Impact of early exposure to fluoride on the executive functioning of Australian children

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This thesis is submitted in partial fulfilment of the Honours degree of Bachelor of Psychology

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October 2019

Word count: 9344

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Abstract

Recent research has arisen which indicates that early exposure to fluoride could have cognitive impacts on the developing brain of children. Currently, there is no concrete high quality evidence within the current literature that establishes no association between fluoride exposure and cognitive development, leading to an increase in distrust regarding the use of fluoride in drinking water. The current study aimed to explore the relationships between early childhood exposure to water fluoridation and measures of executive functioning by applying a population- based cohort study design in a representative sample of children within Australia, taking into account confounders that have been overlooked within previous research. Participants were recruited from a previous national oral health study and invited to complete a questionnaire that included the Behaviour Rating Inventory of Executive Function. A series of regression analyses found no significant association between fluoride exposure and executive functioning in children. Further logistic regression testing found that fluoride exposure was not a significant predictor of elevated levels of executive dysfunction. The population-based evidence of the current study can inform and educate the general public and policy leaders on the understanding and safety of fluoride use in children and their psychological development.

Declaration

This thesis contains no material which has been accepted for the award of any other degree of diploma in any University, and, to the best of my knowledge, this thesis contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web, via the University of Adelaide's digital thesis repository, the Library Search and through web search engines, unless permission has been granted by the School to restrict access for a period of time.

Ching Wen Tiew
October, 2019

Acknowledgements

I would like to take the opportunity to thank sincerely those who supported and advised me during preparation of this thesis.

First and foremost, I wish to acknowledge my academic supervisors, Dr Loc Do, Dr Diep Ha and Dr Rachel Roberts, for their patience, insight and generosity. I appreciate all the support, and the guidance I received in conducting an actual working study. I truly enjoyed my supervision meetings.

I also want to thank my family and friends, and in particular my parents, for their support over this challenging period. I am very lucky to be surrounded by clever, creative people who have inspired me to challenge myself and take risks. Further thanks to those who read the thesis for me and provided valuable feedback in the dying stage.

Chapter 1 – Introduction

The developing brain is more vulnerable to damage caused by toxins than an adult's brain (Choi, Sun, Zhang, & Grandjean, 2012). As a result, the extent to which permanent damage could occur is elevated as the window of developmental vulnerability is significant in-utero and during early childhood (Grandjean & Landrigan, 2006). This means that children may be more susceptible to permanent brain injuries from exposure to low levels of fluoride, which would otherwise have little or no harmful effect in an adult (Weiss, 2000).

In recent years, evidence has emerged suggesting that early childhood fluoride exposure could produce harmful physical (Dhar & Bhatnagar, 2009), neurobehavioural (Calderon et al., 2000; Rocha-Amador et al., 2009) and psychological (Choi et al., 2012; Hirzy, Connett, Xiang, Spittle, & Kennedy, 2016; Malin & Till, 2015) consequences. These findings are particularly relevant due to the prevalence of fluoride, wherein global communities are constantly exposed to fluoride in sources such as their water, dental products, and diet (Calderon et al., 2000). Therefore, a strong research base is essential in informing public policies and practices, and expanding the foundation of knowledge to advise policy leaders in public health on the effects of fluoride.

1.1 Fluoride

1.1.1 Sources of Fluoride.

Fluoride occurs naturally in soil and water. The release of fluoride into the environment can originate from either natural and anthropogenic sources (National Health and Medical Research Council [NHMRC], 2007). Natural atmospheric sources include emissions from volcanos, and anthropogenic emissions include steel production, and other manufacturing (e.g. copper, aluminium) processes (NHMRC, 2007). Additionally, fluoride occurs naturally in water sources, with concentration levels that vary according to region. In

Australia, the concentration of fluoride in natural water sources is generally found to be low (<0.1ml/L), with the exception of sources located in central Australia (NHMRC, 2017a; Neil, 2011; SA Health, 2012). Finally, exposure to fluoride also exists in the form of commercial dental products such as toothpaste, mouthwashes and tablets (NHMRC, 2007). Importantly, however, the consumption and bioavailability of fluoride differs among individuals due to various factors including nutrition, physiology, living conditions, and cultural influences (Hardwick, Barmes, Writer, & Richardson, 2000).

1.1.2 Mechanism of Action of Fluoride.

When fluoride is consumed, it is absorbed through the gut before spreading throughout the body via the circulatory system (Dhar & Bhatnagar, 2009; NRC,1993; Whitford, 1996). Approximately 90% of fluoride in the body is absorbed by teeth, bones or the salivary glands, with the remaining fluoride then ejected from the body through urine (Dhar & Bhatnagar, 2009; Whitford, 1996). Ingested fluoride then synthesises to form tooth structures and, when ingested during teeth development, accumulates on the tooth surface, strengthening the tooth and protecting it against decay (Newbrun, 1975). This effect has led to the widespread use of fluoride to protect against tooth decay.

1.1.3 The Use of Fluoride in The Prevention of Dental Caries.

According to a WHO report (2003), dental caries affects a large proportion of school children (60-90%) and a majority of adults globally, making it a serious health problem (Petersen, 2003; Petersen & Lennon, 2004). In Australia, studies have found that tooth caries are a highly prevalent health problem, with five out of ten children and nine out of ten adults having experienced problems with tooth decay (Do & Spencer, 2016; NHMRC, 2007). Dental caries have sizeable social, health, and economic impacts on the global population (Hardwick et al., 2000; Vargas & Ronzio, 2006). Consequently, there is a need for an efficient and economic method of managing dental caries.

Fluoride is able to counteract dental caries by disrupting the process of demineralisation – the process of calcium and phosphate loss from the enamel due to exposure to acid following the ingestion of food (Featherstone, 1999; Jack et al., 2016; NHMRC,2017a). Fluoride also acts to remineralise damaged surfaces (Featherstone, 1999). In order to obtain the maximum benefits of fluoride, low levels must be consistently maintained in the mouth throughout the day. A strategy to achieve this was to distribute fluoride to the population through the incorporation of fluoride into the drinking water supplies. However, this strategy failed to consider how this could lead to an overexposure of fluoride, particularly during tooth development, which could bring about negative side-effects such as fluorosis – a common developmental disturbance of enamel which can cause discolouration, white striations, and tooth pitting (Do & Spencer, 2007; Jack et al., 2016; Kanduti, Sterbenk, & Artnik, 2016). Therefore, there is a delicate balance of fluoride use between their protective benefits against dental caries and the negative side-effects such as the increased risk of acquiring fluorosis.

1.1.4 Artificial Fluoride Supplementation.

Community water fluoridation (CWF) is the primary population-based strategy in Australia for the prevention of dental caries, since a large number of Australians (89%) are served by public water supplies (Australian Research Centre for Population Oral Health [ARCPOH], Australian Research Centre for Population Oral Health, 2006; 2016; Spencer, Do, & Ha, 2018). The concentration of fluoride in Australia's water supply is within the range 0.6–1.1mg/L – which is considered to be the optimum level by the NHMRC (2007), World Health Organisation (2011) and U.S. Public Health Service (McDonagh et al., 2000; Reeves, 1986). Importantly, this amount still has the capacity to result in a substantial decrease in dental caries while also minimising the risk of dental fluorosis (ARCPOH, 2006; Do & Spencer, 2007).

The efficacy of water fluoridation in the prevention of dental caries, specifically in children, has been documented by two influential systematic reviews by McDonagh et al. (2000) and Iheozor-Ejiofor et al. (2015). Principally, both systematic reviews concluded that there was a significant relationship between exposure to fluoridated water and a decreased level of dental caries. Specifically, Ihezor-Ejiofor and his colleagues established that there was a decrease in the prevalence of dental caries by 15% in the populace, following the commencement of water fluoridation (Iheozor-Ejiofor et al., 2015). Together, these findings support the necessity of intentional fluoride supplementation to prevent against dental caries in a localised population.

It is, however, necessary to outline the limitations of the systematic reviews noted above, as the studies used in these reviews are mostly pre-1975 and the inclusion criteria only accepted a minority of post-1999 studies (Spencer et al., 2018). Exposure of fluoride within the population has since changed. For example, there has been widespread use of fluoridated toothpaste since its introduction. For this reason, one could adjudge that the evidence for water fluoridation shown in the recent systematic reviews are obsolete (Rugg-Gunn et al., 2016). Consequently, there was an incentive to use recent, and thus more representative data from a national health survey conducted on children in 2012-2014 (Do & Spencer, 2016) to study the association between early childhood exposure to fluoride and the incidence of dental caries. A study conducted using the data from the survey found that there was a consistent association between caries prevalence and childhood exposure to fluoride, wherein children with less exposure to fluoride experienced a higher incidence of dental caries (Spencer et al., 2018). Hence, CWF is considered the ideal measure, as it is efficient and socially equitable in decreasing the prevalence of dental caries nationwide.

1.2 Cognitive Development in Children

Considering both the wide use of CWF as a public policy throughout the world and the extensive reach it has in the population, there have been concerns regarding the possible undesirable effects that fluoride could have on neurological development, despite clear evidence that fluoride can be beneficial for dental health (The British Fluoridation Society, 2012; Tinanoff, 2015). This is especially important with the growing literature and subsequent concern over the neurophysiological effects that fluoride could have on the cognitive development in children, as they are biologically more susceptible to neurochemical changes (Grandjean & Landrigan, 2006; Weiss, 2000).

1.2.1 Cognitive Development and Executive Functioning.

Cognitive psychologist Ulric Neissar first coined the term "executive control" in 1967, describing it as an "orchestration of basic cognitive processes during goal-orientated problem solving" (Neisser, 2014; Reebye, 2003, p. 320). His work allowed for the distinction to be made between executive functions and cognitive function (Gioia, Isquith, & Guy, 2001). The term “executive function” is a multidimensional umbrella-label that comprises an assembly of inter-related processes executed during problem-solving behaviour (Gioia et al., 2001). These executive processes are crucial in the integration of external stimuli to form goals and strategies, prepare for action, and validate that plans and actions have been used suitably (Luria, 1973). Executive function is a multifaceted construct comprised of independent but correlated domains of self-regulatory functions, including cognitive, behavioural, and emotional control (Barkley, 2012; Bennetto, Pennington, & Rogers, 1996; Gioia et al., 2001). The current study will use executive functioning as a measure of cognitive development as the association between exposure to fluoride and executive function has not yet been examined in this field of study. Executive functioning is crucial to many aspects of life function – including social, cognitive, and psychological development, academic and life

achievements, and mental and physiological health (Anderson, 2002; Diamond, 2016). Hence, the present study aims to investigate the association between executive functioning and early exposure to fluoride.

1.2.2 Neurophysiological Mechanisms of Fluoride.

The neurophysiological effects of fluoride have been documented in numerous studies and reviews (National Research Council, 2007). Specifically, sustained exposure to high concentrations of fluoride can hinder brain functioning (Bartos et al., 2018; Yuan, Li, Niu, & Wang, 2019; Zhu et al., 2017). Animal studies have indicated that neurological changes (e.g. neuron damage and increased inflammation in the hippocampus) in the brains of rats can be induced through fluoride exposure, affecting memory and/or learning processes (Dong, Wang, Wei, Zhang, & Guan, 2015; Jetti, Raghuveer, & Mallikarjuna, 2016; Yang et al., 2018). These findings are important because similar neurophysiological processes are used in learning and memory in developing children. However, these neurophysiological changes cannot be directly linked to specific changes in behaviour or to known diseases as most were experimental studies based on the withdrawal and re-exposure of fluoride (Spittle, 1994). Therefore, even though there appears to be evidence establishing the neurophysiological impacts that fluoride can have on the brain, fluoride is still widely used as a tool to combat common health problems such as dental caries.

1.2.3 The Association between Fluoride Exposure and Child Cognitive Development.

There is an increasing body of literature that indicates that fluoride is a developmental neurotoxicant in the human body. Over 50 studies have been published in China, India and Iran showing some association between ingestion of fluoride and neurotoxicity (American Environmental Health Studies Project, 2019). Examples include studies by Wang et al. (2007), Malin and Till (2015), Zhang et al. (2015), and a meta-analysis

by Choi, Sun, Zhang, & Grandjean (2012). The review by Choi et al. (2012) in particular generated considerable attention regarding the association between exposure to fluoride and intelligence quotient (IQ) in children and is frequently cited in the debate against water fluoridation. The review included 27 cross-sectional studies, of which 25 studies were conducted in rural areas of China that had naturally high levels of fluoride in the drinking water. Choi et al. (2012) found a robust association between high exposure to fluoride and reduced IQ scores in children residing in areas with high water fluoride concentration (0.88–11.5 mg/L) had notably lower IQ scores. A recent 2018 meta-analysis (Duan, Jiao, Chen, & Wang, 2018) substantiates the findings of Choi et al. (2012) and found a significant relationship between the dosage in water fluoridation and IQ in children, where IQ scores decreased with increased exposure to fluoride exposure.

Although a sizeable number of studies were performed in China, the issue of water fluoridation is not limited to China. In a study conducted in Mexico (Rocha-Amador, Navarro, Carrizales, Morales, & Calderón, 2007), intelligence was measured against exposure to different levels of fluoride in water supplies in three rural communities. After controlling for confounders, there was still a significant association between increased fluoride exposure and an increased risk of lowered intelligence, which corroborates the results found by Choi et al. (2012). However, the concentration of fluoride in the study was significantly greater (3.5 to 6 times) than the recommended limits set by WHO and NHMRC (Rocha-Amador et al., 2007). Hence, with a growing body of literature on the possible harmful effects of CWF on cognitive development, there is an increased resistance against CWF due to the possible effects exposure to fluoride could have on cognitive development.

1.2.4 The Effects of Fluoride Exposure on Neurocognitive Functions.

Apart from intelligence, there is a body of literature that also indicates that exposure to fluoride can lead to neurobehavioral deficits such as impaired visual-spatial organisation,

memory and response time in children (American Environmental Health Studies Project, 2019). In particular, one study in Mexico where 90% of the children had dental fluorosis found that fluoride (measured in urine) was positively correlated with reaction time and negatively correlated with scores in visuospatial organisation (Calderon et al., 2000). Thus, fluoride could also account for deficits in different aspects of cognitive functioning in children, suggesting there is a need to further investigate the effect of fluoride exposure.

1.2.5 The Debate on the Use of Fluoride.

Despite these criticisms, the popularity of community water fluoridation remains largely undiminished. Countries such as the United States of America, Australia, Singapore and China still continue the practice of water fluoridation, while only a handful of countries including Finland, Japan, Germany, and Switzerland have discontinued the use of CWF in recent years (Cheng, Chalmers, & Sheldon, 2007; The British Fluoridation Society, 2012). Moreover, in a 2017 public statement, NHRMC showed their support for water fluoridation in the water supplies of all Australian states and territories (NHMRC, 2017b).

This could be attributed to the inapplicability of fluoride associated effects on neurodevelopment in all cases. In a critical appraisal by Sutton et al. (2015), the quality of evidence derived by Choi et al. (2012) was rated as low. The reasons given were that a large number of the included studies had a lack of complete control over potential confounding variables such as other neurotoxic chemicals (e.g. lead, arsenic). Such chemicals are found to be associated with lower IQ, socioeconomic status, parental education, and nutritional status (Sutton et al., 2015). Additionally, the majority of studies were conducted in China, Iran and Mongolia and small convenient samples were taken from rural areas in the countries. Thus, they were unrepresentative populations sampled from rural areas that had high levels of fluoride in the water supply (Sutton et al., 2015). Furthermore, the meta-analysis was affected by high statistical heterogeneity showing that there were large variations in study outcomes

between studies included (Jack et al., 2016). Overall, no substantial evidence was provided by the meta-analysis to establish the causality of fluoride in reduced children's IQ. Lastly, the fluoride levels in the reviews are found in fluoride-endemic regions in which there is a high level of naturally-occurring fluoride in the drinking water supply. These levels (>1.5 mg/L) are generally higher than the fluoride levels found in drinking water in Australia (0.6–1.1mg/L) which would mean that the results do not directly apply to the water fluoridation context in Australia (Jack et al., 2016; Sutton et al., 2015).

In Australia, fluoride levels are likely to be lower and highly controlled to remain within the optimal concentration level (NHMRC, 2011). In a study conducted in New Zealand, a country with similar socio-economic conditions and healthcare systems to Australia, Broadbent et al. (2015) found no significant differences between unadjusted IQ scores in participants that had early childhood exposure to fluoride and those without early childhood exposure at ages 7-13 and 38 (Broadbent et al., 2015). These results remained consistent after adjusting for potential confounders such as childhood maltreatment, gender, socioeconomic status and birth weight. The authors concluded that fluoride exposure through CWF in New Zealand with fluoride concentrations that were within the NHMRC recommended limit did not influence neurodevelopment (Broadbent et al., 2015).

It is important, however, not to overemphasise the strengths of Broadbent's (2015) study as it has been subjected to numerous critiques. Notably, the small disparity in levels of fluoride exposure between fluoridated and non-fluoridated populations led to limited statistical power to detect an effect on IQ caused by fluoride (Hirzy et al., 2016; Menkes, Thiessen, & Williams, 2014). Furthermore, while confounding variables like socioeconomic status were controlled for, potential confounds operating at suburb levels that could influence IQ were not screened for and considered in the analysis (Oakes, 2004). For example, the sample chosen for children without CWF were taken from a rural district (Mosgiel) and rural

children have been noted by the authors to typically have lower IQ than children from urban areas (Menkes et al., 2014). This is imperative to consider because fluoride exposure was determined by residence, so measurements were clustered into geographical groupings (suburbs) and therefore could introduce a potential confound working within those groupings.

Given the current debate with regard to CWF, it is quite surprising that little high-quality research has been conducted and no clear and explicit evidence has been reported for the adverse effects of CWF at the levels used in countries like Australia that follow NHMRC recommendations. A large number of studies did not have an appropriate design and statistical analysis or did not control for confounding variables (McDonagh et al., 2000). Consequently, despite the extensive literature on the developmental neurotoxicity of fluoride, there remains debate regarding the use of fluoride, considering ambiguities regarding the exposure and intake of fluoride (e.g. dosage and duration of fluoride exposure across the different sources of fluoride) and numerous unmeasured confounders (Menkes et al., 2014). Environmental variables such as socioeconomic status, parental educational status, and family relationships, which were associated with decreased performance on cognitive tasks, were also not controlled for. Hence, the current study attempted to tackle the methodological issues presented in the literature by including social confounders such as gender, residential location, indigenous identity, parental education status, household income, family composition and socioeconomic levels, using a representative sample and a reliable measure of fluoride exposure at the recommended levels by NHMRC.

1.3 Research Aims and Hypothesis

The overarching aim of the study is to explore the relationship of early childhood exposure to water fluoridation on measures of school-age cognitive development by applying a population- based cohort study design in a representative sample of children within

Australia. There remains much debate on the benefits of water fluoridation, and the associated neurodevelopmental toxicity is still a contentious issue (Connett, 2007). By using nationally representative population-based data from the recently conducted National Child Oral Health Study (NCOHS) 2012–14, the current study aimed to provide high quality evidence to systematically evaluate the effects of exposure to optimal levels of fluoride in drinking water on executive functioning.

The current study has three hypotheses to determine the association between early childhood fluoride exposure and its effect on cognitive development in children after having controlled for confounders that were absent in previous studies such as gender, residential location, indigenous identity, parental education status, household income, family composition and socioeconomic levels:

(1) It is expected that there will be no association between the levels of early childhood exposure to fluoride and executive functioning in the sample.
(2) It is expected that there will be no difference in the levels of early childhood exposure to fluoride across the different domains of executive function (cognitive, emotional and behavioural).
(3) It is expected that there will be no difference in the level of early childhood exposure to fluoride between children with normative and clinically elevated levels of executive dysfunction.

Chapter 2 – Method

2.1 Study sample

The dataset for this study was taken from the NCOHS, a population-based cross-sectional survey of children aged 5-14 years (Do & Spencer, 2016). NCOHS is the first comprehensive national study of child oral health in Australia. It is a large population-based study of children attending schools in all states and territories. The study used a stratified two-stage sample design to attain a representative sample of children from the population within each territory/state (Do & Spencer, 2016). Data collection included comprehensive parental questionnaires and a detailed oral epidemiological examination. The study fieldwork was completed in December 2014, with 24,664 study participants aged 5–14 years with both questionnaire and oral examination data. The present study reports on the first group of participants from the recruitment of these study participants.

2.1.1 Study Demographics.

Demographic characteristics were collected for the child, the parents and the household and includes the child's gender and residential location, child and parent's indigenous identity, parent's education status, household income as well as family composition (Do & Spencer, 2016). The child's gender and residential location was reported and classified into either male or female, and remote/ very remote, outer regional, inner regional or major city using the Remoteness Area Structure of the Australian Statistical Geography Standard (ASGS; Australian Bureau of Statistics, 2018). Parents were asked to indicate their country of birth, highest level of education and total household income before tax. Country of birth was categorised into two groups: born in Australia or born outside Australia. If one parent indicated that they were born overseas, both parents would be categorised under born outside Australia. Household income was categorised into three income groups: low (<$60 000); medium (between $60 000 and $120 000); and high (>$120

000). Education levels were categorised into three groups: low (school-level training); medium (vocational training) and high (tertiary training). Both child and parent reported their indigenous identity: nonindigenous or indigenous. Family composition was categorised into two groups: one parent or two parents (includes step-parents). Socio-economic Indexes for Areas (SEIFA; Australian Bureau of Statistics, 2016) was used to determine Area-level socioeconomic status which corresponded with the family's residential location. The demographics for the dataset is adapted and summarised in Table 1 (Spencer et al., 2018, p. 4)

Table 1

Child, parent and household characteristics of the NCOHS weighted dataset (Spencer et al., 2018, p. 4)

	Factors	*n*	Weighted Percentage of Children (%)
Child's demographic characteristics			
Child Sex			
	Male	12,348	51.2
	Female	12,316	48.8
Child's Indigenous Identity			
	Nonindigenous	23,113	95.1
	Indigenous	1102	4.9
Child's residential location			
	Major city	12,994	68.0
	Inner regional	5,505	19.7
	Outer regional	5,224	9.8
	Remote/Very remote	941	2.5
Parent/guardian demographic characteristics			
Parent country of birth			
	Australian Born	16,048	63.6
	Overseas Born	8,340	36.4
Parent's indigenous identity			
	Nonindigenous	23,113	95.9
	Indigenous	8,340	4.1
Parent education status			
	High School	7,301	29.6
	Vocational Training	5,500	22.3
	Tertiary Education	11,863	48.1
Household demographic characteristics			
Family Composition	One parent	4.030	20.9
	Two parent	20,173	79.1
Household income			
	Low	6,898	32.5
	Medium	9,755	38.4
	High	6,430	29.1

2.2 Recruitment Procedure

The current study was approved by the University of Adelaide Human Research Ethics Committee (Approval Number: H-2019-020). Parents/primary caregivers of the children who participated in the NCOHS 2012-14 and agreed to be re-contacted for research purposes were sent a primary approach package containing a parental letter of invitation and information sheet which outlined respondents' right to withdraw from the study at any time

(see Appendix B). Completion of the questionnaire was taken as consent for participating in the study. A rolling invitation was sent out in May 2019 to an estimated 15,000 participants across all states of Australia. Due to time constraints, the cut off period for recruitment was in July 2019, and hence, only first responders were used in the current study.

2.2.1 Questionnaire.

Parents of the study participants were sent a questionnaire (see Appendix C). They could choose to complete the questionnaire online or paper-based. The questionnaire had five parts: (a) Child's Dental Behaviours and Practices; (b) Child's Behaviours; (c) Child's General Health and Daily Activities; (d) Family Information; (e) Child's Dental Service Evaluation. The current study mainly used data from part (b) in which cognitive development was measured.

2.3 Measures

As the current study was a part of a larger study which comprised of additional assessments as well as other data collected, only the measures pertinent to the current study will be described below.

2.3.1 Demographic Information.

The data used in the current study was collected in the NCOHS as part of the larger study that is described under study demographics.

2.3.2 Lifetime Exposure to Fluoridated Water.

The NCOHS questionnaire collected a detailed residential history from birth to the time of the survey and included questions on the consumption of public water. The residential history of NCOHS participants was then consolidated with the postcode-level fluoride concentration database to allow computation of the individual-level per cent of lifetime exposure to fluoridated water (%LEFW) (Do, Ha, & Spencer, 2015). Australian Research

Centre for Population Oral Health (ARCPOH) retains a database of the fluoride concentration of all public water supplies in Australia. Using this database, residential locations are then matched to the water supplies and categorised into three separate groups of fluoride concentration: (a) <0.3 ppm; (b) 0.3– <0.7 ppm, and (c) ⩾0.7 ppm. The computation of %LEFW was computed to express the percent lifetime access to the equivalent of ⩾0.7 ppm of fluoride in the water supply. Participant's exposure to fluoride was calculated up to the time in which they were surveyed. Studies have affirmed that this method of assessing lifetime exposure to fluoridated water is highly robust and accurate (Do & Spencer, 2007; Slade, Davies, Spencer, & Stewart, 1995).

2.3.3 Cognitive Development.

The Behaviour Rating Inventory of Executive Function Edition 2 (BRIEF2) is a questionnaire that measures behavioural materialisation of executive function (Gioia & Isquith, 2011).

BRIEF2 was administered for school children aged 5–18, utilising the Parent forms. BRIEF2 uses a 3-point scale: Never, Sometimes, and Often. BRIEF2 has 63 items that provide nine empirically and theoretically derived clinical scales that measure domains of executive functioning. With this, BRIEF2 yields three indexes (Cognitive, Emotional and Behavioural Regulation) and one composite score (Global Executive Composite) (Dodzik, Gioia, Isquith, Guy, & Kenworthy, 2017). The Cognitive Behavioural Index (CRI) characterises the individual's ability to use both organisation and planning to systematically resolve problems while the Behavioural Regulation Index (BRI) characterises the individual's capability to maintain and control his/her emotional responses and behaviours. Emotion Regulation Index (ERI) characterises the individual's capability in regulating emotional responses and adapt to changes in his/her surrounding environment and demands. BRIEF2 was chosen due to high reliability. Cronbach's alpha was used to measure internal

consistency and test-retest reliability correlations across the indexes and composite, and are reported in Table 2 and Table 3 respectively, indicating that the indexes and composite have high levels of reliability (Gioia, Isquith, Guy, & Kenworthy, 2015, p. 101). Additionally, three validity scores are used to provide additional information about the validity of the protocol: Inconsistency, Negativity and Infrequency scales (Gioia et al., 2015). The Infrequency scores measured the level in which similar BRIEF2 items were answered in the manner to which was deem inconsistent comparative to the clinical sample. The Negative score measured the level in which participants answered unusually negatively on designated BRIEF2 items comparative to the clinical sample. Lastly, the Inconsistency scale measured the extent to which participants answered similar BRIEF2 items inconsistently comparative to the clinical samples. BRIEF2 has been shown to demonstrate high validity, with strong correlations with other measures that designed to capture related constructs (e.g. externalising behaviours, inattention and impulsivity). Higher correlation were strongest for externalising scores (r =.45) for the Child Behaviour Checklist (Achenbach & Edelbrock, 1983) and the Behaviour Assessment System for Children (r= .75) (Reynolds & Kamphaus, 2004).

T scores (M = 50, SD = 10) were used to determine the level of executive functioning of participants on the BRIEF2. These scores are attained by transforming and standardising raw scale scores according to age and gender. The T scores gave information about an participant's scores comparative to the scores of participants in the standardisation sample, with higher scores reflecting more pathology (Gioia et al., 2015). Summed total GEC scores above 65 were considered potentially clinically significant and scores above 70 were considered clinically significant as recommended by the authors (Gioia et al., 2015).

Table 2

*Internal Consistency Coefficients (α) and Test-retest correlation (*r*) for the BRIEF2 Parent Form (Gioia et al., 2015, pp. 101,111)*

	Internal Consistency Coefficients (α)	Test-retest correlation (*r*)*
n	2,892	163
Behavioural Regulation Index	.91	.83
Emotional Regulation Index	.92	.82
Cognitive Regulation Index	.95	.89
Global Executive Index	.96	.88

* Average interval of 3 weeks

2.3.4 Confounding Variables.

The current study identified confounding factors a priori based on previous literature describing variables that might alter children's cognitive development apart from fluoride ingestion (Broadbent et al., 2015; Choi et al., 2012; Sutton et al., 2015). Child and family factors assessed were collected as part of the demographics and were controlled for in statistical analyses as covariates.

2.4 Statistical Analyses

Data was analysed using Statistical Package for the Social Sciences (SPSS) Version 25.0 (IBM Corp., 2017). Firstly, the associations between exposure to fluoride and executive functioning were determined using general linear regression analyses. A logistic regression was used to assess whether difference in the level of lifetime exposure to fluoride would impact on the likelihood that participants would experience clinically elevated scores. All regression analyses were adjusted for a group of covariates that were previously identified as important predictors of children's behaviour: gender, residential location, indigenous identity, parental education status, household income, family composition and socioeconomic levels

Chapter 3: Results

3.1 Data Screening

The dataset was screened for missing responses and the initial examination of boxplots identified a number of outliers across the different domains of executive functioning. However, due to the nature of the questionnaire, all scores remained within the range of possible scores and upon further inspection, appeared to be consistent responses. Outliers were found to be consistently higher than the rest of the data set, indicating higher pathology amongst some participants which is expected within a population sample (Gioia et al., 2015). Therefore, in order to maintain the most reflective representation of the sample, all outliers were retained (Field, 2013).

Following the BRIEF2 protocols (Gioia et al., 2015) for missing responses, questionnaires with more than 12 missing responses and individual scales that had more than one missing responses were not scored and were removed (N=245). Additionally, participants who scored higher than six on the inconsistency scale (N=16) and the negative scale (N=6) were also removed as it would impact upon study validity (Gioia et al., 2015). Following the validity protocols of BRIEF2, participants that scored higher than one on the infrequency scale should not be scored. However, the dataset was found to have an anomalous number of responses that scored more than one (N=170). As BRIEF2 is a newer edition, the literature using BRIEF2 was limited and to the author's knowledge at the point of writing, there was no paper that discussed the use of the infrequency scale. As such, the authors of BRIEF2 were contacted but were not able to advise at the point of writing. Since the dataset had high validity on both the inconsistency and negative scales, it was decided that the current study would not incorporate the infrequency scales. Validity of questionnaires would therefore be scored solely based on the inconsistency and negative scales. Consequently, the final data set consisted of 947 participants out of the initial 1214.

Descriptive statistics and histograms were visually examined to assess data distribution and reveal outliers for all variables. Initial Shapiro-Wilk analysis indicated that all variables were not normally distributed but further inspection of histograms showed a close to normal distribution for BRIEF2 T scores. Following standard procedures, a parametric test (multiple regression) was deemed suitable. Durbin-Watson statistic test found that there was no auto-correlation in the data (Durbin-Watson value = 1.89). No variables showed multicollinearity as demonstrated by low level of multicollinearity (VIF = 1.01–1.49) (Alin, 2010). Therefore, the assumptions of a multiple linear regression were met.

3.1.2 Reliability.

Table 3 reports the Cronbach's α coefficients and standard deviations of the indexes and composite score. A commonly accepted criterion for acceptable reliability for α is .6–.7, with .8 or higher indicating good reliability (Gliem & Gliem, 2003). Internal consistency of BRI, MI and GEC were reported as high (range =.83–.98)

Table 3

Means and Standard Deviation of Indexes of BRIEF2 Indexes and Composite with Cronbach's Coefficients (α)

	M(SD)	BRIEF2 (Parent Form)
Behavioural Regulation Index	46.33(8.44)	.83
Cognitive Regulation Index	44.15(7.96)	.96
Emotional Regulation Index	48.83(9.36)	.93
Global Executive Index	45.35(8.91)	.98

3.2 Descriptive statistics

3.2.1 Lifetime Exposure to Fluoride

Data for lifetime exposure to fluoride (%LEWF) was obtained from NCOHS and was found to be found to be bimodal as most participants either experienced full exposure or

minimal exposure to fluoride (see Appendix A). Due to the non-normal distribution, %LEFW was categorised into three groups: minimal exposure (<25%, *N*=239), partial exposure (25–99%, *N*= 172), and full exposure (100%, *N*=496).

3.2.2 Demographic Variables.

Frequencies and percentages for the demographic variables across the three fluoride exposure groups are presented in Table 4. A larger proportion of participants (54.9%) experienced full exposure to fluoridated water. Overall, a visual inspection of the frequencies of the demographic demonstrate a similar proportion of participants in each confounding variable across the fluoride exposure groups. There are some observable small differences such as higher proportions of participants with low income in the minimal (19.7%) exposure group than partial (17.4%) and full (12.1%) exposure groups. The proportion of parents born in Australia was higher in the minimal group (70.7%) than all other exposure groups (59.5% and 67.9%). Finally, there is a sizeable proportion of participants in the full exposure group that lived in major cities (74.2%) whereas the majority of participants in the minimal exposure group that lived in inner regional areas (41.4%). Frequencies and percentages for excluded participants were reported in table 5. A visual comparison between the study sample and excluded participants show that there is a slightly higher proportion of one parent households and parents born in Australia in the excluded participants group while the rest of the demographic groups show minimal differences.

Table 4

Child, parent and household characteristics across the three fluoride exposure groups

Demographic characteristics	Factors	Percentage lifetime exposure to water fluoridation, LEFW%						
		Minimal Exposure		Partial Exposure		Full Exposure		Total
		N	%	N	%	N	%	N
Child Sex								
	Male	112	46.9	86	50.0	237	47.8	470
	Female	127	53.1	86	50.0	259	52.2	494
Child's Indigenous Identity								
	Nonindigenous	230	96.2	165	95.9	488	98.4	927
	Indigenous	7	2.9	6	3.5	8	1.6	22
Child's Residential Location								
	Major city	66	27.6	82	47.7	368	74.2	530
	Inner regional	99	41.4	41	23.8	82	16.5	227
	Outer regional	66	27.6	39	22.7	41	8.3	160
	Remote/Very remote	8	3.3	10	5.8	5	1.0	35
Parent Country Of Birth								
	Australian Born	169	70.7	103	59.9	337	67.9	640
	Overseas Born	69	28.9	69	40.1	158	31.9	310
Parent Education Status								
	Completed Bachelor's degree	164	68.6	134	77.9	486	77.8	690
	Vocational	42	17.6	27	15.7	68	13.7	138
	High School	28	11.7	11	6.4	41	8.3	87
Family Composition								
	One parent	18	6.5	21	12.2	43	8.7	89
	Two parent	220	92.9	151	87.8	452	91.1	861
Household income								
	Low	47	19.7	30	17.4	60	12.1	164
	Medium	106	44.4	65	37.8	217	43.8	394
	High	75	31.4	73	42.4	208	41.9	359

Table 5

Demographic variable frequencies for participants excluded and included in the study

Factors		Study Sample		Excluded Participants	
		N	%	N	%
Gender					
	Male	470	48.8	106	46.7
	Female	494	51.2	121	53.3
Child's Indigenous Identity					
	Nonindigenous	927	97.7	220	99.5
	Indigenous	22	2.3	1	0.5
Child's Residential Location					
	Major city	530	55.7	131	58.4
	Inner regional	227	23.8	49	22.0
	Outer regional	160	16.8	41	18.4
	Remote/Very remote	35	3.68	2	0.9
Parent Country Of Birth					
	Australian Born	640	67.4	164	73.9
	Overseas Born	310	32.6	58	26.1
Parent Education Status					
	Completed Bachelor's degree	690	75.4	162	75.7
	Vocational	138	15.1	23	10.7
	High School	87	9.51	29	13.6
Family Composition					
	One parent	89	6.3	33	14.8
	Two parent	861	93.7	190	85.2
Household income					
	Low	164	17.9	49	22.7
	Medium	394	43.0	88	40.7
	High	359	39.1	79	36.6

3.3 Bivariate Association Between Fluoride Exposure and Executive function

To explore the relationship between fluoride exposure and executive function, the study looked at the mean scores and standard deviations of BRIEF2 index scores across fluoride exposure groups. Additionally, the study investigated the effects of fluoride exposure on clinical executive dysfunction in the children by assessing the proportion of children that had elevated GEC scores across fluoride exposure groups. The average scores across BRI, CRI and GEC were half a standard deviation lower in comparison to the normative cohort described in the BRIEF2 professional manual (Gioia et al., 2015).

3.3.1 Association between Fluoride Exposure and Executive function.

Table 6 displays the group means and standard deviations for the three indexes and the composite. A visual comparison of the index and composite means suggested that there were no differences in T scores across the three exposure groups (minimal, partial and full exposure).

Table 6

Group Means on the BRIEF2 T Scores Indexes and Composites

Composite or scale	Fluoride Exposure Groups								
	Minimal Exposure			Partial Exposure			Full Exposure		
	M	SD	95%CI	M	SD	95%CI	M	SD	95%CI
Behavioural Regulation Index	45.6	8.0	44.7-46.8	46.6	9.2	45.2-48.0	46.0	7.7	45.3-46.3
Emotional Regulation Index	48.1	9.0	47.0-49.3	49.3	9.6	47.8-50.7	48.5	8.8	47.7-49.3
Cognitive Regulation Index	43.5	7.3	42.6-44.5	44.3	8.3	43.1-45.6	43.9	7.5	43.2-44.5
Global Executive Index	44.7	8.4	43.6-45.7	45.6	9.3	44.2-47.0	45.0	8.3	44.3-45.8

3.4 Multivariate Association between Fluoride Exposure and Executive Functioning

Previous studies have often excluded confounding variables such as gender, residential location, indigenous identity, parental education status, household income, family composition and socioeconomic levels. In order to fully explore the relationships between these variables and its impact on executive function, several multiple regressions were conducted concurrently with both the covariates and fluoride exposure.

3.4.1 Multiple Regression Analysis.

Four separate multiple regression analysis were conducted to investigate if lifetime exposure to fluoride significantly predicted executive function on BRIEF2 indexes and composites (BRI, ERI, CRI and GEC) across the fluoride exposure groups in conjunction with confounding variables. The results of the regression were then reported in Table 7 and further explained below.

First, BRI scores were examined to investigate the effect of early exposure of fluoride on the behavioural domain of executive function. Results indicate the overall regression model was significant ($R^2 = .033$, $F(7, 938) = 1.85$, $p = .019$) with the variables accounting for 3.3% of the variance. Identifying as indigenous was found to have significant positive regression weight in the model and were predicted to have higher BRI scores.

Next, ERI scores were examined to investigate the effect of early exposure of fluoride on the emotional domain of executive functioning. Results indicate the overall regression model was significant ($R^2 = .032$, $F(17, 932) = 1.79$, $p = .025$) with the variables accounting for 3.2% of the variance. Belonging to a single guardian household and having high household income was found to have significant positive regression weights in the model and predicted to have higher ERI scores.

Next, CRI scores were examined to investigate the effect of early exposure of fluoride on the cognitive domain of executive functioning. Results indicate the overall regression

model was significant (R^2 = .042, F(17, 937) = 2.38, p =.001) with the variables accounting for 4.2% of the variance. Males, identifying as indigenous and belonging to a single guardian household was found to have significant positive regression weights in the model, and were predicted to have higher CRI scores.

Lastly, GEC scores were examined to investigate the effects of fluoride exposure on executive functioning in general. Results indicate the overall regression model was significant (R^2 = .035, F(17, 936) = 1.98, p =.010) with the variables accounting for 3.5% of the variance. Having identified as indigenous and belonging to a single guardian household was found to have significant positive regression weights in the model that indicated lower executive functioning. Post hoc power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) implied that the power to distinguish effects at the 0.036 level was .98 for the overall regression in estimating GEC scores (see Appendix D)

Table 7

Summary of Multiple Regression Analysis for Variables Predicting BRIEF2 Indexes and Composites

	Behavioural Regulation Index				Emotional Regulation Index				Cognitive Regulation Index				Global Executive Composite			
Predictor	*B*	*SE B*	*t*	*p*	*B*	*SE B*	*t*	*p*	*B*	*SE B*	*t*	*p*	*B*	*SE B*	*t*	*p*
Intercept	42.29	2.96	14.28	<.01	47.54	3.29	14.47	<.01	42.95	2.75	15.62	<.01	43.15	3.09	13.96	<.01
Fluoride Exposure																
Minimal Exposure	REF															
Partial Exposure	.94	.82	1.15	.25	1.22	.91	1.34	.18	.75	.76	.98	.33	.99	.86	1.16	.25
Full Exposure	.80	.69	1.17	.24	1.03	.77	1.34	.18	.70	.64	1.09	.28	.89	.72	1.23	.22
Sex																
Male	REF															
Female	-.67	.53	-1.25	.21	-.01	.59	-.02	.98	-1.50	.50	-3.04	<.01	-.87	.56	-1.57	.12
Socioeconomic Status																
SEIFA 1	REF															
SEIFA 2	.54	1.00	.54	.59	.47	1.12	.42	.67	.55	.93	.59	.55	.58	1.05	.55	.58
SEIFA 3	-.68	1.01	-.67	.50	-.52	1.13	-.46	.65	-.49	.94	-.52	.61	-.66	1.06	-.62	.54
SEIFA 4	-.26	.97	-.26	.79	-.10	1.09	-.09	.93	.29	.90	.32	.75	.07	1.02	.07	.95
SEIFA 5 (Highest)	-.37	1.02	-.36	.72	-.21	1.13	-.16	.85	.38	.95	.40	.69	.02	1.06	.02	.99
Indigenous Identity																
Non-Indigenous	REF															
Indigenous	4.69	1.79	2.62	.01	3.16	1.96	1.59	.11	3.47	1.66	2.09	.04	4.05	1.87	2.17	.03

Country of Birth																
Australian-Born	REF															
Overseas-Born	.03	.60	.04	.97	.11	.66	.17	.87	-.08	.55	-.14	.89	-.01	.62	-.02	.96
Educational Level																
High School	REF															
Vocational	1.88	1.06	1.78	.08	1.45	1.18	1.23	.22	1.45	1.18	1.19	.98	1.51	1.10	1.37	.17
Tertiary	-.12	.89	-.14	.89	-.72	.99	-.72	.47	-.72	.99	-.56	.83	-.53	.93	-.57	.57
Residential Location																
Remote	REF															
Outer Regional	.31	1.57	.20	.84	.14	1.74	.08	.93	-.32	1.45	-.22	.86	-.07	1.64	-.04	.97
Inner Regional	1.73	1.55	1.12	.27	1.91	1.72	1.11	.27	1.39	1.44	.97	.33	1.73	1.62	1.07	.28
Major City	-.02	1.54	-.01	.99	-.36	1.71	-.21	.83	-.50	1.43	-.35	.73	-.36	1.61	-.23	.82
Family Composition																
One Parents	REF															
Two Parent	-1.69	.98	-1.72	.09	-2.41	1.09	-2.22	.03	-2.01	.91	-2.20	.03	-2.18	1.02	-2.13	.03
Family Income																
Low	REF															
Medium	.05	.88	.06	.95	-.61	.99	-.62	.54	>.01	.82	.01	.10	-.14	.92	-.15	.88
High	-.39	.60	-.65	.52	-1.58	.67	-2.35	.02	-.83	.56	-1.48	.14	-.99	.63	-1.57	.12

Note. %LEFW = individual-level per cent of lifetime exposure to fluoridated water
SEIFA was divided into quintiles and represented as four dummy variables with SEIFA 1, the lowest SEIFA group serving as the reference group.

3.4.2 Clinically Elevated Scores.

Direct logistic regression was performed to assess the impact of different levels of fluoride exposure on the likelihood that respondents would have clinically elevated GEC scores. Due to the small number of cases within the model, cases considered potentially clinically elevated (GEC scores >65) were included in the model. The model contained nine independent variables including the confounders as covariates. When fluoride exposure was entered into the covariate-adjusted model, the likelihood of receiving scores of 65 or above did not differ significantly across categories of exposure (see Table 8).

Table 8

Summary of Logistic Regression for Variables Predicting Clinically Elevated Scores

Predictors	B	S.E.	Wald	df	Sig.	Exp(B)	*95%CI*	
							Lower	Upper
Constant	-1.24	1.15	1.15	1	.28	.29		
Fluoride Exposure								
Minimal Exposure	REF							
Partial Exposure	.12	.51	.06	1	.81	1.13	.41	3.10
Full Exposure	-.03	.45	.01	1	.94	.97	.40	2.35
Sex								
Male	REF							
Female	-.59	.36	2.75	1	.10	.55	.27	1.11
Socioeconomic Status								
SEIFA 1	REF							
SEIFA 2	.50	.62	.66	1	.42	1.65	.49	5.53
SEIFA 3	.16	.65	.06	1	.81	1.18	.33	4.23
SEIFA 4	-.54	.69	.61	1	.44	.59	.15	2.25
SEIFA 5 (Highest)	.12	.68	.03	1	.86	1.13	.30	4.29
Indigenous Identity								
Non-Indigenous	REF							
Indigenous	1.32	.72	3.39	1	.07	3.75	.92	15.34
Country of Birth								
Australian-Born	REF							
Overseas-Born	.15	.42	.12	1	.72	1.16	.51	2.64
Educational Level								
High School	REF							
Vocational	.28	.60	.22	1	.64	1.32	.41	4.25
Tertiary	-.69	.57	1.45	1	.23	.50	.16	1.54
Residential Location								
Remote	REF							
Outer Regional	-.70	.89	.62	1	.43	.50	.09	2.82
Inner Regional	-.375	.87	.19	1	.67	.69	.13	3.75
Major City	-.926	.92	1.02	1	.31	.40	.07	2.38
Family Composition								
One Parents	REF							
Two Parent	-.707	.57	1.57	1	.21	.49	.16	1.49
Family Income								
Low	REF							
Medium	-.54	.52	1.07	1	.30	.58	.21	1.62
High	.10	.56	.03	1	.86	1.10	.37	3.27

Chapter 4: Discussion

The aim of the present study was to assess the association between early childhood exposure to fluoride and executive functioning, taking into account different confounding variables not previously explored in existing literature. Specifically, it aimed to demonstrate that there would be no association between executive function as a whole, its related domains (behavioural, emotional and cognitive), and early exposure to fluoride. The study also aimed to determine if level of early childhood exposure to fluoride was associated with having clinically elevated levels of executive dysfunction. The results of the study supported our hypothesis, demonstrating no evidence was found to establish that there is an association between fluoride exposure and executive functioning, as well as determining that fluoride exposure did not contribute to clinical elevations of behavioural dysfunction.

4.1 Relationship Between Executive Functioning and Early Exposure to Fluoride

4.1.1 Hypotheses 1 and 2.

As hypothesised and consistent with the findings by Broadbent et al. (2015), no evidence was found to establish an association between early exposure to fluoride and executive functioning. Additionally, results indicated that there was no evidence to establish that fluoride exposure impacted upon performance across the different domains of executive function. Nonetheless, despite having achieved non-significant results, it should be noted that the model indicated that there was a tendency for BRIEF2 scores to be higher with fluoride exposure. However, results also indicated that the effect size of fluoride exposure was higher in the partial exposure group when compared to the full exposure group, which is inconsistent with the anti-fluoride literature which indicated that higher fluoride levels correlated with lower IQ scores (Choi et al., 2012; Grandjean & Landrigan, 2006). Therefore, our results

suggest that no evidence was found to establish that early exposure to fluoride is associated with executive functioning.

The difference observed between the results of this study and the studies included in Choi et al's (2012) meta-analysis may be partially attributed to numerous confounding variables that were not controlled for in past studies, such as demographic variables (gender, socio-economic status, residential location etc.). One of the main oversights observed in the literature is the use of convenience samples found in rural areas with high levels of endemic fluoride in the groundwater. Rural populations have been found to have lower IQ scores compared to urban populations (Alexopoulos, 1997). Furthermore, in areas with high levels of endemic fluoride, fluoride levels have to be artificially adjusted downwards in water improvement facilities (Choi et al., 2012). The process of treating water through such a facility also removed lead from drinking water (Broadbent et al., 2015). Moreover, water improvement plants such as the ones in China are often located in more affluent areas, which therefore suggests that differences in IQ could be attributed to a number of external influences such as SES levels, residential location, or removal of lead (Broadbent et al., 2015). Conversely, since the majority of water sources in Australia have low levels of endemic fluoride, the difference in sample characteristics may have contributed the differences in findings between the Chinese studies and the current study (NRC, 2017b).

To summarise, in the context of community water fluoridation, early exposure to fluoride was not shown to have a significant effect on any domains of executive functioning after controlling for the confounding effects of the other independent variables in the model. Therefore, there is no evidence to establish a relationship between early exposure to fluoride and executive functioning in the Australian population. Confounding variables such as family composition and indigenous identity contributed to most domains of executive function, suggesting that participants that identified as indigenous or belonged to a single guardian

household experience higher pathology in the Australian population. This suggests that there may be a significant relationship between these variables and executive functioning in children as opposed to fluoride exposure itself. Although the preliminary analysis indicates promising results, this is still an ongoing study and a larger sample with additional statistical analysis that is required to better establish non-associations.

4.1.2 Hypothesis 3.

As hypothesised, results showed that fluoride exposure was not found to be a statistically significant predictor of participants having potentially clinically elevated GEC scores. Therefore, we can be more confident in there not being an effect after having controlled for a number of potential confounders. This indicates that there is no evidence to suggest an association between fluoride exposure and increased clinical executive dysfunction. This is inconsistent with previous literature claiming that exposure to fluoride might cause or contribute to executive dysfunction such as ADHD (Malin & Till, 2015). Similar to the Choi's study, Malin and Till's (2015) study did not control for a multitude of confounders – household income was the only covariate included. In contrast, another study found a significant association between residential altitude and the prevalence of ADHD. The study's analysis included the varying levels of water fluoridation, average state elevation, and a multitude of covariates which included social factors (Perrott, 2017). Results indicated that the prevalence of ADHD was not associated with fluoride exposure when the other covariates were included in the analysis. This suggests that difference in results from Malin and Till's study was the lack of control of confounding variables.

Furthermore, it is important to note that the difference of 0.4 in mean IQ scores that was described in Choi et al's (2012) study between the exposed and reference population is clinically negligible despite being statistically significant (Jekel, Katz, Elmore, & Wild, 2007). Studies have argued that clinical importance should be prioritised over statistical

significance since p-values can be changed by increasing sample size, mean difference and standard deviations of the variable of the population in the study (Jekel et al., 2007; Rothman, Greenland, & Lash, 2008; Sabour & Ghorbani, 2013). Therefore, future research should explore the clinical nature of executive dysfunction in the population as opposed as to just presenting difference in mean scores.

4.2 Comparison of BRIEF2 scores to Normative Samples.

The current study sample demonstrated lower scores on executive functioning when compared with the normative population (Gioia et al., 2015). One possible explanation could be attributed to volunteer bias since participants were given the choice to complete the questionnaire. Research has found that in general, volunteers come from a higher SES group, are more educated, have higher IQ scores, and are more approval-motivated (Rosenthal, 1965). This could be seen in the current study's demographics, in which a larger proportion of participants were found to have medium/high income with a tertiary education.

Additionally, as the current study is part of a bigger ongoing study, the study sample consisted of first responders. Researchers have reasoned that late responders (participants that return the second or third posting) are almost equivalent to non-responders (Papageorgiou, Croft, Ferry, Jayson, & Silman, 1995). Early responders were found to have a stronger function of intuition, giving them a consciousness that motivates them to finish and return the questionnaire rapidly (Randall, 2015). One study in particular suggested that first responders were more concerned about their physical and mental wellbeing, whereas, late respondents were more likely to answer negatively to questions that touched on mental functions and emotional status (Paganini-Hill, Hsu, Chao, & Ross, 1993). This suggests that the study sample might be more likely to have higher intuition and awareness of their child's behaviour, and score behavioural issues in their children more positively. Consequently, both

volunteer bias and early responders could explain for the lower levels of pathology in the current study sample.

4.3 Social Factors Impacting Upon Executive Functioning

As anticipated, demographic confounders were important in measuring executive function. The study found that family composition and indigenous status in particular were consistently significantly associated with executive functioning. These results has been partly corroborated by extensive literature indicating that social factors such as socioeconomic status, family composition and home environment are significantly associated with child executive functions (Ardila, Rosselli, Matute, & Guajardo, 2005; Featherstone, Cundick, & Jensen, 1992; Hanscombe et al., 2012).

An assessment of the present study's results revealed that participants that identify as indigenous have generally higher scores. These results were corroborated by governmental studies of parents and carers that have found a higher occurrence of behaviour difficulties in Indigenous children (Department of Education and Early Childhood Development, 2010; Li, Jacklyn, Carson, Guthridge, & Measey, 2006). However, it is important to note that the BRIEF has not been validated in indigenous populations and normative samples used to create the standardised groups of measure only included participants from the U.S population. Moreover, one study found that a number of questions in the BRIEF were found to be irrelevant – identified by parents and teachers – to Aboriginal children attending community schools (Wagner et al., 2017). This suggests that there might be an issue with the validity of BRIEF2 with regards to the extent to which BRIEF incorporates different cultural values and beliefs. The lack of cross-cultural adaption of BRIEF2 could then account for higher scores observed in the indigenous population.

Overall, extensive literature has shown that the development of a child's cognitive processing are affected by early life conditions such as social disadvantage (Ardila et al.,

2005; Berthelsen, Hayes, White, & Williams, 2017; Featherstone et al., 1992; Hanscombe et al., 2012). All of these social factors will then impact upon the executive functioning of the children, regardless of early childhood exposure of fluoride. Therefore, it is imperative that studies take into account demographic variables when investigating an association between fluoride exposure and executive functioning. Consequently, this could account for the difference between the results of this study and studies that did not take into account demographic confounders (Choi et al., 2012).

4.4 Methodological Strengths

One of the study's primary strength was the use of a population-based cohort study design in the most representative sample of children within Australia within the field of research. The dataset adapted from NCOHS offers a comprehensive set of data that include a range of socioeconomic factors and other possible confounding variables that are known to impact on executive functioning. Additionally, the data included children who had different levels of early exposure to fluoride in water across Australia, allowing the study to better understand the relationship between exposure to fluoride and executive functioning in children. Furthermore, the study achieved high statistical power given the effect size of fluoride exposure which was considered to be small using Cohen's (2013) criteria. Therefore, this study's sample size of 947 was more than adequate for the main objective of this study, which also allows for expected attrition.

Moreover, the participants of the current study group are reasonably similar in their characteristics to populations in developed countries such as North America, United Kingdom, and Scandinavian countries (Poulton et al., 2002). Therefore, the results are not only directly pertinent to the Australian child population, but other countries that use CWF at an optimal level (0.7 – 1.2ppm), allowing the results to be generalised to other similar populations.

Furthermore, the use of the BRIEF2 introduces a new measure of cognitive development in the context of water fluoridation that to the author's knowledge has not explored. The use of a reliable measure of executive functioning adds to the understanding of the daily functioning of children in their home and school settings which other studies that simply look at intelligence do not. Additionally, while the BRIEF2 has not been used in the context of fluoride exposure, it has been utilised in a research setting similar to the current study, investigating the effect of executive functioning in a classroom setting of children that had been exposed to a neurotoxin (e.g. arsenic) found in their environment. One cross-sectional study in particular investigated the relationship between arsenic found in drinking water and executive functioning in children using the first edition of the BRIEF (Wright et al., 2006). The results of the study were found to correlate in the expected direction with related measures that found no association between arsenic exposure and children's behaviour (Roy et al., 2011; Tofail et al., 2008). Thus, the BRIEF has shown to demonstrate validity within this field of research, allowing researchers to better understand executive function problems in everyday behaviour and was well suited to the aims of the study.

Another significant factor that distinguishes the current study from previous literature is the accurate classification of fluoride exposure that is absent in the literature. The calculation of exposure of fluoride has been standardised to take into account different concentrations of fluoride intake. This was assessed through a questionnaire that investigated water sources at all stages of the child's life such as the removal of fluoride through the use of filters, and residential locations through the child's lifetime. Additional sources of fluoride exposure were also assessed within the questionnaire, such as use of dental products (e.g. mouth rinse, toothpaste and fluoride drops) (Do & Spencer, 2016). Additionally, water authorities in the states and territories have set strict controls on the concentration of fluoride within the water supplies using legislation or Codes of Practice which ensures that the level

of water fluoridation is consistent throughout Australia (NHMRC, 2011). This allowed the accurate and standardised calculation of childhood exposure to water fluoridation. However, it is important to note that exposure to fluoride for participants was only calculated up to the time in which the NCOHS survey was conducted and does not measure additional fluoride exposure between the NCOHS study and the current. Nonetheless, the study's main focus is the impact of early exposure to fluoride on executive functioning and the use of %LEFW is still viable.

In summary, having used a robust standardised measurement of exposure to fluoride as well as controlling for social demographic variables, it can be concluded that in the context of CWF, the study has been able to provide enough substantiation that there is no evidence that would indicate an association between early exposure to fluoride and executive functioning in this cohort. To the author's knowledge, the integration of nationally representative datasets of fluoride exposure and developmental cognitive outcomes is a novel approach internationally.

4.5 Limitations

This study was not without limitations, and findings should be interpreted in light of the following methodological and theoretical concerns. Firstly, despite having attained a non-significant result, it is not possible to conclude that the effect is completely absent based on statistical non-significance ($p > .05$). Rejecting the hypotheses that fluoride exposure does not have an effect on executive functioning in children only suggest that there was not enough evidence to establish an association. Therefore, through the use of a traditional statistical test, the current study is not able to statistically support the hypothesis that the true effect size of fluoride exposure is zero (Lakens, 2017). In order to attain more specific predictions on the effect size of exposure to fluoride on executive functioning, non-inferiority testing can be used to establish that early exposure to fluoride does not impact upon psychological

outcomes. However, as the data set for the current study was recruited from part of a larger study, the sample size was not big enough to conduct a non-inferiority test.

Secondly, the study sample was drawn from a larger study that is still in the process of recruitment nationwide. As such, the current study did not attain an equal number of the representative sample of children from every territory/state. Nonetheless, this study did manage to attain a diverse range of participants national-wide across the different demographic groups, which has not previously been achieved in the current field of research. Thus, the current study has attained a population sample from a diverse range across the different confounding groups while the majority of previously mentioned studies have used small unrepresentative convenient samples.

Thirdly, one should consider the issues that came with using BRIEF2 as a measurement of cognitive development. First, the BRIEF2 test is a questionnaire based measure and can be susceptible to respondents' bias which is the tendency for participants to respond inaccurately questions and choose responses they believe are more socially desirable (Grimm, 2010). Furthermore, parent forms were used and the literature suggest that parents are susceptible to bias when providing information on their children due to personal judgements (Achenbach, 2009). Additionally, children's behaviour can differ accordingly with different context and interaction partners, therefore, a single informant form might be prone to further bias (Achenbach, 2009). Hence, reports by multiple informants – such as the additional use of teacher's forms might be beneficial. However, for the size of the study and research aims to investigate the effect of fluoride exposure to early exposure to fluoride, the use of a questionnaire was deemed to be a cost-efficient way to amass information from a large population in a reasonably short period of time. Moreover, BRIEF2 does not measure all domains of executive functioning but executive functioning consists of a multitude of interrelated domains that coexist together – e.g. set shifting, word and idea generation,

organization and planning skills (Anderson, 2002). Individual testing of children using additional tests of executive functioning – e.g. Wisconsin Card Sorting Test (WCST; Heaton, 1981), Design Fluency Test (Jones-Gotman & Milner, 1977), and different types of Tower tests (Jones-Gotman & Milner, 1977; Newell & Simon, 1972; Shallice, 1982)– would give a more comprehensive look at executive function of each child. However, such testing is resource-intensive and was beyond the scope of the current study and has not been conducted in this area of research.

Lastly, similarly to Broadbent's study (2015), the current study was susceptible to the neighbourhood effect due to the study design in which suburb-level confounding variables were not controlled for. Within-neighbourhood social interactions could impact upon children's cognitive development. A study found that there was higher occurrence of health problems in individuals living in lower-SES neighbourhoods, independent of individual SES (Roux et al., 2001). This would tie in with the variance in dental caries experience that was found to vary between suburb areas in a multilevel analysis conducted on the NCOHS dataset of children exposed to fluoridated water (Do & Spencer, 2015). Thus, indicating that there could be confounding factors within suburb areas that could potentially affect both oral health and psychological outcomes.

4.6 Practical and Policy Implications

There has been a rise in concern over the use of a community-based fluoride intervention and there has been widespread concerns within the population to oppose and stop the use of fluoridated water (Armfield, 2007; Knox, Garner, Dyason, Pearson, & Pit, 2017; Podgorny & McLaren, 2015). The perceived threat of fluoride comes from a lack of confidence in the current literature on water fluoridation (Podgorny & McLaren, 2015). Currently, there is a lack of high-quality evidence on the safety of fluoride use relevant to populations of developed countries. Therefore, it is unsurprising that there are groups of

people who are concerned over being constantly exposed to fluoride. The findings of the study can inform and educate the general public on the understanding and safety of fluoride use in children and their psychological development.

Furthermore, findings from the current study both substantiates and broadens the knowledge base concerning early exposure to fluoride on a child's psychological development in the Australian context. This is imperative because changing CWF policies would impact on the lower- socioeconomic members of society who are not in constant exposure with fluoride through the use of supplements or dental products (Do et al., 2014). Lowered level of fluoride in the water could potentially lead to an increase in dental caries within these populations. Therefore, considering these issues, there is a need for concrete evidence on the safety of fluoride use so as to ensure that fluoridation remains as an intervention to decrease the levels dental caries. The population-based evidence allows for us to provide high quality evidence in the context of use of CWF in developed countries to advise policy leaders such as the NHMRC, ARC, the education system, and various organisations related to child development.

4.7 Future research and conclusions

Future research should aim to decrease the use of clustered participants or include a measurement of factors within suburbs that may influence psychological outcomes so as to reduce the neighbourhood effect. Next, the constraints of this project prevented a complete evaluation and establishment of non-association of psychological development of children that had been exposed to fluoride. To improve this, future studies can use a test of non-inferiority that would firmly establish that there is no association between fluoride exposure and executive functioning. Additionally, more extensive standardised measures of the different domains of executive functioning can be used.

Lastly, while the current study and literature has investigated the relationship between early exposure to fluoride and executive functioning, there has yet to be a study that has scrutinised the precise level of fluoride exposure that would affect executive functioning in children. Therefore, future studies can estimate exact dose–response relations by using individual-level measures of fluoride exposure over time.

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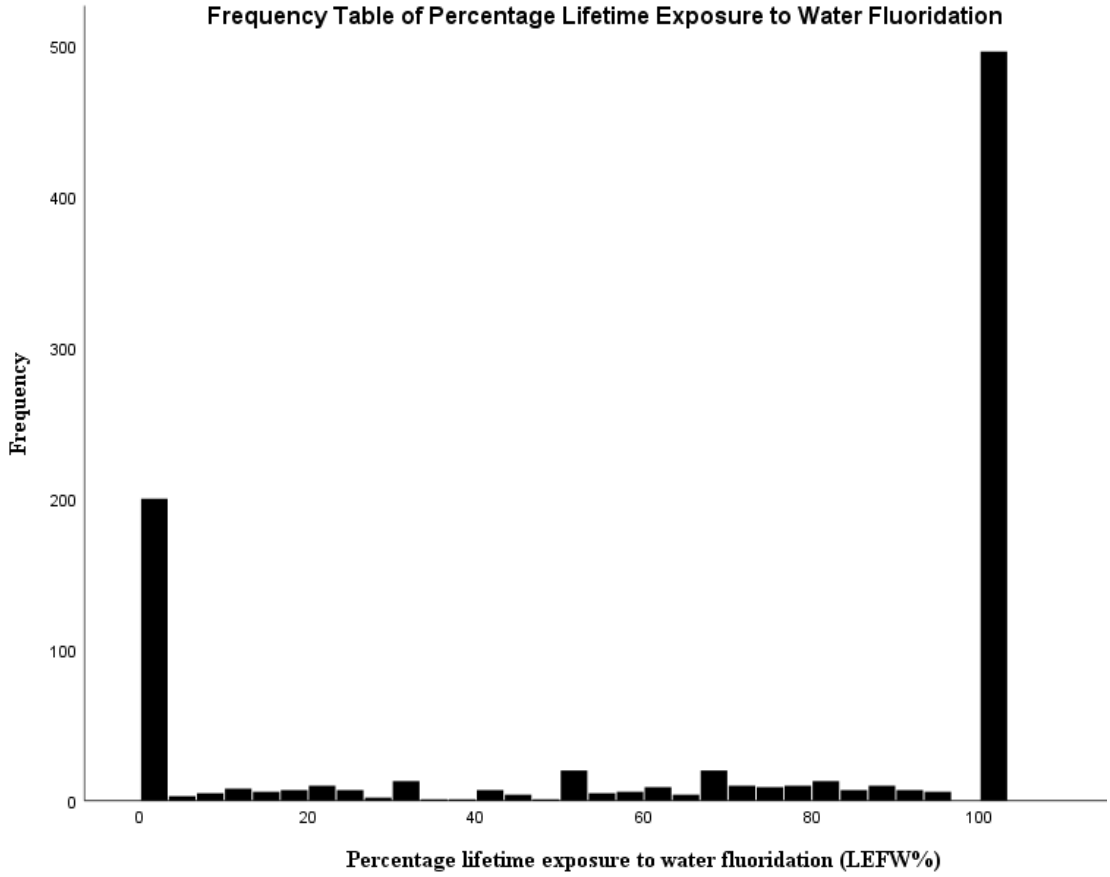
Appendices

Appendix A - Frequency Table



Appendix B - Information sheet and consent form

PARTICIPANT INFORMATION SHEET

PROJECT TITLE: Tooth for Health
HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: [redacted]
PRINCIPAL INVESTIGATOR: Professor Loc Do

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?
This research project is about dental habits, general health and early childhood development and how these relate to outcomes in children and young adults in Australia. We want to examine a range of potential influences, including environmental factors, demographics and the different ways families managed children's health. Details of those factors were collected in a questionnaire and dental examination of the National Child Oral Health Study 2012-14, in which you and your child took part.

Who is undertaking the project?
This project is being conducted by an international research team led by Professor Loc Do, a dental researcher at The University of Adelaide. The team includes Dr Alyssa Sawyer, a psychological researcher, and Dr Diep Ha and Emeritus Professor John Spencer, dental researchers at The University of Adelaide, Professor Alison Jones, a health expert at the University of Wollongong, and Dr Sam Leary, a statistician at the University of Bristol UK.
The project has received funding from the National Health and Medical Research Council.

Why am I being invited to participate?
You and your child participated in the National Child Oral Health Study (NCOHS) 2012-14. NCOHS was a nation-wide study conducted by researchers at The University of Adelaide in collaboration with state/territory dental services, where parents completed a questionnaire about various factors related to child dental health and children were seen by a dental team to assess their teeth and gums. You agreed for us to re-contact you for research purpose.

What am I being invited to do?
You are being invited to complete another questionnaire at your own time. The questionnaire asks about your child's perception of dental health, school and social activities, social and emotional behaviours and cognitive functioning, and use of dental services. You can choose to complete the questionnaire online or on paper.

A small group of children will also be invited to meet with a trained psychologist who will undertake a standard intelligence test. Such interviews would take place in a location and at a time convenient to you and your child. We may request your permission to video record the interview for quality assurance purpose. The interviews will be assessed by a senior psychologist. The test will not be used as a diagnostic test. When necessary, the senior psychologist will discuss with you about further clinical assessment of your child by your own healthcare providers.

How much time will my involvement in the project take?
Completion of the questionnaire would take up to 30 min. An interview would take 40 to 60 min.
There will not be a repeat of those activities.

Are there any risks associated with participating in this project?
No risk is expected from participating in this project. Some people may feel anxious about the intelligence test.

What are the potential benefits of the research project?
While there may not be direct benefit to you and/or your child from participating in this project, its findings will provide valuable information to understand links between dental and general health of children and young adults.

Version 4 Date updated: 06 June 2019

Such information will be important to advise the policymakers, dental care providers and the community about important factors affecting health.

Can I withdraw from the project?
Participation in this project is completely voluntary. Your right to decline will be respected and this will not affect your dental care or health services in any way. You may also withdraw from the Study at any time by contacting the researchers.

What will happen to my information?
The personal information that you provide are accessible only to the principal investigator of this project. Yours and your child's dental health will be de-identified and stored in the secure network of The University of Adelaide and accessible only to the named investigators.

We will analyse the collected information to explore possible associations with child dental health. We will publish the findings in relevant scientific journals. The study findings will be reported in combined forms. Personal details including residential locality, age and gender that may enable re-identification of a person will not be published.

Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.

Who do I contact if I have questions about the project?
Please contact the research team leader, Professor Loc Do at [redacted] or email [redacted]

What if I have a complaint or any concerns?
The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number [redacted]. This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research (2007). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:
Phone: +61 8 8313 6028
Email: hrec.adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000
Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If I want to participate, what do I do?
We will send you a questionnaire via email or to your postal address with instruction on how to complete it. For those selected for interviews, we will contact you to organise a convenient time and location to meet.

Yours sincerely,

Professor Loc Do
Professor Alison Jones
Dr Sam Leary
Dr Alyssa Sawyer
Dr Diep Ha
Emeritus Professor John Spencer

Appendix C - Questionnaire in full

THE UNIVERSITY of ADELAIDE

TOOTH for HEALTH

Parent's Questionnaire

Dear Parent,

Thank you for agreeing to help with this important study.

Please answer the following questions and return the questionnaire in the reply-paid envelope provided.

Please give one answer for each question unless otherwise stated.

The pages in this booklet are double sided. Please make sure you answer the questions on both sides of the page.

Please note: there are **NO RIGHT or WRONG answers**.

We are interested in your views and opinions. We would like you to answer all the questions as accurately and as honestly as you can. If you find there is no answer exactly fitting you, please take the response that fits you best.

Please feel free to contact us if you have any questions about the study or the questionnaire or if you want to complete the questionnaire online.

All information provided will be **STRICTLY CONFIDENTIAL**

Please inform us of your best contact details:

Mobile: ..... Email.....

IF YOU HAVE ANY ENQUIRIES, PLEASE CONTACT THE "TOOTH for HEALTH" TEAM AT THE UNIVERSITY OF ADELAIDE

[redacted]

ID:

1

PART A: YOUR CHILD'S DENTAL BEHAVIOURS AND PRACTICES
In this section we would like you to answer some questions about your child's teeth and mouth.

A1 Did YOUR CHILD brush his/her teeth before bedtime yesterday?

Yes ☐1 No ☐2

A2 How often does YOUR CHILD usually brush his/her teeth?

Three or more times per day ☐1 Once per day ☐3
Twice per day ☐2 Less than one time per day ☐4

A3 How long does YOUR CHILD usually brush his/her teeth

<30 seconds ☐1 30 seconds–1 min ☐2 1–2 min ☐3 2+ min ☐4

A4 What type of toothpaste is usually used for YOUR CHILD?

Standard fluoride toothpaste ☐1 Fluoride toothpaste for children under 6 years ☐2
Non-fluoride toothpaste ☐3 Don't know/Not sure ☐4

A5 How much toothpaste is usually put on YOUR CHILD's toothbrush?


Full length ☐1


Pea size ☐2


Smear layer ☐3

A6 What does your child usually do after tooth-brushing?

Just spit ☐1 Rinse and spit ☐2 Just swallow ☐3 Rinse and swallow ☐4 Don't know ☐5

A7 Has your child ever had a toothache?

No ☐1 Yes ☐2 *(If Yes, please specify below)*

	When (age)	What caused it		
1st time	.....Years	Tooth decay ☐1	Injury ☐2	Don't know ☐3
2nd time	.....Years	Tooth decay ☐1	Injury ☐2	Don't know ☐3
3rd time	.....Years	Tooth decay ☐1	Injury ☐2	Don't know ☐3

A8 Has your child ever had a tooth removed because it was decayed or abscessed?

No ☐1
Yes ☐2 *If Yes, when (please write down age)*.....Years.....months
.....Years.....months

2

A9 Please provide details of your child's use of dental services during the last five years

(Please write down for each visit)

Time	When (age)	Services received
Example: 1st visit	*9 years old*	*Oral health advice; filling; fluoride varnish*
1st visit		
2nd visit		
3rd visit		
4th visit		
5th visit		

A10 During the last 12 months, did you delay or avoid a dental visit for your child?

No ☐1

Yes ☐2 (If Yes, *please specify below what you had to delay*)

A check-up ☐1 Treatment for a problem that was causing pain ☐3

A preventive care ☐2 Treatment for a problem that was NOT causing pain ☐4

A11 Please give us your opinion on each statement below

	Strongly disagree	Moderately disagree	Slightly disagree	Neither disagree nor agree	Slightly agree	Moderately agree	Strongly agree
1. I intend for my child to visit the dentist in the next 12 months	☐1	☐2	☐3	☐4	☐5	☐6	☐7
2. It is important for children to visit the dentist every year	☐1	☐2	☐3	☐4	☐5	☐6	☐7
3. I want my child to visit the dentist	☐1	☐2	☐3	☐4	☐5	☐6	☐7

A12 Having my child visit the dentist in the next 12 months would be... *(TICK ONE BOX ONLY)*

Extremely difficult	Quite difficult	Slightly difficult	Neither difficult nor easy	Slightly easy	Quite easy	Extremely easy
☐1	☐2	☐3	☐4	☐5	☐6	☐7

A13 Does your child feel afraid or anxious when going to the dentist?

Not at all ☐1 A little ☐2 Moderately ☐3 Very ☐4 Extremely ☐5

A14 How hard would it be for you to pay a $150 dental bill for your child?

Not hard at all ☐1 Not very hard ☐2 A little bit hard ☐3 Very hard ☐4 Could not pay ☐5

A15 How much is your child's overall well-being affected by the condition of his/her teeth, lips, jaw or mouth?

Not at all ☐1 Very little ☐2 Some ☐3 A lot ☐4 Very much ☐5

3

A16 The following questions ask about symptoms and discomfort that children may experience due to the conditions of their TEETH, LIPS, MOUTH AND JAWS

During last 3 months, how often has YOUR CHILD	Never	Once or twice	Sometimes	Often	Every day or almost everyday	Don't know
...had pain in the teeth, lips, jaw or mouth?	☐1	☐2	☐3	☐4	☐5	☐6
...had bleeding gums?	☐1	☐2	☐3	☐4	☐5	☐6
...had bad breath?	☐1	☐2	☐3	☐4	☐5	☐6
...had food stuck on the roof of the mouth?	☐1	☐2	☐3	☐4	☐5	☐6
...breathed through the mouth?	☐1	☐2	☐3	☐4	☐5	☐6
...had trouble sleeping?	☐1	☐2	☐3	☐4	☐5	☐6
...taken longer than others to eat a meal?	☐1	☐2	☐3	☐4	☐5	☐6
...had difficulty drinking or eating hot or cold foods?	☐1	☐2	☐3	☐4	☐5	☐6
...been irritable or frustrated?	☐1	☐2	☐3	☐4	☐5	☐6
...missed school (e.g. pain, appointments, surgery)?	☐1	☐2	☐3	☐4	☐5	☐6
...had a hard time paying attention in school?	☐1	☐2	☐3	☐4	☐5	☐6
...not wanted to talk to other children?	☐1	☐2	☐3	☐4	☐5	☐6
...worried that he/she is not as healthy as other people?	☐1	☐2	☐3	☐4	☐5	☐6
...worried that he/she is different from other people?	☐1	☐2	☐3	☐4	☐5	☐6
...acted shy or embarrassed?	☐1	☐2	☐3	☐4	☐5	☐6
...been asked questions by other children about his/her teeth, lips, mouth or jaws?	☐1	☐2	☐3	☐4	☐5	☐6

A17 The following questions ask about effects that your child's oral conditions may have on PARENTS AND OTHER FAMILY MEMBERS.

During the last 3 months, because of your child's TEETH, LIPS, MOUTH or JAWS, how often have YOU or OTHER FAMILY MEMBERS	Never	Once or twice	Sometimes	Often	Every day or almost everyday	Don't know
...been upset?	☐1	☐2	☐3	☐4	☐5	☐6
...had sleep disrupted?	☐1	☐2	☐3	☐4	☐5	☐6
...taken time off work (e.g. due to pain, appointments, surgery)?	☐1	☐2	☐3	☐4	☐5	☐6
...had less time for yourself or the family?	☐1	☐2	☐3	☐4	☐5	☐6
...worried that your child will have fewer life opportunities (e.g. for dating, getting married, having children, getting a job he/she will like)?	☐1	☐2	☐3	☐4	☐5	☐6
...blamed you or another person in the family?	☐1	☐2	☐3	☐4	☐5	☐6
...argued with you or others in the family?	☐1	☐2	☐3	☐4	☐5	☐6
...required more attention from you or others in the family?	☐1	☐2	☐3	☐4	☐5	☐6

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PART B: CHILDHOOD BEHAVIOURS
We would like to know if your child has had problems with these behaviours during the LAST SIX MONTHS. Please answer all the items the best that you can. Please do not skip any items.
Think about your child as you read these statements and place a clear "X" in the box that best describes your child's behaviour.

B1. During the last six months, how often has each of the following behaviours been a problem?	Never	Sometimes	Often
Overreacts to small problems	☐1	☐2	☐3
When given two things to do, remembers only the first or last	☐1	☐2	☐3
Is unaware of how his/her behaviour affects or bothers others	☐1	☐2	☐3
When instructed to clean up, puts things away in a disorganized, random way	☐1	☐2	☐3
Becomes upset with new situations	☐1	☐2	☐3
Has explosive, angry outbursts	☐1	☐2	☐3
Has trouble carrying out the actions needed to complete tasks (such as trying one puzzle piece at a time, cleaning up to earn a reward)	☐1	☐2	☐3
Does not stop laughing at funny things or events when others stop	☐1	☐2	☐3
Needs to be told to begin a task even when willing to do it	☐1	☐2	☐3
Has trouble adjusting to new people (such as babysitter, teacher, friend, or a day care worker)	☐1	☐2	☐3
Becomes upset too easily	☐1	☐2	☐3
Has trouble concentrating on games, puzzles, or play activities	☐1	☐2	☐3
Has to be more closely supervised than similar playmates	☐1	☐2	☐3
When sent to get something, forgets what he/she is supposed to get	☐1	☐2	☐3
Is upset by a change in plans or routine (for example, order of daily activities, adding last minute errands to schedule, change in driving route to store)	☐1	☐2	☐3
Has outbursts for little reason	☐1	☐2	☐3
Repeats the same mistakes over and over even after help is given	☐1	☐2	☐3
Acts wilder or sillier than others in groups (such as birthday parties, play group)	☐1	☐2	☐3
Cannot find clothes, shoes, toys, or books even when he/she has been given specific instructions	☐1	☐2	☐3
Takes a long time to feel comfortable in new places or situations (such as visiting distant relatives or new friends)	☐1	☐2	☐3
Mood changes frequently	☐1	☐2	☐3
Makes silly mistakes on things he/she can do	☐1	☐2	☐3
Is fidgety, restless, or squirmy	☐1	☐2	☐3
Has trouble following established routines for sleeping, eating, or play activities	☐1	☐2	☐3
Is bothered by loud noises, bright lights, or certain smells	☐1	☐2	☐3
Small events trigger big reactions	☐1	☐2	☐3
Has trouble with activities or tasks that have more than one step	☐1	☐2	☐3
Is impulsive	☐1	☐2	☐3

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B1. During the last six months, how often has each of the following behaviours been a problem?	**Never**	**Sometimes**	**Often**
Has trouble thinking of a different way to solve a problem or complete an activity when stuck	☐1	☐2	☐3
Is disturbed by changes in the environment (such as new furniture, things in room moved around, or new clothes)	☐1	☐2	☐3
Angry or tearful outbursts are intense but end suddenly	☐1	☐2	☐3
Needs help from adult to stay on task	☐1	☐2	☐3
Does not notice when his/her behaviour causes negative reactions	☐1	☐2	☐3
Leaves messes that others have to clean up even after instruction	☐1	☐2	☐3
Has trouble changing activities	☐1	☐2	☐3
Reacts more strongly to situations than other children	☐1	☐2	☐3
Forgets what he/she is doing in the middle of an activity	☐1	☐2	☐3
Does not realize that certain actions bother others	☐1	☐2	☐3
Gets caught up in the small details of a task or situation and misses the main idea	☐1	☐2	☐3
Has trouble "joining in" at unfamiliar social events (such as birthday parties, picnics, holiday gatherings)	☐1	☐2	☐3
Is easily overwhelmed or overstimulated by typical daily activities	☐1	☐2	☐3
Has trouble finishing tasks (such as games, puzzles, pretend play activities)	☐1	☐2	☐3
Gets out of control more than playmates	☐1	☐2	☐3
Cannot find things in room or play area even when given specific instructions	☐1	☐2	☐3
Resists change of routine, foods, places, etc.	☐1	☐2	☐3
After having a problem, will stay disappointed for a long time	☐1	☐2	☐3
Cannot stay on the same topic when talking	☐1	☐2	☐3
Talks or plays too loudly	☐1	☐2	☐3
Does not complete tasks even after given directions	☐1	☐2	☐3
Acts overwhelmed or overstimulated in crowded, busy situations (such as lots of noise, activity, or people)	☐1	☐2	☐3
Has trouble getting started on activities or tasks even after instructed	☐1	☐2	☐3
Acts too wild or out of control	☐1	☐2	☐3
Does not try as hard as his/her ability on activities	☐1	☐2	☐3
Has trouble putting the brakes on his/her actions even after being asked	☐1	☐2	☐3
Unable to finish describing an event, person, or story	☐1	☐2	☐3
Completes tasks or activities too quickly	☐1	☐2	☐3
Is unaware when he/she does well and not well	☐1	☐2	☐3
Gets easily side-tracked during activities	☐1	☐2	☐3
Has trouble remembering something, even after a brief period of time	☐1	☐2	☐3
Becomes too silly	☐1	☐2	☐3
Has a short attention span	☐1	☐2	☐3
Plays carelessly or recklessly in situations where he/she could be hurt (such as playground, swimming pool)	☐1	☐2	☐3
Is unaware when he/she performs a task right or wrong	☐1	☐2	☐3

B2 **The following items collect information on how your child usually behaves. The information helps in understanding potential links between behaviours and dental health.**

For each item, please mark the box for Not True, Somewhat True or Certainly True.
It would help us if you answered all items as best you can even if you are not absolutely certain.
Please provide answers on the basis of your child's behaviour over the **last six months**

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐1	☐2	☐3
Restless, overactive, cannot stay still for long	☐1	☐2	☐3
Often complains of headaches, stomach aches or sickness	☐1	☐2	☐3
Shares readily with other young people, for example CDs, games, food	☐1	☐2	☐3
Often loses temper	☐1	☐2	☐3
Would rather be alone than with other young people	☐1	☐2	☐3
Generally well behaved, usually does what adults request	☐1	☐2	☐3
Many worries or often seem worried	☐1	☐2	☐3
Helpful if someone is hurt, upset or feeling ill	☐1	☐2	☐3
Constantly fidgeting or squirming	☐1	☐2	☐3
Has at least one good friend	☐1	☐2	☐3
Often fights with other young people or bullies them	☐1	☐2	☐3
Often unhappy, depressed or tearful	☐1	☐2	☐3
Generally liked by other young people	☐1	☐2	☐3
Easily distracted, concentration wanders	☐1	☐2	☐3
Nervous in new situations, easily loses confidence	☐1	☐2	☐3
Kind to younger children	☐1	☐2	☐3
Often lies or cheats	☐1	☐2	☐3
Picked on or bullied by other young people	☐1	☐2	☐3
Often volunteers to help others (parents, teachers, other children)	☐1	☐2	☐3
Thinks things out before acting	☐1	☐2	☐3
Steals from home, school or elsewhere	☐1	☐2	☐3
Gets along better with adults than with other young people	☐1	☐2	☐3
Many fears, easily scared	☐1	☐2	☐3
Good attention span, sees chores or work through to the end	☐1	☐2	☐3

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B3. **Do you have any other comments or concerns?**

B4 Overall, do you think that your child has difficulties in one or more of the following areas: emotions, concentration, behaviour or being able to get on with other people?

No	Yes- minor difficulties	Yes- definite difficulties	Yes- severe difficulties
☐1	☐2	☐3	☐4

If you have answered "YES", please answer the following questions about these difficulties:

B5. How long have these difficulties been present?	**Less than a month**	**1-5 months**	**6-12 months**	**Over a year**
	☐1	☐2	☐3	☐4

B6 Do the difficulties upset or distress your child?	Not at all	Only a little	Quite a lot	A great deal
	☐1	☐2	☐3	☐4

B7. Do the difficulties interfere with your child's everyday life in the following areas?	Not at all	Only a little	Quite a lot	A great deal
HOME LIFE	☐1	☐2	☐3	☐4
FRIENDSHIPS	☐1	☐2	☐3	☐4
CLASSROOM LEARNING	☐1	☐2	☐3	☐4
LEISURE ACTIVITIES	☐1	☐2	☐3	☐4

B8. Do the difficulties put a burden on you or the family as a whole?	Not at all	Only a little	Quite a lot	A great deal
	☐1	☐2	☐3	☐4

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PART C: YOUR CHILD'S GENERAL HEALTH AND HIS/HER DAILY ACTIVITIES
General health and activities may have a link to dental health

C1 During the last five years, has your child ever had to take medication, including antibiotics to treat any health condition?

No ☐1 Yes ☐2 (please specify below)

	Type of medication (please name)	Condition being treated	For how long (days)	Child's age when taking medication
Medication # 1				
Medication # 2				
Medication # 3				
Medication # 4				

C2 Has a healthcare provider ever told you that your child had/has any of the following?

A behavioural health condition (ADD, ADHD)	Yes ☐1	No ☐2
Autism, Asperger's disorder, other Autism Spectrum Disorder	Yes ☐1	No ☐2
A learning disability (dyslexia, dyscalculia)	Yes ☐1	No ☐2
A mental health condition (depression, anxiety)	Yes ☐1	No ☐2
An ear infection (otitis media, glue ear)	Yes ☐1	No ☐2
Other special needs (epilepsy, physical impairment)	Yes ☐1	No ☐2
Asthma	Yes ☐1	No ☐2
Diabetes	Yes ☐1	No ☐2
Allergy (please specify if **YES**)_____	Yes ☐1	No ☐2
Eczema	Yes ☐1	No ☐2

C3 During the last 12 months...

… has your child had trouble concentrating in school because of dental problems?	Yes ☐1	No ☐2
… has your child missed school because of dental problems?	Yes ☐1	No ☐2
… has your child missed school to visit a dental provider?	Yes ☐1	No ☐2

C4 How would you describe your child's performance in school during the last 12 months?

Excellent ☐1 Above average ☐2 Average ☐3 Below average ☐4

C5 How would you rate your child's dental health? (tick one box only)

Excellent ☐1 Very good ☐2 Good ☐3 Fair ☐4 Poor ☐5

C6 How would you rate your child's general health? (tick one box only)

Excellent ☐1 Very good ☐2 Good ☐3 Fair ☐4 Poor ☐5

C7 Since birth, has your child ever had treatment in the hospital under general anaesthetic?

No ☐1 Yes ☐2 (please specify below)

Example: Type of treatment Tonsillitis When 10 years (age)

Type of treatment_____When_____ (age)

Type of treatment_____When_____ (age)

Type of treatment_____When_____ (age)

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PART D: GENERAL INFORMATION ABOUT YOUR FAMILY

This part collects information about your household. These questions will help us to decide if different methods of preventing dental problems work equally well for all groups within the community and to ensure that the researchers obtain an accurate cross-section of all households.

ANY INFORMATION YOU PROVIDE WILL BE STRICTLY CONFIDENTIAL.

	Mother	Other Parent/Partner
D1 **What is your current work status?** (Please tick one box for each column)	☐₁ Full time employed ☐₂ Part time employed ☐₃ Currently not employed ☐₄ Home duties ☐₅ Pensioner ☐₆ Other	☐₁ Full time ☐₂ Part time employed ☐₃ Currently not employed ☐₄ Home duties ☐₅ Pensioner ☐₆ Other .....
D2 **What is your current main occupation?** (Please tick one box for each column)	☐₁ Professional ☐₂ Para-professional/ Trade person ☐₃ Clerk / Salesperson ☐₄ Manual worker / Drivers ☐₅ Other	☐₁ Professional ☐₂ Para-professional/Trade person ☐₃ Clerk / Salesperson ☐₄ Manual worker / Drivers ☐₅ Other .....
D3 **What is the highest level of education you have?** (Please tick one box for each column)	☐₁ Some high school ☐₂ Completed high school ☐₃ Some vocational training ☐₄ Completed vocational training ☐₅ Some University or College ☐₆ Completed University or College	☐₁ Some high school ☐₂ Completed high school ☐₃ Some vocational training ☐₄ Completed vocational training ☐₅ Some University or College ☐₆ Completed University or College

D4 **Which category does your TOTAL household income per year (before tax) fall into?**
(Include any salaries, pensions, allowances, benefits etc. received by all persons in the household)
(please tick one box only)

Up to $20,000	☐₁	$100,001 to $120,000	☐₆
$20,001 to $40,000	☐₂	$120,001 to $140,000	☐₇
$40,001 to $60,000	☐₃	$140,001 to $160,000	☐₈
$60,001 to $80,000	☐₄	$160,001 to $180,000	☐₉
$80,001 to $100,000	☐₅	Over $180,000	☐₁₀

D5 **How many people currently live in your household (including yourself)?**

..... adults (over 15 years) .....children (0-15 years)

D6 **Is your child covered by a healthcare concession card?**

Yes ☐₁
No ☐₂
Don't know/ Can't say ☐₃

D7 **Are you covered by private health insurance other than Medicare?**

No ☐₁
Yes ☐₂ *If Yes, does the private health insurance cover dental care?*
No ☐₁ Yes ☐₂

D8 **Is your child's MAIN place of residence a...?** (please tick one box only)

One-parent household ☐₁ Two-parent household ☐₂

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PART E: EVALUATION OF YOUR CHILD'S DENTAL SERVICES
The following questions ask for evaluation of dental services your child has received. This will provide us with important information about the quality of child dental health services.

PLEASE CONTINUE TO ANSWER WITH REGARDS TO YOUR CHILD'S LAST DENTAL VISIT.

PLEASE DO NOT INCLUDE VISITS FOR ORTHODONTIC TREATMENT OR EMERGENCY VISITS FOR TRAUMA.

*"**Dental care provider**" refers to the dentist or oral health therapist that provided dental care to your child.*

*"**Dental clinic**" refers to the place where your child made his/her last dental visit for routine dental care and may include a school dental service clinic or a private dental practice.*

E1. Did you attend the dental clinic with your child at his/her LAST dental visit? *(Tick one box only)*

☐1 Yes

☐2 Spouse/partner/other family member attended (*please consult him/her about items below)*

☐3 No *(please answer to the best of your knowledge for the rest of this part B)*

E2 At your child's LAST dental visit, how would you rate the dental care your child received? *(Tick one box only)*

Excellent	Very good	Good	Fair	Poor
☐1	☐2	☐3	☐4	☐5

E3. Please answer the following section with reference to your child's LAST dental visit. Read each statement then select one of the boxes to indicate your level of DISAGREEMENT or AGREEMENT with that statement. *(Tick one box only for each statement)*

At my child's last dental visit...	Strongly disagree				Strongly agree
1. The dental care my child received improved his/her oral health	☐1	☐2	☐3	☐4	☐5
2. My child's oral health would have been worse if he/she had not received the dental treatment	☐1	☐2	☐3	☐4	☐5
3. The dental care my child received improved his/her oral well-being	☐1	☐2	☐3	☐4	☐5
4. My child was given advice on oral self care	☐1	☐2	☐3	☐4	☐5
5. The care my child received was appropriate for his/her dental needs	☐1	☐2	☐3	☐4	☐5
6. There was a strong emphasis on prevention of future dental problems	☐1	☐2	☐3	☐4	☐5
7. I felt confident that my child received no more treatment than was needed	☐1	☐2	☐3	☐4	☐5
8. The clinic was well maintained and tidy	☐1	☐2	☐3	☐4	☐5

At my child's last dental visit...	Strongly disagree				Strongly agree
9. The clinic appeared to have enough staff	☐1	☐2	☐3	☐4	☐5
10. The clinic appeared to be well-equipped	☐1	☐2	☐3	☐4	☐5
11. The staff at the clinic were friendly and happy	☐1	☐2	☐3	☐4	☐5
12. My child did not get recommended dental treatment because of the cost	☐1	☐2	☐3	☐4	☐5
13. I felt protected financially against possible expenses for my child's dental care	☐1	☐2	☐3	☐4	☐5
14. The dental care my child received was good value for money	☐1	☐2	☐3	☐4	☐5
15. The dental care my child received was a good investment for his/her future oral health	☐1	☐2	☐3	☐4	☐5
16. I deferred/delayed making my child's last dental visit because of the cost	☐1	☐2	☐3	☐4	☐5
17. My child was able to access care when needed	☐1	☐2	☐3	☐4	☐5
18. The days/hours the clinic was open prevented my child from getting care when wanted	☐1	☐2	☐3	☐4	☐5
19. The distance to the clinic prevented my child from getting care when wanted	☐1	☐2	☐3	☐4	☐5
20. Communication between the dental care provider and my child was appropriate for my child	☐1	☐2	☐3	☐4	☐5
21. My child was relaxed about attending the clinic for dental care	☐1	☐2	☐3	☐4	☐5
22. I received enough information to make an informed decision on consent for treatment	☐1	☐2	☐3	☐4	☐5
23. My child's dental care provider gave useful feedback about my child's oral health	☐1	☐2	☐3	☐4	☐5
24. The dental services my child received were efficient	☐1	☐2	☐3	☐4	☐5
25. The staff at the clinic worked well together as a team	☐1	☐2	☐3	☐4	☐5
26. My child seemed at ease when he/she was with the dental care provider	☐1	☐2	☐3	☐4	☐5
27. My child had no bad effects from the dental treatment provided	☐1	☐2	☐3	☐4	☐5
28. The staff at the clinic showed consideration for personal well-being (including that of my child and of themselves)	☐1	☐2	☐3	☐4	☐5
29. I felt confident that good infection control measures were in place	☐1	☐2	☐3	☐4	☐5
30. I had confidence in my child's dental care provider	☐1	☐2	☐3	☐4	☐5
31. My child's dental care provider had the skills needed for my child's care	☐1	☐2	☐3	☐4	☐5
32. My child's dental care provider had the knowledge needed for my child's care	☐1	☐2	☐3	☐4	☐5

At my child's last dental visit...	Strongly disagree				Strongly agree	No dental problem
33. My child's dental care provider adopted relevant new approaches in caring for oral health	☐1	☐2	☐3	☐4	☐5	☐6
34. My child was seen by the same dental care provider he/she usually sees	☐1	☐2	☐3	☐4	☐5	☐6
35. My child's dental care provider consulted with or referred my child to other experts/specialists when needed	☐1	☐2	☐3	☐4	☐5	☐6
36. My child's dental care provider issued my child a recall notice when a recall visit was needed	☐1	☐2	☐3	☐4	☐5	☐6
37. The dental care provider had seen my child's previous dental records (including records from other providers)	☐1	☐2	☐3	☐4	☐5	☐6
38. The dental treatment my child received fixed his/her oral problems	☐1	☐2	☐3	☐4	☐5	☐6

Child Dental Benefit Scheme

The Child Dental Benefit Scheme (CDBS), commenced in 2014, is a scheme run by Medicare. Children aged under 18 years will be eligible if they receive certain government benefits for at least some parts of the calendar year.

E4. Does your family currently receive Family Tax Benefit Part A (FTB A) or other benefits?

☐1 Yes, FTB A ☐2 Yes, Other benefits ☐3 Neither ☐4 Don't know

E5. Have you received a Child Dental Benefit Scheme for your child? *(Tick one box only)*

☐1 Yes ☐2 No ☐3 Not Applicable (child over 17 years)

E6. Have you used the Child Dental Benefit Scheme for your child? *(Tick one box only)*

☐1 Yes ☐2 No ☐3 Don't know

E7. If Yes, how long ago did you use the Child Dental Benefit Scheme for your child? *(Tick one box only)*

☐1 Less than 6 months ago
☐2 6 months to less than 12 months ago
☐3 12 months to less than 18 months ago
☐4 18 months to less than 2 years ago
☐5 2 years or more ago

E8. If Yes, where did you use the Child Dental Benefit Scheme for your child?

☐1 School Dental Service/Government Clinic
☐2 Private practice

E9. If Yes, which service did you use the Child Dental Benefit Scheme for?

☐1 Dental check-up
☐2 Tooth filling
☐3 Tooth removal
☐4 Other treatment (specify_____)

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PART F: BIRTH PLACE AND RESIDENTIAL MOVEMENTS

F1. The following table provides us with valuable information about your child's water intake during last 10 years.

Read the example below and then complete the table. Write the name of each city or town your child has lived in and the years that he/she lived there. Then indicate the main source of drinking water he/she usually used day-to-day.

PLEASE NOTE

- ☐ Only include places where your child has lived for six months or more.
- ☐ If your child moved between suburbs within a **metropolitan** area of a major city (e.g. Brisbane or Melbourne) there is no need to report these as two separate locations.
- ☐ Most common filters (e.g. Puratap, Brita, Pur, Sunbeam) do NOT remove fluoride.
- ☐ A **filter that removes fluoride** uses **reverse osmosis** or **distillation** to filter water.
  - A **reverse osmosis** filter is usually installed under the sink (though there are some bench top units), and is more expensive than a normal carbon filter.
  - A **distillation** filter will take several hours to filter the water.
- ☐ You should list more than one period of time in a city or town if;
  - a water filter was installed during the time you lived there, or
  - your child changed their usual source of drinking water (e.g. moved residence within city or town).

EXAMPLE

- ☐ This is an example of a child who currently lives in *Balmoral (Brisbane)*. She drinks tap water and a water filter is installed that removes fluoride.
- ☐ Prior to that she lived for **two months** in *Redcliffe*. As she lived there for less than six months it is not included in the table.
- ☐ She lived at Unley (Adelaide), SA from 2009 until 2015, and in Payneham (Adelaide), SA from 2005 to 2009. During that time she drank tank (rain) and unfiltered tap/mains water regularly. At both residences, she mainly drank tap/mains water.
- ☐ She lived in Ashton (Adelaide Hills) for nine months after she was born, where she drank tank water. She only lived in Ashton for part of a year, so the same year is written in the 'From' and 'To' boxes.

Her details would be filled in as follows:

	City or town (or Country if not Australia)	Aust State or Territory	Years of residence: From	Years of residence: To	Usual main source of water? *(Tick one box only for each location)*	Filter that removes fluoride? *(reverse osmosis or distillation)*
1	*Balmoral* *Current location	*Qld*	*2015*	*2019*	☑1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☑1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter
2	*Unley*	*SA*	*2009*	*2015*	☑1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☑3 No filter
3	*Ashton*	*SA*	*2009*	*2009*	☐1 Tap/mains/public ☐2 Bore ☑3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☑3 No filter

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City or town (or Country if not Australia)	Aust State or Territory	Years of residence		Usual main source of water? *(Tick one box only for each location)*	Filter that removes fluoride? *(reverse osmosis or distillation)*
		From	To		
1. ..... *Current location	.....	.....	.....	☐1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter
2.	.....	.....	.....	☐1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter
3.	.....	.....	.....	☐1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter
4.	.....	.....	.....	☐1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter
5.	.....	.....	.....	☐1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter
6.	.....	.....	.....	☐1 Tap/mains/public ☐2 Bore ☐3 Rain/tank ☐4 Bottled	☐1 Yes ☐2 No *(carbon or charcoal filter)* ☐3 No filter

If you have any trouble filling this table in, please don't hesitate to give us a call on the Tooth for Health: 08 8313 3964
We would be more than happy to help you fill it in.

F2. To complete the table below, consider the usual amount of water your child consumed in a day and indicate how much of that water came from tap/mains/public supply.

Include filtered and unfiltered tap water. Do this for each age range. Please answer with your best estimate. (Tick one box only for each age period)

AGE	How much of all drinking water was from tap/mains/public?				
	Almost none (0 – 19%)	Less than half (20 – 39%)	About half (40 – 59%)	More than half (60 – 79%)	Almost all (80 – 100%)
5 – 10 years	☐1	☐2	☐3	☐4	☐5
10 – 15 years	☐1	☐2	☐3	☐4	☐5
15 years – Now	☐1	☐2	☐3	☐4	☐5

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THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

Please check that you have answered each question correctly then return your completed questionnaire in the reply-paid envelope provided.

If you have any questions, please telephone the TOOTH for HEALTH research team on [redacted]

[redacted]
The University of Adelaide
ADELAIDE SA 5005

If you have any comments, please feel free to provide below

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Appendix D - G Power Analysis