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ORIGINAL ARTICLE

Promoting regular parental supervised toothbrushing: An additive intervention design adopting the Health Action Process Approach

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Abstract

The study aimed to test the efficacy of the core elements of the Health Action Process Approach (HAPA) in an intervention among parents to promote regular supervised toothbrushing of preschool-aged children. The pre-registered study (https://osf.io/fyzh3/) tested the effects of an intervention employing information provision, behavioural instruction, implementation intention and mental imagery techniques, adopting a randomised controlled design in a sample of Australian parents of preschoolers ($N = 254$). The intervention used an additive design with four conditions—education, self-efficacy, planning and action control—progressively layered to show the cumulative impact of incorporating self-efficacy, planning and action control strategies with a foundational education component. The intervention was delivered online, and participants completed self-report measures of parental supervised toothbrushing and HAPA-based social cognition constructs pre-intervention and 4 weeks post-intervention. Although no significant intervention effects on behaviour were observed, mixed-model analyses of variance (ANOVAs) revealed an increase in intention and task self-efficacy within the action control condition and an increase in action planning in both the action control and planning conditions from pre-intervention to follow-up. Despite no anticipated changes in behaviour, these findings endorse the use of theory- and evidence-based behaviour change strategies to inspire change in HAPA-based determinants of parental supervised toothbrushing: intention, action planning and task self-efficacy.

KEYWORDS

HAPA, implementation intentions, mental imagery, parental supervised toothbrushing, preschoolers

INTRODUCTION

Early childhood caries is the most prevalent preventable chronic disease in childhood and a key public health challenge affecting preschoolers worldwide (Australian Institute of Health and Welfare, 2020; K. J. Chen et al., 2019; El Tantawi et al., 2018). Despite being a highly preventable disease, a recent meta-analysis estimates that almost half of preschool-aged children worldwide have experienced dental caries (Uribe et al., 2021). Preventive intervention through the manual removal of dental biofilm (i.e. toothbrushing) is the most common and effective means of self-care for maintaining good oral health (Van Der Weijden & Slot, 2011; World Health Organization, 2018). For young children, parents are recommended to perform twice-daily parental supervised toothbrushing using fluoride toothpaste until children are at least 5 years of age (Australian Institute of Health and Welfare, 2012; Do, 2020).

The development of oral hygiene habits is heavily influenced by parental involvement (Blinkhorn et al., 2001; Hamilton et al., 2018; Hariyani et al., 2020; Mohebbi et al., 2008), with the preschool years offering a crucial period for building and establishing lifelong good oral hygiene behaviours. It is important to establish and pass on regular toothbrushing habits from parent to child during the preschool years to prevent the onset of early childhood caries before the eruption of permanent dentition. Parents generally report high levels of motivation to act in the best interests of their children's health and safety, including their oral health (Hagger, Keech, & Hamilton, 2020; Smith et al., 2021; Spinks & Hamilton, 2015). However, research has well documented that intentions do not reliably predict behaviour, and people often fail to act upon even their best intentions (Hagger & Chatzisarantis, 2009; McEachan et al., 2011; Sheeran & Webb, 2016; C.-Q. Zhang et al., 2019). Furthermore, the high prevalence of dental caries experience in young children worldwide (Kassebaum et al., 2015; Uribe et al., 2021), along with recent self-report evidence (Royal Children's Hospital Melbourne, 2018), indicates that parents are not meeting the recommended preventive behavioural guidelines of twice-daily parental supervised toothbrushing for their preschool-aged children to prevent the development of early childhood caries.

Common barriers preventing parents from acting on their intentions to perform twice-daily supervised toothbrushing often include perceived beliefs of being too tired, too busy, forgetting or having an uncooperative child (Berzinski et al., 2020; Marshman et al., 2016). To promote the translation of oral hygiene intentions into behaviour, research has identified the importance of constructs that underpin motivational and self-regulatory processes such as attitude, self-efficacy, planning and action control (Gholami et al., 2015; Hamilton et al., 2018; Smith et al., 2021; Zhou et al., 2014). These findings, along with recent meta-analytic evidence (Hamilton et al., 2020), indicate that self-regulatory skills may be necessary for equipping parents with the means to overcome barriers that interfere with their ability to follow-through on their intentions to perform regular parental supervised toothbrushing. In recent studies (Hamilton et al., 2018; Hariyani et al., 2020; Smith et al., 2020, 2021), the importance of theory-based interventions to enhance parental involvement in promoting their young children's oral hygiene behaviour has been emphasised. Furthermore, a recent systematic review examining home-based toothbrushing interventions for parents of young children noted a significant absence of theoretical foundations among the interventions included in the review (Aliakbari et al., 2021).

A HAPA-based intervention promoting parental supervised toothbrushing

The Health Action Process Approach (HAPA) (Schwarzer, 2008) is a dual-phase theoretical framework that distinguishes between motivational and volitional phases of behavioural enactment and has been applied to predict multiple health behaviours (Schwarzer & Hamilton, 2020). In the motivational phase of the model, intention is posited as a primary predictor of behaviour, with outcome expectancies (i.e. beliefs that the target behaviour will lead to outcomes that have utility for the individual and conceptually similar to *attitudes* towards a behaviour) and task self-efficacy (i.e. beliefs in one's capacity to successfully perform a behaviour and overcome challenges and barriers to its performance) both positioned as factors influencing intention. Informed by a recent meta-analysis (Smith et al., 2020) that identified ‘attitudes’ as a significant correlate of parental supervised toothbrushing and recognising the importance of emotional and value-driven components within attitudes, the present study chose to target ‘attitudes’ to preserve the theoretical integrity of the HAPA model while streamlining the research process. It is common for researchers to measure ‘attitudes’ as a surrogate for ‘outcome expectancies’ due to substantial conceptual overlap between the constructs (e.g. Hamilton et al., 2020; Smith et al., 2021).

The HAPA also posits risk perception (i.e. belief in the severity of a health condition that may arise from not performing the target behaviour and personal vulnerability towards it) as a direct predictor of intention. For instance, risk perceptions related to severe complications from illnesses have clear, explicit and proximal links to behaviours that reduce risks (e.g. vaccination). However, risk perception has been shown to yield smaller effects on intention and, indirectly, on behaviour compared with the beliefs that relate to engaging in behaviour itself, such as attitude and task self-efficacy (Schwarzer & Hamilton, 2020; C.-Q. Zhang et al., 2019). Furthermore, in the context of parental supervised toothbrushing, risk perceptions do not have a clear, explicit and proximal link to reduced risk and are not pertinent to an ‘at-risk’ population. Risk perceptions were, therefore, not expected to have a pervasive influence on parents' behaviour and were not targeted in the present study. In the volitional phase of the HAPA, planning (e.g. action and coping planning) and action control (i.e. monitoring and evaluation of a behaviour against a desired behavioural standard) are important self-regulatory strategies, with planning linking behavioural intention to subsequent behavioural enactment and action control as an important direct determinant of behaviour.

Previous research supports the application of the HAPA to preventive health behaviours, with prominent roles for outcome expectancies, self-efficacy, planning and action control (Schwarzer & Hamilton, 2020; C.-Q. Zhang et al., 2019). Moreover, recent meta-analytic and prospective correlational research demonstrates that outcome expectancies, self-efficacy, planning and action control are effective in predicting parental supervised toothbrushing (Smith et al., 2020, 2021). The HAPA, therefore, can be used as the basis for developing effective behaviour change interventions, with research demonstrating that intervention strategies or techniques targeting its key motivational and volitional constructs can result in behaviour change (Schwarzer & Hamilton, 2020). Building on this research, the current study aimed to test the efficacy of the core elements of the HAPA (i.e. outcome expectancies, self-efficacy, planning and action control) to promote regular parental supervised toothbrushing among parents of preschool-aged children.

The intervention adopts evidence-based behaviour change strategies proposed to affect change in the targeted determinants (Hagger, Cameron, et al., 2020). Specifically, the intervention adopts strategies of information provision, behavioural instruction, implementation intentions and mental imagery, which target change in the attitude (aka outcomes expectancies), task self-efficacy, action and coping planning, and action control constructs from the HAPA (Conroy & Hagger, 2018; Hagger et al., 2012; Hamilton & Johnson, 2020; Knäuper et al., 2009, 2011; Koka & Hagger, 2017; Schwarzer et al., 2015). Behavioural instruction aimed to increase self-efficacy towards the targeted behaviour by providing clarity on what the behaviour was, why it was important and how it could be executed; it had previously shown success in promoting self-efficacy towards oral self-care (Schwarzer et al., 2015; Warner & French, 2020). To complement this, we employed implementation intentions in an 'if–then' format, which has been proven to bridge the gap between intentions and actions, particularly in populations high in motivation but struggling with behaviour change (Gollwitzer & Sheeran, 2006). The mental imagery technique, informed by best practice techniques and previous intervention research (Conroy & Hagger, 2018; Hagger & Conroy, 2020; Smith et al., 2022), involved mentally representing and rehearsing future actions and was tailored in this study to target action control in the context of participants' adoption of a behavioural self-monitoring strategy. Both implementation intentions and mental imagery techniques were valuable in fostering self-initiated behaviour change and offered low-cost and low-burden alternatives to traditional person-to-person or practitioner-led interventions (Knittle et al., 2020).

The present study

The present pre-registered study aimed to test the efficacy of the core elements of the HAPA (i.e. outcome expectancies, self-efficacy, planning and action control) to promote regular parental supervised toothbrushing among parents of preschool-aged children. The intervention adopted a four-group randomised controlled design, with intervention materials delivered online using resources that can easily be implemented in real-world settings. The randomised controlled trial used an additive design in which parents of preschool-aged children were randomly assigned to an active control (education) arm or one of the three experimental arms (the self-efficacy and education condition [self-efficacy+]; the planning, self-efficacy and education condition [planning+]; or the action control, planning, self-efficacy and education group [action control+]). By using an additive design, we aimed to test whether the additional treatment components present in the experimental treatment arms provide greater benefit, compared with the components that are held constant across the control and intervention arms (e.g. testing the full package of HAPA-based intervention components against components just targeting self-efficacy and planning, or self-efficacy alone). The intervention was embedded in an online survey administered to a cohort of Australian parents of preschoolers recruited from an online survey panel. The study provided all participants with educational information, and then participants in the experimental arms were guided through some or all of the self-enacted exercises designed to target change in the HAPA constructs.

We hypothesised that parental supervised toothbrushing would increase across baseline (T1) and the 4-week follow-up post-intervention (T2) for the three experimental arms: self-efficacy+ condition (H1), planning+ condition (H2) and action control+ condition (H3) compared with the active control condition. It was further expected that the action control+ condition relative to all other groups would have greater increases in parental supervised toothbrushing across baseline (T1) and the 4-week follow-up post-intervention (T2) (H4). In addition, we pre-registered exploratory analyses investigating intervention effects on the targeted secondary outcomes: intention, attitude, task self-efficacy, action planning and action control towards parental supervised toothbrushing.

METHODS

Participants

Participants were Australian parents and caregivers of preschoolers ($N = 252$, 72.6% women) ranging in age from 18 to 70 years (M = 35, $SD = 7.49$). Participants were eligible for recruitment if they lived in Australia, were aged 18 years or older and were the parent or caregiver of at least one 2–5-year-old child who usually resides in the same household as them. See the online repository for an overview of participant demographic characteristics: https://osf.io/e8chn.

Participants were recruited using a research panel provider, *KANTAR*. An a priori statistical power analysis was conducted using G*Power v3.1 for a mixed-model analysis of variance (ANOVA) estimating fixed effects, main effects and interactions for the two key independent variables: intervention condition and time. The effect size was set to detect a small effect ($f = .18$), based on previous research on effectiveness of imagery interventions (Conroy & Hagger, 2018), with power and alpha set at .95 and .01, respectively, adjusted to protect from inflation of type I error rate due to multiple tests. The analysis returned a minimum required sample size of $N = 184$ (46 participants in each condition). To allow for 40% attrition, the target sample size of up to 300 participants at the baseline was set. As a pre-specified stopping rule, online recruitment ceased once 300 participants had completed the baseline (Time 1 [T1]) survey. However, a less conservative a priori power analysis with power set at .80 was performed after pre-registration and before recruitment due to practical constraints including resource limitations due to the COVID-19 pandemic. The revised power estimation indicated a minimum required sample size of $N = 148$. As such, to allow for 40% attrition, we were satisfied to stop T1 recruitment once 250 participants had completed baseline.

Design and procedure

The study was pre-registered prior to data collection on the Open Science Framework: https://osf.io/fyzh3/. The University Human Research Ethics Committee approved the study (reference: 2019/852). The study has been reported in accordance with the CONSORT 2010 checklist for reporting randomised trials (Schulz et al., 2010). Data were collected between 5 March and 8 April 2021. Participants completed the online study over two online data collection sessions, 4 weeks apart. In Session 1, participants received study information and provided informed consent and then completed baseline measures of study variables followed by the intervention content of the condition to which they were assigned. In Session 2, participants completed T2 measures of all study variables. See Figure 1 for the CONSORT 2010 flow diagram of the intervention. The study adopted a double-blind parallel four-condition mixed (within–between) randomised controlled design. Participants were randomly assigned to one of the four additive study arms: the active control (education-only) condition or one of the three experimental arms (the self-efficacy and education [self-efficacy+] condition; the planning, self-efficacy and education [planning+] condition; or the action control, planning, self-efficacy and education [action control+] condition). Participants were not made aware of the condition to which they were assigned. The research team had no contact with intervention participants, and the research panel provider responsible for contacting participants was not made aware of the intervention conditions. A table summarising the additive design is available in Supporting Information S1 and in the online repository, and further details of the study design and procedure are available in the study pre-registration document: https://osf.io/e8chn.

Simple randomisation was used to allocate participants to one of the four study conditions. The randomisation was conducted by the Qualtrics randomisation feature following completion of the pre-intervention survey. The Qualtrics randomisation feature uses a Mersenne Twister pseudorandom number generator that is seeded using a Unix timestamp (in milliseconds).

HAPA-based intervention development and optimisation

The intervention content was informed by best practice techniques for mental imagery interventions (Conroy & Hagger, 2018; Hagger & Conroy, 2020; Hamilton et al., 2021) and based on examples and mechanisms identified in prior research investigating mental imagery intervention techniques for behaviour promotion (Hagger et al., 2011; Hamilton et al., 2021; Knäuper et al., 2011). The intervention was presented to participants as a slideshow displayed on their screens. Participants were instructed to read a series of slides that provided information and instructions for self-enacted parental supervised toothbrushing exercises. They had the ability to manually advance through the slides. A timer was used on all slides containing intervention stimuli to prevent participants advancing through the information and activities too quickly without fully engaging in the content. The intervention utilised a range of behaviour change techniques that were aligned with the targeted HAPA constructs in the trial (Kok et al., 2016). The content and procedure of the four intervention components are outlined below. A summary of the behaviour change techniques aligned with the HAPA theoretical constructs is available in Supporting Information S2, and materials for each of the intervention components are available in the online repository: https://osf.io/e8chn (i.e. 'Intervention Slideshow').

Part 1: Educational component

Participants in the education-only condition (i.e. active control condition) were presented only with the educational component of the intervention. For the educational component,

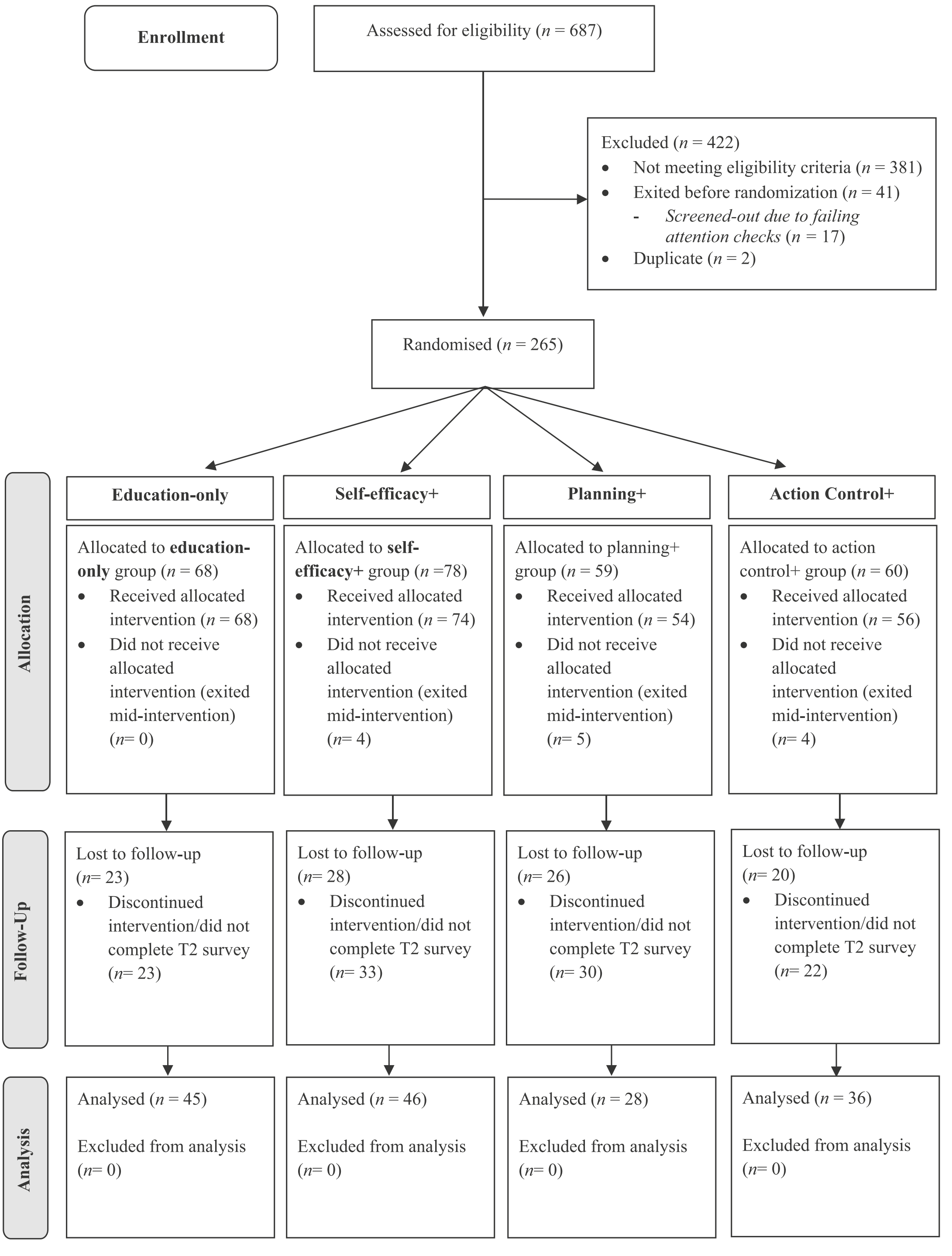

FIGURE 1 CONSORT 2010 flow diagram.

participants were presented with an infographic from the Australian Dental Association that contained general information and guidelines for caring for the oral health of preschool-aged children (e.g. parents should supervise their children's toothbrushing, teeth should be brushed twice daily and a soft child's brush with a paediatric toothpaste [500–550 ppm of fluoride] should be used). After reviewing the educational guidelines, participants completed a single-item measure of goal intention, where they were presented with the statement 'I am willing to form a goal to supervise my child's toothbrushing 2 times each day for the next 4 weeks', with responses recorded on a 7-point scale (1 = *strongly disagree* to 7 = *strongly agree*). Information provision about the importance of engaging in a target behaviour (e.g. providing information about health consequences and highlighting the pros over the cons of a particular course of action, using credible sources) targets behaviour change by promoting positive attitudes towards the behaviour (Hamilton & Johnson, 2020).

Part 2: Self-efficacy component

In addition to the educational component of the intervention, participants assigned to the self-efficacy+ condition were also presented with a series of slides containing step-by-step instructions on how to correctly supervise their young child's toothbrushing behaviour. Behavioural instruction techniques target behaviour change by increasing task self-efficacy towards performing the behaviour in future and involve providing information about what a behaviour is, why it is done and how it is done (Warner & French, 2020). Behavioural instruction has shown to be a successful technique for increasing self-efficacy towards oral self-care (Schwarzer et al., 2015). Following the behavioural instruction, participants were also presented with the testimonials of three parents of preschool-aged children. The testimonials comprised brief narratives describing parents having successfully implemented regular supervision of their preschooler's toothbrushing. Testimonials were presented as a quote from the person, accompanied by their image, first name, city of residence and age of child.

Part 3: Planning component

In addition to the educational and self-efficacy components of the intervention, participants assigned to the planning+ condition also completed action planning and coping planning exercises. Action planning was targeted via the formation of action plans, where parents recorded when, where and before/after which regular activity they would perform parental supervised toothbrushing (e.g. 'I will supervise my child's toothbrushing every morning in the downstairs bathroom, right after breakfast'), with separate plans recorded for mornings and evenings. After recording their action plans, participants performed an implementation intentions exercise where they were instructed to generate up to three coping plans in relation to supervising their child's toothbrushing in the next 4 weeks using an 'If–then' format, where the 'If' statement is the identified barrier to performing the behaviour and the 'Then' statement is the planned action to overcome this barrier. For example, a participant might have come up with: (e.g. '*If* … my child is resisting having their teeth brushed, *Then I will* … play a toothbrushing song to make it a fun activity'). Evidence shows that implementation intentions are effective at promoting enactment of intended behaviours beyond mere formation of a goal intention (Gollwitzer & Sheeran, 2006), which has particular relevance in a population with high motivation but has difficulty translating intentions to behaviour. Furthermore, the adoption of imagery and implementation intention techniques together has been shown to promote behaviour change in previous intervention studies (Hagger et al., 2012; Knäuper et al., 2009, 2011; Koka & Hagger, 2017).

Part 4: Action control component

In addition to the educational, self-efficacy and planning components of the intervention, participants assigned to the action control+ condition were also guided through a mental imagery exercise targeting the implementation and maintenance of a parental supervised toothbrushing self-monitoring strategy. Mental imagery techniques target change in behaviour by promoting positive attitudes and increasing self-efficacy towards performing the behaviour in the future, and it involves individuals mentally representing and rehearsing future actions and consequences (Conroy & Hagger, 2018; Kavanagh et al., 2005; Pham & Taylor, 1999). In the present study, the mental imagery technique has been tailored to target action control, in addition to attitudes and task self-efficacy, by guiding participants through mental representation and rehearsal of implementing and utilising a self-monitoring strategy. Meta-analytic evidence supports the effectiveness of these imagery techniques on behaviours and social-cognitive constructs (Conroy & Hagger, 2018). Furthermore, implementation intentions and mental imagery intervention techniques promote self-initiated behaviour change. Low-cost and low-burden strategies such as these can overcome the need for person-to-person contact or expensive practitioner-delivered interventions (Knittle et al., 2020). Therefore, the decision to have participants select a preferred behavioural self-monitoring strategy was guided by the aim to develop an effective intervention that requires minimal person-to-person contact and uses minimal resources, while also being tailored to the individual. A process mental imagery task was used in conjunction with instructing participants to select and then implement a preferred self-monitoring strategy to bolster implementation and adherence of the chosen self-monitoring strategy in a format that also requires minimal direct contact and resources.

First, participants were instructed to think of a strategy they would use to monitor themselves supervising their child's twice-daily toothbrushing for the next 4 weeks. Participants were advised that the choice of strategy was their own, with some example strategies also provided for inspiration (e.g. using a toothbrushing chart and setting smartphone reminders). Once a preferred self-monitoring strategy was decided upon, participants recorded their strategy in a text entry box and then completed a single-item measure of goal intention where they were presented with the statement ‘I am willing to form a goal to implement my strategy to monitor myself supervising my child's toothbrushing 2 times each day for the next 4 weeks’, with responses recorded on a 7-point scale (1 = *strongly disagree* to 7 = *strongly agree*). Following this, participants were directed to engage in a mental imagery task, dedicating several minutes to vividly envisage the implementation of their preselected self-monitoring strategy. They were encouraged to conjure a detailed and consistent mental representation of themselves utilising this strategy over the forthcoming 4-week period to monitor supervising their child's toothbrushing routine. Subsequent to the mental imagery exercise, participants were asked to document a succinct synopsis of the imagery they conceived during the task in a designated text entry box. This provided a reflective account of their mental rehearsal, further reinforcing their commitment to the planned behavioural strategy.

Treatment fidelity

As explained by Borrelli (2011), treatment fidelity encompasses three main components: fidelity of treatment delivery (e.g. adherence to the intervention protocol and consistent use of the planned intervention techniques), fidelity of treatment receipt (e.g. participant comprehension of the intervention content and recall of the instructional information) and fidelity of treatment enactment (e.g. accurate application of the learned strategies or skills within the intervention context). In the current study, we assessed treatment fidelity across these three dimensions.

To improve treatment delivery, we used a timer function on slides to prevent participants from proceeding to the next slide until sufficient time had passed to read the information and instructions on the slides, with longer timers embedded on pages of the study directing the performance of the mental imagery exercises. Forced responding was also used to monitor treatment delivery, where participants were not permitted to proceed to the next page of the survey without responding to the open-ended questions, or the imagery fidelity measures.

To assess treatment receipt, several open-ended responses were recorded throughout the intervention to verify understanding of the information and adherence to the instructions provided. For the planning component, participants recorded their action plans and coping plans in an open text box during the intervention. Prior to the process mental imagery exercise, participants described their preferred strategy to monitor themselves supervising their child's twice-daily toothbrushing for the next 4 weeks (e.g. 'put toothbrushing chart in the bathroom and mark it off each morning and night'). After the process mental imagery exercise, participants were asked to write a few sentences summarising their process imagery (e.g. 'I'm going to print the brushing chart and hang it on the bathroom mirror, with a marker to tick the box when teeth are done each time'). All qualitative responses were coded as 'related' or 'unrelated' based on whether the responses provided were each relevant to their respective activities and instructions. Of the responses from the $n = 110$ participants in a condition that received the planning intervention, one evening action plan and one morning action plan, and six open-ended responses for the coping plans, were coded as unrelated. Of the $n = 56$ participants in a condition that received the action control intervention, two responses describing the preferred self-monitoring strategy and three of the open-ended responses summarising the process mental imagery were coded as unrelated.

To assess treatment enactment, we included a measure of 'imagery fidelity' directly after the process imagery exercise to ensure participants were actively implementing the process imagery techniques as instructed and not just passively receiving the intervention. We assessed imagery fidelity using a four-item scale modified from Knäuper et al. (2011). The four items assess vividness (e.g. 'How VIVID was the mental image that you had of the process of monitoring yourself supervising your child's toothbrushing 2 times each day for the next 4 weeks?'; 1 = *not at all vivid* to 7 = *very vivid*), clarity (e.g. 'How CLEAR was the mental image that you had of the process of monitoring yourself supervising your child's toothbrushing 2 times each day for the next 4 weeks?'; 1 = *not at all clear* to 7 = *very clear*), detail (e.g. 'How DETAILED was the mental image that you had of the process of monitoring yourself supervising your child's toothbrushing 2 times each day for the next 4 weeks?'; 1 = *not at all vivid* to 7 = *very vivid*) and ease of imagery ('How EASY or DIFFICULT was it for you to create these images?'; 1 = *extremely difficult* to 7 = *extremely easy*). High mean imagery fidelity scores were observed for the process imagery exercise ($M = 5.50$, $SD = 0.94$).

Measures

Study measures were carried out on multi-item psychometric instruments developed using published guidelines and adapted for use with the target behaviour in the current study

(Schwarzer, 2008). All measures were assessed at baseline (T1) and at the 4-week follow-up (T2). All items were rated on a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*), unless otherwise specified. See the online repository for full measures and their reliability in the present study: https://osf.io/e8chn.

Behaviour

To measure regular parental supervised toothbrushing, participants were first presented with the following information: 'Regular supervision of your child's toothbrushing means (a) brushing your child's teeth for them; or assisting, observing, and advising your child as they brush their own teeth, and (b) performing this behavior 2 times every day.' Participants then responded to two questions: (1) 'In the past 4 weeks, how often did you supervise your child's toothbrushing?' measured on a 7-point Likert scale (1 = *never* to 7 = *always*); (2) 'In the past 4 weeks I have regularly supervised my child's toothbrushing' measured on a 7-point Likert scale (1 = *false* to 7 = *true*).

HAPA constructs

Three items measured intention to engage in the target behaviour in the next 4 weeks (e.g. 'It is likely that I will supervise my child's toothbrushing'); four items measured task self-efficacy with respect to engaging in the target behaviour for the next 4 weeks (e.g. 'I am confident that I can start regularly supervising my child's toothbrushing immediately, even if I have to force myself to start right now'); attitude towards engaging in the target behaviour in the next week was measured in response to the common stem: 'Supervising my child's toothbrushing in the next 4 weeks would be …' with responses provided on three 7-point semantic differential scales (1 = *unpleasant* to 7 = *pleasant*; 1 = *bad* to 7 = *good*; 1 = *worthless* to 7 = *valuable*); four items measured action planning with respect to engaging in the target behaviour in the next 4 weeks (e.g. 'I have made a plan for when to supervise my child's toothbrushing'); and three items measured action control with respect to engaging in the target behaviour in the next 4 weeks (e.g. 'I have consistently monitored when, how often, and how to supervise my child's toothbrushing').

Baseline participant characteristics

Demographic information such as gender, age, number of young children, ethnicity, education, employment status and annual household income was measured at baseline. See the online repository for detailed information about participant demographic characteristics overall and per condition: https://osf.io/e8chn.

Imagery ability

Imagery ability was measured using a 10-item scale drawn from the International Personality Item Pool (IPIP) (Goldberg, 1999) and designed to measure Factor V (Intellect and Imagination) of Goldberg's Big-Five Factor Markers (Goldberg, 1992). Responses were provided on 5-point scales (1 = *very inaccurate* to 5 = *very accurate*). For example, 'Typically, I … have a vivid imagination'.

Data quality

Two questions were embedded within the T1 survey to assess attentive responding (Maniaci & Rogge, 2014). The questions instruct the choice of a particular answer so that it is not possible to answer the question incorrectly if the item is read carefully (e.g. 'Please select option "disagree" to ensure you are paying attention') (Maniaci & Rogge, 2014). Participants who did not answer both questions correctly at baseline were screened out of the survey. Goldammer et al. (2020) suggest that checks of this type should be used to guard against inflated item variances, biased item means towards scale midpoints and increased residual variances of construct indicators that occur due to careless responding. In addition, a challenge-response 'CAPTCHA' was also embedded at the beginning of the online survey to distinguish between genuine human users and automated computer programs.

Data analysis

According to our pre-registered data analysis protocol, we planned to evaluate the effect of the intervention on parental supervised toothbrushing using a 4 × 2 mixed-model ANOVA. In the analysis, parental supervised toothbrushing was the dependent variable, with condition (education-only vs. self-efficacy+ vs. planning+ vs. action control+) as the between-participants independent variable and time (baseline [T1] vs. 4-week follow-up [T2]) as the within-participants independent variable. Alpha level for inference was adjusted to .01 to protect from inflation of type I error rate due to multiple tests. Pre-registered exploratory analyses for the effect of the intervention on the social cognition constructs (i.e. task self-efficacy, intention, action planning, action control and attitude) were also carried out using a series of 4 × 2 mixed-model ANOVAs with identical design. However, $\alpha = .05$ was used as the threshold for statistical significance for exploratory analyses on secondary outcomes. Where an ANOVA indicated a significant Time × Condition interaction for any of the outcome variables, simple effects analyses using estimated marginal means were examined for that outcome.

To assess differences between participants lost to follow-up and those retained in the trial, a one-way multivariate ANOVA (MANOVA) was performed with attrition status (dropouts vs. completers) as the independent variable and baseline behaviour and social cognition factors as the dependent variables (i.e. behaviour, intention, task self-efficacy, attitude, action planning and action control). Results indicated no significant differences between dropouts ($n = 97$) and completers ($n = 155$) on baseline behaviour and social cognition factors, $F(8,243) = 0.54$, $p = .827$, $\eta_p^2 = .017$. Dropouts and completers were also compared on demographic characteristics, revealing significant differences between the groups on age and income. Participants retained in the trial were older and generally reported higher annual household income than those who were lost to follow-up. Participants' demographic characteristics by attrition status and results of attrition analyses are available online: https://osf.io/e8chn.

As per the pre-registration, missing data were imputed using the expectation–maximisation (E–M) algorithm, which was carried out separately per randomised group (Sullivan et al., 2018).

This approach was deemed appropriate given missing data did not exceed 40% (Jakobsen et al., 2017), and Little's (1988) test indicated that missingness could be assumed to have occurred completely at random. Finally, most variables in the analyses showed significant negative skewness and kurtosis, and data transformations were performed to correct the significant departures from normality, as per the pre-registration. The transformations failed to correct the significant negative skewness and kurtosis; thus, the untransformed variables were analysed.

RESULTS

Pre-registered analyses

Estimated marginal means, standard errors and 99% confidence intervals of study variables by time and condition are reported in Table 1. Line graphs depicting the results of the ANOVAs are available in Supporting Information S3, and data and output files of the analyses are available in the online repository: https://osf.io/e8chn.

Behaviour

Contrary to predictions, we found no statistically significant Time × Condition interaction effect on parental supervised toothbrushing, $F(3,248) = 1.19$, $p = .313$, $\eta_p^2 = .005$. Similarly, we observed no significant main effects of time, $F(1,248) = 1.23$, $p = .269$, $\eta_p^2 = .005$, or condition, $F(3,248) = 1.13$, $p = .336$, $\eta_p^2 = .014$.

Secondary outcomes

We found a significant main effect of time on intention, $F(1,248) = 10.91$, $p = .001$, $\eta_p^2 = .042$, where a general increase of intention from T1 (M = 5.84, *SD* = 1.03) to T2 (M = 6.01, *SD* = 1.11) was observed. This main effect of time was qualified by a significant Time × Condition interaction effect on intention, $F(3,248) = 3.89$, $p = .010$, $\eta_p^2 = .045$. Simple effects analyses indicated an effect of time on intention for participants assigned to the action control+ condition, $F(1,248) = 16.80$, $p < .001$, $\eta_p^2 = .063$. Pairwise comparisons indicated higher levels of intention at T2 (M = 6.13, *SD* = 0.95) compared with T1 (M = 5.86, *SD* = 1.03) for participants allocated to the action control+ condition ($p < .001$, $d = 0.27$). A significant change to intention over time was not observed for the other conditions.

We found a significant main effect of time on action planning, $F(1,248) = 15.396$, $p < .001$, $\eta_p^2 = .058$, where a general increase of action planning from T1 (M = 5.34, *SD* = 1.24) to T2 (M = 5.64, *SD* = 1.21) was observed. This main effect was qualified by a significant Time × Condition interaction effect on action planning, $F(3,248) = 3.18$, $p = .024$, $\eta_p^2 = .037$. Simple effects analyses indicated an effect of time on action planning for participants assigned to the planning+ condition, $F(1,248) = 5.22$, $p = .023$, $\eta_p^2 = .021$, and the action control+ condition, $F(1,248) = 16.45$, $p < .001$, $\eta_p^2 = .062$. Pairwise comparisons indicated higher levels of action planning at T2 (M = 5.63, *SD* = 1.34) compared with T1 (M = 5.22, *SD* = 1.16) for participants allocated to the planning+ condition ($p = .023$, $d = 0.33$) and higher levels of action planning at T2 (M = 5.82, *SD* = 0.95) compared with T1 (M = 5.10, *SD* = 1.49) for participants

TABLE 1 Estimated marginal means, standard errors and confidence intervals of study variables by time and condition ($N = 252$).

	Baseline											
	Education-only ($n = 68$)			Self-efficacy+ ($n = 74$)			Planning+ ($n = 54$)			Action control+ ($n = 56$)		
	M	*SE*	99% CI	M	*SE*	99% CI	M	*SE*	99% CI	M	*SE*	99% CI
Behaviour	6.27	.13	5.93, 6.60	6.01	.12	5.68, 6.33	6.06	.15	5.68, 6.44	5.91	.14	5.54, 6.29
Intention	6.00	.13	5.75, 6.24	5.90	.12	5.66, 6.13	5.81	.14	5.54, 6.09	5.73	.14	5.45, 6.00
Task self-efficacy	5.88	.12	5.64, 6.13	5.82	.12	5.59, 6.05	5.74	.14	5.47, 6.01	5.62	.14	5.35, 5.89
Attitude	6.17	.12	5.92, 6.41	5.93	.12	5.70, 6.17	6.09	.14	5.81, 6.36	5.98	.14	5.71, 6.25
Action planning	5.50	.15	5.21, 5.80	5.46	.14	5.18, 5.74	5.22	.17	4.88, 5.55	5.10	.17	4.78, 5.43
Action control	5.43	.13	5.17, 5.69	5.44	.13	5.19, 5.69	5.32	.15	5.03, 5.62	5.40	.15	5.10, 5.69

Abbreviation: CI, confidence interval.

TABLE 1 (Continued)

	4-week follow-up											
	Education-only ($n = 68$)			Self-efficacy+ ($n = 74$)			Planning+ ($n = 54$)			Action control+ ($n = 56$)		
	M	*SE*	99% CI	M	*SE*	99% CI	M	*SE*	99% CI	M	*SE*	99% CI
Behaviour	6.19	.15	5.79, 6.59	6.03	.15	5.65, 6.41	6.36	.17	5.92, 6.81	5.98	.17	5.55, 6.42
Intention	6.04	.14	5.77, 6.31	5.89	.13	5.63, 6.14	6.04	.15	5.74, 6.34	6.13	.15	5.83, 6.42
Task self-efficacy	5.90	.13	5.63, 6.16	5.85	.13	5.60, 6.11	5.75	.15	5.45, 6.04	5.98	.15	5.69, 6.27
Attitude	6.18	.11	5.95, 6.40	5.98	.11	5.76, 6.20	5.97	.13	5.72, 6.22	5.91	.13	5.67, 6.13
Action planning	5.54	.15	5.25, 5.83	5.61	.14	5.34, 5.89	5.63	.17	5.30, 5.95	5.82	.16	5.50, 6.14
Action control	5.47	.15	5.18, 5.76	5.51	.14	5.23, 5.80	5.44	.17	5.11, 5.77	5.62	.16	5.29, 5.94

Abbreviation: CI, confidence interval.

allocated to the action control+ condition ($p < .001$, $d = 0.58$). A significant change to action planning over time was not observed for the education-only or self-efficacy+ conditions.

No significant main or interaction effects for time and condition on measures of attitude or action control were observed. However, it should be noted that we observed effects of the intervention on task self-efficacy, which failed to reach the conventional levels of statistical significance by a trivial margin. For example, we observed a main effect of time on task self-efficacy, $F(1,248) = 3.61$, $p = .059$, $\eta_p^2 = .014$, where a general increase of task self-efficacy from T1 (M = 5.75, $SD = 1.03$) to T2 (M = 5.87, $SD = 1.12$) was observed. This main effect was qualified by a Time × Condition interaction, $F(3,248) = 2.51$, $p = .059$, $\eta_p^2 = .029$. Simple effects analyses indicated an effect of time on task self-efficacy for participants assigned to the planning+ condition, $F(1,248) = 10.50$, $p = .001$, $\eta_p^2 = .041$. Pairwise comparisons indicated higher levels of task self-efficacy at T2 (M = 5.98, $SD = 0.82$) compared with T1 (M = 5.75, $SD = 1.03$) for participants allocated to the action control+ condition ($p = .001$, $d = 0.25$). Effects of time on task self-efficacy were not observed for the other conditions.

DISCUSSION

This pre-registered intervention aimed to test the efficacy of the core elements of the HAPA to promote regular parental supervised toothbrushing among parents of preschool-aged children. The intervention adopted an additive design employing behavioural instruction, implementation intentions and mental imagery techniques aimed to change behaviour compared with an active control condition that only received general guidelines for caring for young children's oral health issued by the Australian Dental Association. Contrary to our pre-registered hypotheses, we found no effects of the intervention on parental supervised toothbrushing. Self-reported parental supervised toothbrushing was high at baseline and at the 4-week follow-up post-intervention, with no significant within- or between-subjects effect on behaviour observed. The intervention did, however, exhibit significant effects on intention for people in the action control+ condition, and intervention effects on action planning for people in the planning+ and action control+ conditions. Furthermore, estimated marginal means for intervention effects on task self-efficacy were trending favourably in the expected direction for those in the action control+ condition.

HAPA-based intervention effects

Contrary to our predictions and previous research using imagery and planning interventions to change health behaviour (Hamilton et al., 2021; Keech et al., 2021), we found no effects of the intervention on parental supervised toothbrushing. There are a number of factors that may have attenuated the effects of the intervention on parental supervised toothbrushing. Parental supervised toothbrushing rates were very high across all conditions at baseline and follow-up, making gains in behaviour particularly difficult to achieve. It is also possible that the self-reported parental supervised toothbrushing was substantially overestimated at both time points, which is reflected in the data that show dental caries in young children (K. J. Chen et al., 2019). There is evidence to support the use of self-reported toothbrushing frequency as a proxy measure for clinical oral hygiene indices (Gil et al., 2015); however, recent research has highlighted inaccuracies of self-reported parental supervised oral hygiene behaviour of preschoolers when compared with observation and video recordings (Martin et al., 2019). Overestimating parental supervised toothbrushing may be explained by social desirability and wanting to appear to be acting in the best interests of their child's health. Alternatively, reflecting and reporting on behaviour performed for another person may be more difficult than recalling behaviour performed for oneself, which may have also encouraged over-reporting of parental supervised toothbrushing.

Another consideration is that the mode of delivery of the intervention components may have limited intervention efficacy. The intervention exercises were presented online as a slideshow, whereas previous studies have used audio and video to guide participants through the exercises (Hamilton et al., 2021; Keech et al., 2021). The additional attentional effort required to read to information on the slides may have interrupted the comprehension and assimilation of intervention messages. However, previous research has demonstrated the efficacy of interventions using text-based intervention delivery for changing behaviour (Hagger et al., 2012; Knäuper et al., 2009). Furthermore, participants reported high levels of vividness, clarity, detail and ease of performance following the process mental imagery exercise, supporting the fidelity of the text-based imagery intervention.

Although targeting the motivational and self-regulatory processes specified by the HAPA did not lead to an actual behaviour change in the present study, several effects of the intervention on the secondary outcomes were observed. As expected, action planning significantly increased from baseline to follow-up for the two conditions that completed the action plans and implementation intentions exercise (i.e. planning+ and action control+), which targeted change in action planning, relative to the conditions that did not include the planning intervention component (i.e. education-only and self-efficacy+). Meta-analytic evidence shows action planning to directly predict behaviour and to mediate the intention–behaviour relationship, across multiple behaviours (C.-Q. Zhang et al., 2019). Similarly, there is a substantive body of literature supporting the efficacy of action plans and implementation intentions as self-regulatory intervention techniques in interventions targeting health behaviour change (Bieleke et al., 2021; Hagger & Luszczynska, 2014). Therefore, in lieu of an observed change to behaviour, the significant improvement to action planning over time for these two conditions supports the efficacy of action plans and implementation intentions as self-regulatory strategies for promoting parental supervised toothbrushing, by means of improving action planning.

Furthermore, intervention effects favouring the action control+ condition were observed for intention and trending in the positive direction for task self-efficacy. Participants in the action control+ condition received all intervention components and were the only group guided through the mental imagery exercise aimed at promoting the uptake and maintenance of a self-monitoring task to track twice-daily parental supervised toothbrushing. We propose several explanations for the improvements to task self-efficacy and intention observed only for the action control+ condition. First, it may be that the mental imagery exercise generated improvements to intention and task self-efficacy. This is supported by meta-analytic findings of the effects of mental imagery interventions on health behaviour, whereby significant positive effects of imagery on key outcomes including intention and self-efficacy were observed (Conroy & Hagger, 2018). Alternatively, improved intention and task self-efficacy may have been the cumulative effect of all intervention components—which would be consistent with literature finding in support of multicomponent theory-based interventions for promoting health behaviour change (Y. Chen et al., 2020; Evans et al., 2012; Makvandi et al., 2015; Y. Zhang et al., 2020). However, improvements in psychological constructs did not translate into behaviour change in the present study, consistent with the findings of a recent HAPA-based intervention study that targeted influenza prevention behaviour among older adults (C.-Q. Zhang et al., 2023). This emphasises the need for further research to better understand the mechanisms of action underlying these techniques and their effectiveness in eliciting sustainable health behaviour change.

Although targeted in the intervention, no main or intervention effects were observed for attitude and action control. This was not unexpected for attitude, which was targeted in all four conditions, and, thus, a Time × Condition interaction was not anticipated, and the lack of a main effect of time on attitude could be explained by a ceiling effect caused by high levels of attitude at baseline. However, we would have expected intervention effects favouring the action control+ condition for changes to action control, given that this group was the only one to complete the mental imagery exercise, which was designed to promote the adoption and maintenance of a twice-daily parental supervised toothbrushing self-monitoring strategy (e.g. using a brushing chart). It is possible that the mental imagery exercise failed to target action control as intended. The qualitative summaries of the imagery participants recorded directly after the imagery task suggest that this may have been the case, with some ambiguity surrounding whether the process of performing behavioural self-monitoring versus the process of performing the parental supervised toothbrushing had been imagined, based on participants' qualitative summaries of the imagery.

The slight pivot towards 'self-monitoring of parental supervised toothbrushing' as the target behaviour in the action control intervention component may have resulted in some confusion. Moreover, it is also conceivable that the mental imagery exercise led to improvements of intention and task self-efficacy towards engaging in regular parental supervised toothbrushing, regardless of whether participants imagined self-monitoring their behaviour or imagined performing the behaviour itself, during the mental imagery exercise. This would explain the intervention effects on task self-efficacy and intention favouring the action control+ condition. Furthermore, allowing participants to choose a preferred self-monitoring strategy prior to the imagery exercise may have been too abstract, compared with prescribing a specific self-monitoring strategy for participants to visualise themselves implementing and maintaining. Another consideration is that dose may have been a contributing factor to the lack of observed intervention effects on action control for the action control+ condition, as meta-analytic evidence suggests that the efficacy of mental imagery interventions is improved by the inclusion of a follow-up imagery component, such as sending 'booster' text messages or having participants maintain an imagery-related diary (Conroy & Hagger, 2018).

Strengths, limitations and avenues for future research

The present research has a number of strengths, particularly its focus on a key parental health behaviour aimed at preventing early childhood caries and promoting good oral health in preschool-aged children. Furthermore, the study tested a theory-driven intervention, which was based on the HAPA, and adopted information provision, behavioural instruction, implementation intentions and mental imagery strategies based on prior research and guidelines for best practice (Conroy & Hagger, 2018; Hamilton et al., 2021; Keech et al., 2021). The study also used a pre-registered randomised controlled design and was delivered in a cost-effective online format using resources that can easily be implemented in real-world settings. The implications of the additive intervention design are twofold. First, the effects of the educational component, which consisted of an infographic containing standard toothbrushing guidelines for young children, were held constant across all conditions. Therefore, any effects of the intervention could potentially be interpreted as being over and above the effects of simple knowledge transmission. Furthermore, the lack of intervention effects on behaviour or any of the secondary outcomes for the active control group is consistent with research that argues that knowledge transmission alone is generally not sufficient to produce behaviour change (e.g. Freeman, 2009; Kay & Locker, 1998).

Current findings, however, should be considered in light of some limitations. First, all outcome measures relied exclusively on self-report and retrospective recall, and high baseline levels of behaviour and associated beliefs left little room for improvement at follow-up. The evidence for the reliability and validity of self-report measures of oral hygiene behaviour is mixed (Gil et al., 2015; Martin et al., 2019). While the self-report measures used in the intervention exhibited adequate reliability here and in previous research, their use may introduce additional error variance through recall bias and socially desirable responding. We acknowledge that there are significant financial and logistical challenges to developing non-self-report measures of behaviours such as parental supervised toothbrushing; however, future studies should consider means by which researchers may gain concurrent validity for the self-report measures, for example, through covert observation in discreet settings; or equipping participants with toothbrushes capable of recording usage data; or by measuring, and then controlling for, social desirability in the model.

Furthermore, in light of the findings from this study, which indicate high levels of parental supervised toothbrushing among the sample population, it would be valuable to explore this topic further in a community where parental supervision is not as prevalent. This might involve focusing on parents of children shown to have the poorest oral health (e.g. low socio-economic groups [Stormon et al., 2019]), who may be more receptive to an intervention targeting oral health behaviour change. Conducting a study in such a setting would provide insights into the effectiveness of interventions and strategies aimed at improving parental supervised toothbrushing behaviours in populations with lower baseline levels of supervision.

The single 4-week follow-up period also precludes any inference of long-term changes to behaviour or the beliefs relating to parental supervised toothbrushing. As such, we recommend future research with additional follow-up time points to investigate the long-term effects of these kinds of intervention strategies on behaviour and beliefs. Furthermore, the fidelity of the imagery exercise for targeting action control could not be confirmed in the present study. Future research employing mental imagery techniques to promote action control may benefit from prescribing a self-monitoring strategy that is to be the subject of the process mental imagery exercise and providing participants with the necessary materials (e.g. providing a brushing chart with stickers kept in the bathroom). Future research may also benefit from exploring whether dose moderates intervention effects by delivering an additional follow-up or 'booster' to the imagery component of the intervention.

We also recommend testing the present intervention strategies with alternative modes of delivery. Using videos or voice-over narration to guide participants through the exercises may help to overcome any attentional burden associated with reading information from slides, while preserving the advantages of online delivery (e.g. cost-effective, limited equipment needed and easily implemented in real-world settings). Alternatively, future research testing the intervention using in-person delivery of behaviour change strategies and providing physical intervention packs may be more useful for informing the development of chair-side behavioural intervention protocols that are easily adopted and implemented by dental health professionals.

CONCLUSIONS

The present study tested the efficacy of a pre-registered, online, HAPA-based intervention aimed at promoting parental supervised toothbrushing. Overall, present findings suggest already high levels of parental supervised toothbrushing, which is crucial for the prevention of early childhood caries and the transference of positive oral hygiene behaviours from parent to child. Despite null findings with respect to the hypothesised effects of the intervention on behaviour, the results of the pre-registered exploratory analyses provide support for the application of theory- and evidence-based behaviour change strategies to inspire change in previously identified motivational and volitional determinants of parental supervised toothbrushing: intention, action planning and task self-efficacy. Further research is needed to examine the effects of more objective measures of behaviour, individual differences (e.g. socio-economic status), the number of follow-up data collection and intervention delivery time points, and different modes of intervention delivery on the impact of the intervention on parental supervised toothbrushing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data for this study are available on the Open Science Framework repository: https://osf.io/e8chn.

ETHICS STATEMENT

The Griffith University Human Research Ethics Committee approved the study (reference: 2019/852).

CLINICAL TRIAL REGISTRATION

The study was pre-registered prior to data collection on the Open Science Framework: https://osf.io/fyzh3/.

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REFERENCES

Aliakbari, E., Gray-Burrows, K. A., Vinall-Collier, K. A., Edwebi, S., Marshman, Z., McEachan, R. R. C., & Day, P. F. (2021). Home-based toothbrushing interventions for parents of young children to reduce dental caries: A systematic review. *International Journal of Paediatric Dentistry*, *31*(1), 37–79. https://doi.org/10.1111/ipd.12658

Australian Institute of Health and Welfare. (2012). *Australia's health 2012*.

Australian Institute of Health and Welfare. (2020). *Australia's children*.

Berzinski, M., Morawska, A., Mitchell, A. E., & Baker, S. (2020). Parenting and child behaviour as predictors of toothbrushing difficulties in young children. *International Journal of Paediatric Dentistry*, *30*(1), 75–84. https://doi.org/10.1111/ipd.12570

Bieleke, M., Keller, L., & Gollwitzer, P. M. (2021). If-then planning. *European Review of Social Psychology*, *32*(1), 88–122. https://doi.org/10.1080/10463283.2020.1808936

Blinkhorn, A. S., Wainwright-Stringer, Y. M., & Holloway, P. J. (2001). Dental health knowledge and attitudes of regularly attending mothers of high-risk, pre-school children. *International Dental Journal*, *51*(6), 435–438. https://doi.org/10.1002/j.1875-595X.2001.tb00856.x

Borrelli, B. (2011). The assessment, monitoring, and enhancement of treatment fidelity in public health clinical trials. *Journal of Public Health Dentistry*, *71*(s1), S52–S63. https://doi.org/10.1111/j.1752-7325.2011.00233.x

Chen, K. J., Gao, S. S., Duangthip, D., Lo, E. C. M., & Chu, C. H. (2019). Prevalence of early childhood caries among 5-year-old children: A systematic review. *Journal of Investigative and Clinical Dentistry*, *10*(1), e12376. https://doi.org/10.1111/jicd.12376

Chen, Y., Tan, D., Xu, Y., Wang, B., Li, X., Cai, X., Li, M., Tang, C., Wu, Y., Shu, W., Zhang, G., Huang, J., Zhang, Y., Yan, Y., Liang, X., & Yu, S. (2020). Effects of a HAPA-based multicomponent intervention to improve self-management precursors of older adults with tuberculosis: A community-based randomised controlled trial. *Patient Education and Counseling*, *103*(2), 328–335. https://doi.org/10.1016/j.pec.2019.09.007

Conroy, D., & Hagger, M. S. (2018). Imagery interventions in health behavior: A meta-analysis. *Health Psychology*, *37*(7), 668–679. https://doi.org/10.1037/hea0000625

Do, L. G. (2020). Guidelines for use of fluorides in Australia: Update 2019. *Australian Dental Journal*, *65*(1), 30–38. https://doi.org/10.1111/adj.12742

El Tantawi, M., Folayan, M. O., Mehaina, M., Vukovic, A., Castillo, J. L., Gaffar, B. O., Arheiam, A., Al-Batayneh, O. B., Kemoli, A. M., Schroth, R. J., & Lee, G. H. M. (2018). Prevalence and data availability of early childhood caries in 193 United Nations countries, 2007–2017. *American Journal of Public Health*, *108*(8), 1066–1072. https://doi.org/10.2105/AJPH.2018.304466

Evans, A., Ranjit, N., Rutledge, R., Medina, J., Jennings, R., Smiley, A., Stigler, M., & Hoelscher, D. (2012). Exposure to multiple components of a garden-based intervention for middle school students increases fruit and vegetable consumption. *Health Promotion Practice*, *13*(5), 608–616. https://doi.org/10.1177/1524839910390357

Freeman, R. (2009). Health promotion and the randomised controlled trial: A square peg in a round hole? *BMC Oral Health*, *9*, 1. https://doi.org/10.1186/1472-6831-9-1

Gholami, M., Knoll, N., & Schwarzer, R. (2015). A brief self-regulatory intervention increases dental flossing in adolescent girls. *International Journal of Behavioral Medicine*, *22*(5), 645–651. https://doi.org/10.1007/s12529-014-9459-6

Gil, G. S., Morikava, F. S., Santin, G. C., Pintarelli, T. P., Fraiz, F. C., & Ferreira, F. M. (2015). Reliability of self-reported toothbrushing frequency as an indicator for the assessment of oral hygiene in epidemiological research on caries in adolescents: A cross-sectional study. *BMC Medical Research Methodology*, *15*(1), 14. https://doi.org/10.1186/s12874-015-0002-5

Goldammer, P., Annen, H., Stöckli, P. L., & Jonas, K. (2020). Careless responding in questionnaire measures: Detection, impact, and remedies. *The Leadership Quarterly*, *31*(4), 101384. https://doi.org/10.1016/j.leaqua.2020.101384

Goldberg, L. R. (1992). The development of markers for the big-five factor structure. *Psychological Assessment*, *4*(1), 26–42. https://doi.org/10.1037/1040-3590.4.1.26

Goldberg, L. R. (1999). A broad-bandwidth, public domain, personality inventory measuring the lower-level facets of several five-factor models. In *Personality psychology in Europe* (Vol. 7, pp. 7–28).

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology*, *38*(2006), 69–119. https://doi.org/10.1016/S0065-2601(06)38002-1

Hagger, M. S., Cameron, L. D., Hamilton, K., Hankonen, N., & Lintunen, T. (2020). The handbook of behavior change. In K. Hamilton, L. D. Cameron, M. S. Hagger, N. Hankonen, & T. Lintunen (Eds.), *The handbook of behavior change*. Cambridge University Press. https://doi.org/10.1017/9781108677318.046

Hagger, M. S., & Chatzisarantis, N. L. D. (2009). Integrating the theory of planned behaviour and self-determination theory in health behaviour: A meta-analysis. *British Journal of Health Psychology*, *14*(2), 275–302. https://doi.org/10.1348/135910708X373959

Hagger, M. S., & Conroy, D. (2020). Imagery, visualization, and mental simulation interventions. In M. S. Hagger, L. Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), *The handbook of behavior change* (pp. 479–494). Cambridge University Press. https://doi.org/10.1017/9781108677318.033

Hagger, M. S., Keech, J. J., & Hamilton, K. (2020). Managing stress during the COVID-19 pandemic and beyond: Reappraisal and mindset approaches. *Stress and Health*, *36*, 396–401. https://doi.org/10.1002/smi.2969

Hagger, M. S., Lonsdale, A., & Chatzisarantis, N. L. D. (2011). Effectiveness of a brief intervention using mental simulations in reducing alcohol consumption in corporate employees. *Psychology, Health & Medicine*, *16*(4), 375–392. https://doi.org/10.1080/13548506.2011.554568

Hagger, M. S., Lonsdale, A., & Chatzisarantis, N. L. D. (2012). A theory-based intervention to reduce alcohol drinking in excess of guideline limits among undergraduate students. *British Journal of Health Psychology*, *17*(1), 18–43. https://doi.org/10.1111/j.2044-8287.2010.02011.x

Hagger, M. S., & Luszczynska, A. (2014). Implementation intention and action planning interventions in health contexts: State of the research and proposals for the way forward. *Applied Psychology. Health and Well-Being*, *6*(1), 1–47. https://doi.org/10.1111/aphw.12017

Hamilton, K., Cornish, S., Kirkpatrick, A., Kroon, J., & Schwarzer, R. (2018). Parental supervision for their children's toothbrushing: Mediating effects of planning, self-efficacy, and action control. *British Journal of Health Psychology*, *23*(2), 387–406. https://doi.org/10.1111/bjhp.12294

Hamilton, K., & Johnson, B. T. (2020). Attitudes and persuasive communication interventions. In M. S. Hagger, L. Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), *The handbook of behavior change* (pp. 445–460). Cambridge University Press. https://doi.org/10.1017/9781108677318.031

Hamilton, K., Keech, J. J., Peden, A. E., & Hagger, M. S. (2021). Changing driver behavior during floods: Testing a novel e-health intervention using implementation imagery. *Safety Science*, *136*, 105141. https://doi.org/10.1016/j.ssci.2020.105141

Hamilton, K., van Dongen, A., & Hagger, M. S. (2020). An extended theory of planned behavior for parent-for-child health behaviors: A meta-analysis. In *Health psychology*. American Psychological Association. https://doi.org/10.1037/hea0000940

Hariyani, N., Do, L. G., Spencer, A. J., Thomson, W. M., Scott, J. A., & Ha, D. H. (2020). Maternal caries experience influences offspring's early childhood caries—A birth cohort study. In *Community dentistry and oral epidemiology* (Vol. 48, pp. 561–569). https://doi.org/10.1111/cdoe.12568

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials—A practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1), 162. https://doi.org/10.1186/s12874-017-0442-1

Kassebaum, N. J., Bernabé, E., Dahiya, M., Bhandari, B., Murray, C. J. L., & Marcenes, W. (2015). Global burden of untreated caries: A systematic review and metaregression. *Journal of Dental Research*, *94*(5), 650–658. https://doi.org/10.1177/0022034515573272/SUPPL_FILE/DS_10.1177_0022034515573272.PDF

Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: The elaborated intrusion theory of desire. *Psychological Review*, *112*(2), 446–467. https://doi.org/10.1037/0033-295X.112.2.446

Kay, E., & Locker, D. (1998). A systematic review of the effectiveness of health promotion aimed at improving oral health. *Community Dental Health*, *15*(3), 132–144.

Keech, J. J., Hagger, M. S., & Hamilton, K. (2021). Changing stress mindsets with a novel imagery intervention: A randomized controlled trial. *Emotion*, *21*(1), 123–136. https://doi.org/10.1037/emo0000678

Knäuper, B., McCollam, A., Rosen-Brown, A., Lacaille, J., Kelso, E., & Roseman, M. (2011). Fruitful plans: Adding targeted mental imagery to implementation intentions increases fruit consumption. *Psychology and Health*, *26*(5), 601–617. https://doi.org/10.1080/08870441003703218

Knäuper, B., Roseman, M., Johnson, P. J., & Krantz, L. H. (2009). Using mental imagery to enhance the effectiveness of implementation intentions. In *Current psychology* (Vol. 28, pp. 181–186). https://doi.org/10.1007/s12144-009-9055-0

Knittle, K., Heino, M., Marques, M. M., Stenius, M., Beattie, M., Ehbrecht, F., Hagger, M. S., Hardeman, W., & Hankonen, N. (2020). The compendium of self-enactable techniques to change and self-manage motivation and behaviour v.1.0. *Nature Human Behaviour*, *4*(2), 215–223. https://doi.org/10.1038/s41562-019-0798-9

Kok, G., Gottlieb, N. H., Peters, G.-J. Y., Mullen, P. D., Parcel, G. S., Ruiter, R. A. C., Fernández, M. E., Markham, C., & Bartholomew, L. K. (2016). A taxonomy of behaviour change methods: An Intervention Mapping approach. *Health Psychology Review*, *10*(3), 297–312. https://doi.org/10.1080/17437199.2015.1077155

Koka, A., & Hagger, M. S. (2017). A brief intervention to increase physical activity behavior among adolescents using mental simulations and action planning. *Psychology, Health & Medicine*, *22*(6), 701–710. https://doi.org/10.1080/13548506.2016.1211298

Little, R. J. A. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association*, *83*(404), 1198–1202. https://doi.org/10.1080/01621459.1988.10478722

Makvandi, Z., Karimi-Shahanjarini, A., Faradmal, J., & Bashirian, S. (2015). Evaluation of an oral health intervention among mothers of young children: A clustered randomized trial. *Journal of Research in Health Sciences*, *15*(2), 88–93. http://eprints.umsha.ac.ir/1742/1/8.pdf

Maniaci, M. R., & Rogge, R. D. (2014). Caring about carelessness: Participant inattention and its effects on research. *Journal of Research in Personality*, *48*(1), 61–83. https://doi.org/10.1016/j.jrp.2013.09.008

Marshman, Z., Ahern, S. M., McEachan, R. R. C., Rogers, H. J., Gray-Burrows, K. A., & Day, P. F. (2016). Parents' experiences of toothbrushing with children: A qualitative study. *JDR Clinical and Translational Research*, *1*(2), 122–130. https://doi.org/10.1177/2380084416647727

Martin, M., Rosales, G., Sandoval, A., Lee, H., Pugach, O., Avenetti, D., Alvarez, G., & Diaz, A. (2019). What really happens in the home: A comparison of parent-reported and observed tooth brushing behaviors for young children. *BMC Oral Health*, *19*(1), 35. https://doi.org/10.1186/s12903-019-0725-5

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review*, *5*(2), 97–144. https://doi.org/10.1080/17437199.2010.521684

Mohebbi, S. Z., Virtanen, J. I., Murtomaa, H., Vahid-Golpayegani, M., & Vehkalahti, M. M. (2008). Mothers as facilitators of oral hygiene in early childhood. *International Journal of Paediatric Dentistry*, *18*(1), 48–55. https://doi.org/10.1111/j.1365-263X.2007.00861.x

Pham, L. B., & Taylor, S. E. (1999). From thought to action: Effects of process-versus outcome-based mental simulations on performance. *Personality and Social Psychology Bulletin*, *25*(2), 250–260. https://doi.org/10.1177/0146167299025002010

Royal Children's Hospital Melbourne. (2018). *The Royal Children's Hospital Melbourne's National Child Oral Health Poll 2018*.

Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomised trials. *PLoS Medicine*, *7*(3), e1000251–e1000257. https://doi.org/10.1371/journal.pmed.1000251

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology*, *57*(1), 1–29. https://doi.org/10.1111/j.1464-0597.2007.00325.x

Schwarzer, R., Antoniuk, A., & Gholami, M. (2015). A brief intervention changing oral self-care, self-efficacy, and self-monitoring. *British Journal of Health Psychology*, *20*(1), 56–67. https://doi.org/10.1111/bjhp.12091

Schwarzer, R., & Hamilton, K. (2020). Changing behaviour using the health action process approach. In M. S. Hagger, L. Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), *The handbook of behavior change*. Cambridge University Press. https://doi.org/10.1017/9781108677318.007

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and Personality Psychology Compass*, *10*(9), 503–518. https://doi.org/10.1111/spc3.12265

Smith, S. R., Hagger, M. S., Keech, J. J., Moyers, S. A., Hamilton, K., & Smith, S. (2022). Improving hand hygiene behavior using a novel theory-based intervention during the COVID-19 pandemic. *Annals of Behavioral Medicine*, *56*(11), 1157–1173. https://doi.org/10.1093/ABM/KAAC041

Smith, S. R., Kroon, J., Schwarzer, R., & Hamilton, K. (2020). Parental social-cognitive correlates of preschoolers' oral hygiene behavior: A systematic review and meta-analysis. *Social Science & Medicine*, *113322*. https://doi.org/10.1016/j.socscimed.2020.113322

Smith, S. R., Kroon, J., Schwarzer, R., & Hamilton, K. (2021). Social-cognitive predictors of parental supervised toothbrushing: An application of the health action process approach. *British Journal of Health Psychology*. https://doi.org/10.1111/bjhp.12516

Spinks, T., & Hamilton, K. (2015). Investigating key beliefs guiding mothers' dietary decisions for their 2–3 year old. *Appetite*, *89*, 167–174. https://doi.org/10.1016/j.appet.2015.02.004

Stormon, N., Ford, P. J., & Lalloo, R. (2019). Oral health in the longitudinal study of Australian children: An age, period, and cohort analysis. *International Journal of Paediatric Dentistry*, *29*(4), 404–412. https://doi.org/10.1111/ipd.12485

Sullivan, T. R., White, I. R., Salter, A. B., Ryan, P., & Lee, K. J. (2018). Should multiple imputation be the method of choice for handling missing data in randomized trials? *Statistical Methods in Medical Research*, *27*(9), 2610–2626. https://doi.org/10.1177/0962280216683570

Uribe, S. E., Innes, N., & Maldupa, I. (2021). The global prevalence of early childhood caries: A systematic review with meta-analysis using the WHO diagnostic criteria. *International Journal of Paediatric Dentistry*, *31*(6), 817–830. https://doi.org/10.1111/IPD.12783

Van Der Weijden, F., & Slot, D. E. (2011). Oral hygiene in the prevention of periodontal diseases: The evidence. *Periodontology 2000*, *55*(1), 104–123. https://doi.org/10.1111/j.1600-0757.2009.00337.x

Warner, L. M., & French, D. P. (2020). Self-efficacy interventions. In M. S. Hagger, L. Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), *Handbook of behavior change* (pp. 461–478). Cambridge University Press. https://doi.org/10.1017/9781108677318.032

World Health Organization. (2018). *Oral health fact sheet 2018*.

Zhang, C.-Q., Zhang, R., Chung, P.-K., Duan, Y., Lau, J. T. F., Chan, D. K. C., & Hagger, M. S. (2023). Promoting influenza prevention for older adults using the Health Action Process Approach: A randomized controlled trial. *Applied Psychology. Health and Well-Being*. https://doi.org/10.1111/APHW.12445

Zhang, C.-Q., Zhang, R., Schwarzer, R., & Hagger, M. S. (2019). A meta-analysis of the health action process approach. *Health Psychology*, *38*(7), 623–637. https://doi.org/10.1037/HEA0000728

Zhang, Y., Yin, Y., Liu, J., Yang, M., Liu, Z., & Ma, X. (2020). Impact of combined theory-based intervention on psychological effects and physical activity among Chinese adolescents. *International Journal of Environmental Research and Public Health*, *17*(9), 3026. https://doi.org/10.3390/ijerph17093026

Zhou, G., Sun, C., Knoll, N., Hamilton, K., & Schwarzer, R. (2014). Self-efficacy, planning and action control in an oral self-care intervention. *Health Education Research*, *30*(4), 671–681. https://doi.org/10.1093/her/cyv032

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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