assess the construct?
- Is toothbrushing frequency measured in the sample?
- Is a quantitative comparison offered **between** toothbrushing and a construct in Fig 1?

Figure 1. Psychological Constructs

Remember - these **MUST** be associated with TOOTHBRUSHING. not general, holistic or “overall” oral hygiene/health. The study **MUST** seek to measure them specifically, not just include these words (i.e. attitudes) in the description of another construct or item.

Theory of Planned Behaviour	Health Belief Model	Health Action Process Approach
Subjective / Social Norms	Susceptibility to oral disease	Planning ability
Behavioural Control	Barriers to toothbrushing	Outcome expectancy
Intentions (toothbrushing)	Benefits of toothbrushing	Coping ability
Attitudes (toothbrushing)	Self-Efficacy (toothbrushing)	Seriousness of oral disease

Appendix C. Response themes extracted from interview transcripts.

- Attitudes towards toothbrushing
 - Percieved outcomes of not toothbrushing
 - Short term pain (i.e. sensitivity, bleeding gums)
 - Aesthetic consequences (i.e. visible cavities, discoloured teeth)
 - Long term damage
 - Bad taste or smell
 - Reasons for toothbrushing
 - For own health and benefit
 - To prevent future pain
 - Because it's a social requirement to brush
- Situation-based Influences
 - Feelings after skipping brushing
 - Regret, guilt or worry
 - Concerned about breath and smell
 - Not concerned at all
 - Thoughts that drive coping behaviour
 - Thinking about negative costs
 - Thinking about the rewards of brushing
 - Thinking about duty and responsibilities
 - Initial triggers for coping thoughts
 - General focus on being proactive and responsible
 - Impending social interaction
 - Feeling plaque or food on the teeth
 - Reason for skipping in the morning
 - Early start and eating breakfast on the go
 - Slept in and had a late night before
 - Feeling sick or hungover
 - Feelings during times that morning brushing is skipped
 - Distracted, rushed, unorganized
 - Thinking about eating food soon
 - Feeling sick or unwell
 - Reason for skipping brushing at nighttime
 - Teeth feel okay and not enough energy to brush
 - Had a busy and unusually late night
 - Consumed alcohol and just fell asleep
 - Feeling too relaxed and comfortable to brush
 - Had worked an unusually long day and too tired
 - Feelings that precede nighttime skipping
 - Feeling tired and that brushing requires too much energy
 - Feeling overly relaxed or distracted (i.e. TV, movies)
 - Hectic and focused on other commitments (i.e. working, studying)

- Intentions
 - Biggest focus to align current oral health with ideal oral health
 - Floss and brush more
 - Nothing, but maybe use mouthwash
 - Other (various unique answers given)
- Self-efficacy
 - Percieved barriers to improving own oral health
 - No access to education or better dental devices
 - Too many work and schedule constraints
 - Own level of motivation
 - Introspection on controlling toothbrushing barriers
 - Need willpower to try, and controlling routines takes practice
 - Relaxing makes my level of control much lower
 - I could control barriers, but there is no immediate reward for doing so
 - When I am stressed my level of control is much lower
- Subjective/Social norms
 - Perception of external idealistic pressures
 - I feel that I should brush and floss more in general
 - I feel that I should spend more time and money on my teeth
 - I feel that I should visit the dentist more often
 - Perceieve reactions from dental behaviour influencers (i.e. parents, partner)
 - They will care and comment if I don't maintain my brushing
 - They won't comment, but will be dissapointed
 - They won't really care, but will be angry that I am neglecting my health
 - They probably wouldn't notice my oral health
 - Percieved everyday social pressures regarding teeth
 - Must have clean, fresh-looking teeth
 - You should brush, but it's okay to skip now and then
 - Perception of "normal" toothbrushing routines
 - People brush twice a day and use mouthwash
 - OH isn't really a huge concern, it's normal to skip brushing
 - People generally try to brush at least once per day
 - Brushing isn't really something people care about at all
 - Source of influences on dental behaviour
 - Parents and early school education
 - Orthodontist
 - Girlfriend/boyfriend/wife/husband

Appendix D. Recruiting brochure used for qualitative study.



SEEKING VOLUNTEERS

Let's face it - we probably don't talk about our teeth that often - or perhaps even like talking about them to begin with!

However, understanding dental health habits is an important research topic that allows dental professionals to develop better and more convenient ways for you to look after your teeth.

This is why the Melbourne Dental School is currently looking for young adults to take part in an over-the-phone survey of dental habits. Whether you brush twice a day, or once a week, it doesn't matter - telling us a little about your dental routine can have a big impact in helping research that benefits the prevention of dental disease.

The surveys are 100% confidential and voluntary, have approval from the Melbourne University Human Ethics Committee, and your participation in this **15 minute phone interview** will be rewarded with a free Colgate brushing pack.

To register and take part, simply email the word
TOOTHBRUSH
in the subject heading to
toothbrushsurvey@gmail.com
You will then receive a recruiting email containing further information, and a list of available times for the interview

free brushing pack

Any questions? Contact the student researcher, Mr Adam Rogers, at adam.rogers@unimelb.edu.au. The responsible researchers for this project are Assoc. Prof. Julie Schur - julieg@unimelb.edu.au and Dr Melaine Hoyas - ceo@dhsa.info

Appendix E. Consent form for participation in qualitative study.

Consent Form

Melbourne Dental School



Project: *A qualitative analysis of variability in oral hygiene behaviour amongst young adults*

Primary Researcher: Dr. Melanie Hayes (*responsible researcher, PhD supervisor*)

Additional Researchers: Mr Adam Rogers (*student researcher, PhD candidate*),
Dr. Julie Satur (*co-researcher, PhD supervisor*)

Name of Participant: _____

Email Address: _____

1. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written plain language statement to keep.
2. I understand that the purpose of this research is to investigate possible reasons associated with changes in my oral hygiene routine.
3. I understand that my participation in this project is for research purposes only.
4. I acknowledge that the possible effects of participating in this research project have been explained to my satisfaction.
5. In this project I will be required to participate in a semi-structured 10-15 minute interview that discusses instances of change to my oral hygiene routine, and explores the thoughts, feelings and attitudes I experience at these times.
6. I understand that my interviews may be audio and/or video-taped.
7. I understand that my participation is voluntary and that I am free to withdraw from this project anytime without explanation or prejudice and to withdraw any unprocessed data that I have provided.
8. I understand that the data from this research will be stored at the University of Melbourne and will be destroyed after 5 years.
9. I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements; my data will be password protected and accessible only by the named researchers.
10. I understand that after I sign and return this consent form, it will be retained by the researcher.

Participant Signature: _____ **Date:** _____

Appendix F. Plain language statement for participation in qualitative study.

Plain Language Statement

Melbourne Dental School

Project: *A qualitative analysis of variability in oral hygiene behaviour amongst young adults*

Dr. Melanie Hayes (Responsible Researcher) Tel: +61 3 9341 1535
 Dr Julie Satur (Co-researcher) Tel: +61 3 9341 1530
 Mr. Adam Rogers (PhD Candidate/Student Researcher)

Email: melanie.hayes@unimelb.edu.au
 Email: juliegs@unimelb.edu.au
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Introduction

Thank you for your interest in participating in this research project. The following will provide you with further information about the project so that you can decide if you would like to take part in this research. Please take the time to read this information carefully. You may ask questions about anything you don't understand or want to know more about. Participation is voluntary. If you don't wish to take part, you don't have to. If you begin participating, you can stop at any time.

What is this research about?

This research project aims to explore reasons for change in day-to-day tooth brushing routines.

What will I be asked to do?

Should you agree to participate you will take part in a 25-30min face-to-face or telephone interview. The interview discusses usual tooth brushing routines and explores thoughts, feelings or attitudes that may dictate your tooth brushing habits.

What are the possible benefits?

Participants will be given a tooth brushing pack (toothbrush, floss and toothpaste) as reimbursement for their time. Outcomes will benefit future interventions, policies, research and treatments that seek to improve dental health.

What are the possible risks?

The risks involved in the project are minimal. Discussion with the interviewer about any concerns that do arise, or concerns relating to your teeth is encouraged after the session or via email.

Do I have to take part?

No. Participation is completely voluntary. You can withdraw at any time, but may not be able to withdraw your individual interview information once your data has been processed and your name and details removed.

Will I hear about the results of this project?

The research team will ask for your email address to communicate study results.

What will happen to information about me?

Audio information will be destroyed after being transcribed to a written document with all identifying information removed. Data will be stored for 10 years following completion of the project.

Who is funding this project?

This research project constitutes research for a PhD. The PhD itself is funded partly by both the University of Melbourne and the Dental Hygienists Association of Australia.

Where can I get further information?

If you would like more information about the project, please contact the researchers; Dr. Melanie Hayes: melaine.hayes@unimelb.edu.au, Dr. Julie Satur: juliegs@unimelb.edu.au, or Mr Adam Rogers: adam.rogers@unimelb.edu.au

Who can I contact if I have any concerns about the project?

This research project has been approved by the Human Research Ethics Committee of The University of Melbourne. If you have any concerns or complaints about the conduct of this research project, which you do not wish to discuss with the research team, you should contact the Manager, Human Research Ethics, Office for Research Ethics and Integrity, University of Melbourne, VIC 3010. Tel: +61 3 8344 2073 or Email: HumanEthics-complaints@unimelb.edu.au. All complaints will be treated confidentially. In any correspondence please provide the name of the research team or the name or ethics ID number of the research project.