The Impact of Early Exposure to Fluoride on Social and Emotional Development in Australian Children

Rachel_Lane

This thesis is submitted in partial fulfilment of the requirements for the Honours degree of Bachelor of Psychological Science

School of Psychology

Faculty of Health and Medical Sciences

University of Adelaide

October 2019

Word Count: 9,417

Table of Contents

List of Figures

List of Tables

Abstract

Tooth decay is a prevalent issue among Australian children. Empirical evidence suggests fluoride plays a preventative role against tooth decay, and water fluoridation has thus become a common practice in several countries. Recently, studies have raised questions about the impact of fluoride on child brain development. Many have focussed on cognition, with few considering emotional or social factors, and have often lacked representative populations, sound fluoride measures and confounder controls. This study aimed to fill gaps in the literature regarding fluoride exposure and socioemotional development, contributing high quality research with a national Australian sample. Participants were recruited from a previous national study on child oral health (N = 943) and completed the Strength and Difficulties Questionnaire, containing questions about social and emotional functioning. A series of regression analyses indicated no significant relationship between social and emotional wellbeing and lifetime exposure to fluoridated water. The minimal exposure group did not predict significantly more or less variance in SDQ scores than the partial (p = .898) or full (p = .996) exposure groups. We can therefore retain the null hypothesis that there is no relationship between fluoride exposure and child socioemotional functioning. Future studies should conduct non-inferiority testing to confirm these conclusions.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or 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.

27th October 2019

Acknowledgements

First and foremost, I would like to extend my sincere gratitude to my academic supervisors. To my psychology supervisor, Dr Rachel Roberts – this thesis would not be what it is had it not been for your invaluable insight, guidance, and regular (much needed) reminders not to stress too much. And to my dentistry supervisors, Dr Loc Do and Dr Diep Ha – thank you for your unwavering generosity of time and resources, for always being willing to help with my data issues, and for helping me get my head around the world of fluoride. The three of you have been so patient and helpful, and I feel so privileged to have been entrusted with this stage of the project and to have worked alongside such knowledgeable, hard-working people.

Secondly, I would like to deeply thank my family and friends, and in particular my church family, for being pillars of support and encouragement throughout this year. Your consideration, words of wisdom, and comedic relief during this process have meant more to me than you all know. And lastly, to my fiancé Chris, who believed I could do this even when I didn't. Thank you for your kindness, patience and refreshing reality-checks. I'm blessed to be surrounded by so many good, empowering people.

CHAPTER I

Introduction

There are several known elements that are essential, or at least beneficial, for the human body to flourish. Many of these elements (e.g. iron and potassium), are consumed through diet and water intake, and are known to have a significant impact on human development. Often, too little of these elements can starve the body of nutrients beneficial for overall wellbeing. On the contrary, excessive amounts can have serious adverse effects on health. In recent years, there has been a significant emphasis on children receiving the optimal amount of nutrients and minerals through their diet and water consumption, as they are known have a direct relationship with physical and psychological development and functioning in later life (Bryan et al., 2004). An element which has received extensive attention in this context is fluoride.

1.1 Fluoride

Fluoride is a natural mineral found in water, air and soil and is the thirteenth most common element, making up 0.06-0.09% of the earth's crust (Fawell, Bailey, & Chilton, 2006; Peckham & Awofeso, 2014). Fluoride naturally occurs in differing concentrations within water sources: seawater contains approximately 1.2-1.5ppm (parts per million) of fluoride, and freshwater contains approximately 0.01 to 0.3ppm (Fawell et al., 2006; Kanduti, Sterbenk, & Artnik, 2016). Small amounts of fluoride are also found naturally in several fruits, vegetables and meats, and higher quantities can be found in certain teas (Murray, 1986). The concentrations of fluoride in these items are generally considered insignificant when consumed as part of a Western-style diet (Murray, 1986), however, in non-Western countries, the ingestion of fluoride via diet may be more substantial (Fawell et al., 2006). Sodium fluoride, a synthetic version of the mineral, has also been intentionally added to

several foods, supplements, and dental products around the world for use against tooth decay (National Health and Medical Research Council [NHMRC], 2007; 2017). After ingestion, approximately 90% of fluoride is absorbed into the gastrointestinal tract and distributed into the bloodstream, with the other 10% being excreted via faeces (Kanduti et al., 2016; World Health Organization [WHO], 2017). Almost all absorbed fluoride then gathers in the calcium-rich areas of the body, in particular, the enamel and dentine of bones and teeth (International Programme on Chemical Safety, 2002; WHO, 2017).

1.1.1 Tooth decay and fluoride

There is extensive empirical evidence which suggests fluoride plays a significant role in the prevention of tooth decay, or dental caries (Cate, 1999; Fawell et al., 2006; Peckham & Awofeso, 2014). Dental carries occur when leftover plaque (often from food or drink) produces acid in the mouth which erodes the outer layer of the teeth (Queensland Health, 2008). Tooth decay is considered a prevalent issue among Australian children and is the most common childhood disease (Do & Spencer, 2016; Gussy, Waters, Walsh, & Kilpatrick, 2006). In 2014, it was found that over one in ten Australian children aged 6-14 years had dental caries which had been left untreated (Do & Spencer, 2016). This high prevalence of dental issues in children has been linked to the regular consumption of high-sugar beverages (Armfield, Spencer, Roberts-Thomson, & Plastow, 2013) and inadequate dental check-ups (Gussy et al., 2006). Tooth decay in children is a significant health issue not only because it causes short-term discomfort and pain, but it has also been shown to predict global developmental stunting (Sachdev, Bansal, & Chopra, 2016), and further oral disease later in life (Do & Spencer, 2016; Gussy et al., 2006).

Over time, fluoride has been identified as having both preventative and restorative effects on tooth decay (WHO, 2002). Decay, or demineralisation, in human teeth is often

caused by the combination of low pH and fluoride levels in the mouth, leading to the gradual erosion of tooth enamel (Cate, 1999; Kanduti et al., 2016). On the other hand, optimal levels of fluoride partnered with neutral pH levels promotes remineralisation, that is, the hardening of tooth minerals back into a healthy state (Cate, 1999). As fluoride gathers on tooth enamel, it forms calcium phosphates and fluorhydroxyapatite (the hard compounds found naturally in teeth), beginning the process of remineralisation (Cate, 1999; Kanduti et al., 2016).

1.1.2 Excessive fluoride exposure and fluorosis

Although optimal exposure to fluoride has proved beneficial for one's oral health, excessive exposure has been strongly linked to the development of dental fluorosis, a condition characterised by mottling of the teeth, or, at chronic exposure to high levels of fluoride, changes to skeletal structure, muscle pain and stiffness (WHO, 2019). Skeletal fluorosis may occur when drinking water contains over 3mg of fluoride per litre and becomes more chronic as this ratio increases (WHO, 2017). Vulnerability to fluorosis appears to vary with age. Past research has shown that, while fluoridated toothpaste acts as a preventative measure against tooth decay for adults, early use of fluoridated products by children can be linked to the onset of fluorosis (Do & Spencer, 2007a; Rogers, 2011; Spencer & Do, 2008). Dental experts have thus emphasised the need for a balance between no fluoride intake, due to its beneficial effects on dental caries, and excessive intake, due to the risk of fluorosis (Do & Spencer, 2007b).

1.1.3 Background of fluoridation in Australia

Developed as a way to harness the beneficial effects of fluoride on dental caries, water fluoridation has emerged as one of the most significant and successful public health advancements in several countries over the last century (Clarkson, Hardwick, Barmes, &

Richardson, 2000). However, this risk-benefit issue has caused extensive debate regarding how to implement the appropriate level of fluoride in drinking water on a national and international level (Awofeso, 2012). In Australia, most states implemented mandatory artificial water fluoridation in the 1960s and 70s (NHMRC, 2017). Queensland, however, only began this practice in 2008, after having one of the highest rates of tooth decay in Australia with only 5% of children in the state having access to fluoridated water (Koh et al., 2015). In 2012, the Queensland Parliament reversed this directive, allowing local governments to decide whether to add fluoride to drinking supplies (Health Protection Unit, 2013). As of 2017, approximately 89% of Australians have access to fluoridated water, including a few small regions which already have naturally occurring fluoride within the recommended level (NHMRC, 2017). This access still varies among states and territories, with Queensland still having the lowest state-wide level of access. Since the implementation of water fluoridation across Australia, there has been a dramatic decline in dental caries nation-wide (Koh et al., 2015; Rugg-Gunn & Do, 2012; Slade, Davies, Spencer, & Stewart, 1995), reducing tooth decay in Australian children by 26%, adolescents by 44%, and adults by 27% (NHMRC, 2017).

Despite the proven success of water fluoridation, there are still disagreements regarding the optimal concentration of fluoride in public water systems (Spencer, Do, Mueller, et al., 2018). This is somewhat expected; as the optimal fluoride exposure depends on several factors which differ between regions (e.g. pH, alkalinity and the extent of fluoride in food and other beverages), an optimal fluoride concentration cannot be universally applied (Viswanathan, Jaswanth, Gopalakrishnan, Siva Ilango, & Aditya, 2009). The current national recommended level in Australia is within the range of 0.6-1.1mg of fluoride per litre of water (NHMRC, 2017; Spencer, 2006). Even within individual cities and towns, finding an optimal

concentration comes with the difficulty that populations in many western countries are exposed to fluoride through many sources (Clarkson et al., 2000), and thus, one's total daily fluoride intake may be significantly greater if fluoride is consumed from substances other than tap water, or significantly lower if one does not drink tap water at all (Peckham & Awofeso, 2014).

1.1.4 Fluoride and the brain

As discussed, extensive research in this area has established the effectiveness of fluoride in maintaining sound oral health. However, a growing body of literature has recently raised questions about fluoride and its impact on brain development (Choi, Sun, Zhang, & Grandjean, 2012). Several overseas studies have suggested exposure to the mineral may lead to lowered cognitive functioning, namely intelligence (Ding et al., 2011; Hong, Cao, Yang, & Wang, 2008; Karimzade, Aghaei, & Mahvi, 2014; Khan et al., 2015; Li, Zhi, & Gao, 1995; Valdez Jiménez et al., 2016) and impaired learning and memory (Jetti, Raghuveer, & Mallikarjuna, 2016; Zhang, Xu, Shen, & Xua, 2008; Zheng, Sun, Ke, Ouyang, & Zhang, 2016). These conclusions have received significant attention, leading some researchers to label fluoride as a neurotoxin (Grandjean & Landrigan, 2014). However, it should be noted that the fluoride levels used in many of these studies greatly exceed the levels found in Australian water, and most of these studies do not have appropriate controls for confounding variables such as parent education, socioeconomic status, or exposure to harmful chemicals known to be present in the studied regions (NHMRC, 2017). This adverse impact of fluoride on the brain is therefore not supported by methodologically sound research.

1.2 Child social and emotional development

1.2.1 Normative social and emotional development

There are several aspects of social and emotional functioning which are necessary for children to thrive and flourish in development (Australian Institute of Health and Welfare, 2012). The understanding in present research is that, just as meeting one's physical needs at a young age can grow children into physically healthy functioning adults, the same transfer occurs in respect to children's social and emotional functioning (Denham, Wyatt, Bassett, Echeverria, & Knox, 2009). As such, there are several domains of social and emotional functioning which have been of interest in recent research.

In the literature, children's emotional and behavioural problems are discussed as either internalising behaviour (within one's internal world) or externalising behaviour (actions in the external world) (Achenbach, 1966; Vandenbos, 2015). Several studies have thus broadly divided children's psychological issues into these two categories (Crijnen, Achenbach, & Verhulst, 1997; Mesman, Bongers, & Koot, 2001; Roelofs, Meesters, ter Huurne, Bamelis, & Muris, 2006; Zeman, Shipman, & Suveg, 2002). Internalising issues are often discussed in the context of emotional problems, such as experiences of depression and anxiety (Zahn-Waxler, Klimes-Dougan, & Slattery, 2000), or peer problems, such as withdrawal behaviours (Watling, 2015). Externalising problems have also received interest, particularly in children's inability to self-regulate their emotions and urges (Thompson & Calkins, 1996), often discussed in terms of aggressive or antisocial behaviours (Bayer et al., 2012; Laird, Jordan, Dodge, Pettit, & Bates, 2001) as well as hyperactivity and issues with inattention (Hinshaw, 1987). A number of factors have been found to influence the prevalence and nature of internalising and externalising behaviours in children. These include sex (Allgood-Merten, Lewinsohn, & Hops, 1990), socioeconomic status (Reiss, 2013) and household income (Dearing, McCartney, & Taylor, 2006).

There have been clear negative outcomes identified in association with having social and emotional difficulties during childhood. There is evidence that difficulties in these areas of functioning can have negative effects on children's academic achievement and overall school experience (Pahl & Barrett, 2007). More specifically, children who behave antisocially are less likely to be accepted and encouraged by their teachers (Shores & Wehby, 1999), and those who are unable to control negative emotions of anger have greater academic difficulties than those who do not (Arnold et al., 1999; McClelland, Morrison, & Holmes, 2000). It has also been identified that social and emotional skills build resilience in children (Masten, Best, & Garmezy, 1990) and act as a protective factor against general life stressors (Garmezy, 1991). These outcomes suggest the importance of implementing policies and interventions which increase children's likelihood of achieving optimal social and emotional development (Australian Institute of Health and Welfare, 2012; Greenberg, Domitrovich, & Bumbarger, 2001).

1.2.2 Recent areas of interest in social and emotional functioning

Despite prevalent research on social and emotional difficulties, there has been a recent multi-disciplinary shift toward strength-based assessments and practice, resulting in an interest not only in children's behavioural weaknesses, but their strengths (Bozic, 2013; Goodman, 1997). In the context of assessment, parents are often more willing to report on their child's difficulties when they also have opportunity to report on their desirable traits (Goodman, 1994). With the recent spread of mental health awareness, there has also been an increased interest in not just emotional problems themselves, but the everyday impact and burden experienced by families affected by these problems (Costello, Egger, & Angold, 2005). This has been studied in the context of children with psychiatric disorders, such as schizophrenia (Bogren, 1997; Knock, Kline, Schiffman, Maynard, & Reeves, 2011), as well

as behavioural conditions, such as autism spectrum disorder (Taylor & Seltzer, 2011). With these recent trends in research, it appears there are several domains necessary to cover when providing a comprehensive assessment of social and emotional wellbeing.

1.2.3 Fluoride in connection to child development

As previously mentioned, fluoride has been linked to lowered cognitive development in several overseas studies. Many of the observed effects in the literature on fluoride have been found in child participants (Hong et al., 2008; Karimzade et al., 2014; Sebastian & Sunitha, 2015). A common hypothesis is that, as infants and children have a heightened vulnerability to neurotoxins and the injuries caused by them (Weiss, 2000), the concentration of fluoride considered appropriate for adults in many countries may have detrimental effects on children (Grandjean & Landrigan, 2014). Likewise, there has been a focus on the impact of fluoride on the development of the foetal brain. Three Chinese studies found that high fluoride levels were associated with neurological damage to developing brains (Du, Wan, Cao, & Liu, 2008; He, Cheng, & Liu, 2008; Yu et al., 2008). However, in each of these studies, no controls for potential confounders were reported, allowing for the possibility of several factors to influence results, such as parent education, socioeconomic status and whether the area in which they reside had high levels of other harmful substances. This lack of control for confounders therefore clouds any potential relationship between fluoride and the developing brain.

1.2.4 Fluoride and socioemotional child development

Despite the large number of studies investigating this relationship between fluoride and cognitive development, the relationship between fluoride and socioemotional development has scarcely been explored. Where it has been investigated, studies have mostly

used animal participants, and thus there is a lack of research investigating fluoride in relation to human social and emotional functioning, let alone child-specific functioning. Two animal studies found that fluoride exposure caused both anxious and depressive symptoms in mice (Li et al., 2019; Liu et al., 2014), however, applying these findings to humans comes with the difficulty that the fluoride levels used as predictors were again substantially higher than what would be found in fluoridated drinking water.

There is also a small body of research linking fluoride exposure to changes in the thyroid gland, known for its connection to emotion and mood (Hage & Azar, 2012). Some research suggests fluoride may contribute to hypothyroidism, the underactivity of the thyroid gland, which often leads to symptoms of depression and apathy (Hage & Azar, 2012; Malin, Riddell, McCague, & Till, 2018; Peckham, Lowery, & Spencer, 2015; Zohreh et al., 2018). Similarly, other studies suggest fluoride may have therapeutic effects on hyperthyroidism, the overactivity of the thyroid gland, which is known to lead to behavioural problems, paranoia and aggression (Galletti & Joyet, 1958; Zachariassen & Flaten, 2009).

1.2.5 Gaps in current literature

The research in this area is far from conclusive, and thus the present study aims to contribute to filling the gaps in knowledge regarding the relationship between fluoride and child social and emotional wellbeing. A significant limitation to the research conducted thus far is a common lack of control for potential confounders which have independently-established effects on development (Jack et al., 2016). This has been exacerbated by frequent reporting of unrepresentative populations, with several studies sampling only from two or three specific towns or counties (Hong et al., 2008; Karimzade et al., 2014; Li et al., 1995). Many have also used inappropriate measurements of fluoride exposure, with some drawing conclusions from current levels of fluoride in the body rather than long-term exposure (Ding

et al., 2011; Li et al., 1995). Those which have assessed the effects of long-term exposure to fluoridated water have often assumed that either the fluoride concentrations in the water of the studied regions have remained stable over time (Khan et al., 2015; Sebastian & Sunitha, 2015), or that participants have never changed residences (Hong et al., 2008; Karimzade et al., 2014). Both flaws in methodology increase studies' susceptibility to the influence of confounding factors. The most thorough method of assessing fluoride exposure is thus a measure of long-term exposure to fluoridated water which considers these two variables, whilst also controlling for confounders relevant to the participant group (Grembowski, 1988). The present study aimed to address and overcome these problems by controlling for potential confounders, utilising a sound measure of fluoride exposure, and recruiting a representative sample.

1.3 The present study

The aim of the present study was to explore any relationship between exposure to fluoridated water and child social and emotional wellbeing, contributing high quality and representative research to the literature. This was investigated both in terms of the level of symptoms of social and emotional problems, and in terms of the proportion of children falling within clinical risk categories.

After controlling for known confounders, it was predicted that:

Hypothesis 1: There would be no association between exposure to fluoride and overall child social and emotional wellbeing.

Hypothesis 2: There would be no association between exposure to fluoride and the different aspects of child social and emotional wellbeing (emotional problems, peer problems, hyperactivity and conduct problems).

Hypothesis 3: The proportion of children rated as falling within the clinical range of social and emotional problems would not differ according to their exposure to fluoride.

Hypothesis 4: There would be no association between exposure to fluoride and the impact of social and emotional problems on everyday life.

Hypothesis 5: There would be no association between exposure to fluoride and the associated burden of social and emotional problems.

CHAPTER II

Method

2.1 Participants

Participants for the present study were obtained from a larger pool of participants from the 2012-2014 National Child Oral Health Study (NCOHS) (Do & Spencer, 2016), a study assessing the oral health of children aged 5-14 years. This was a large, representative study across Australia. The study used a two-stage sample design to recruit participants: in the first step, each jurisdiction provided a list of all public, Catholic and independent primary and secondary schools within their state, and out of these, a group of schools were selected for the study. The exclusion criteria for schools were: too remotely located for a dental van to access, special schools, and small school enrolment (<50 students). Schools were selected based on the necessity to adequately represent all regions of each state, and thus, if a selected school did not agree to participate, they were replaced on a case-by-case basis to ensure the replacement school was from the same region and had a comparable socioeconomic profile. In the second step, children were randomly selected from each school. Overall, the study recruited 24,664 children and their parents, each of whom participated in both stages of the study (parent questionnaire and child oral examination). Demographics for the present study were collected at this time point. All parents gave researchers permission to recontact them in

reference to further research. For the present study, parents and guardians from the NCOHS population were recontacted, and a total of 1,213 participants were recruited across all Australian states. The children referenced in this study were aged 10-17 years at the time of participation.

2.2 Measures

2.2.1 Measurement of demographic variables

The following demographic variables were measured for the study: sex, child Indigenous identity, parent country of birth, household income, parent education, residential location, family composition (measured by number of guardians in household), and socioeconomic status. This information was obtained from the parent questionnaires and child oral examinations used in the NCOHS (2012-2014). The sex of participants was categorised as male or female. Child Indigenous identity was based upon children's answers to the question 'are you of Aboriginal or Torres Strait Islander origin?' Those who answered 'yes' were classified as Indigenous, whereas those who answered 'no' were classified as non-Indigenous. Parent country of birth was collected and ordered into two broad categories: Australian-born or overseas-born. If at least one parent indicated they were born overseas, they were classified together as overseas-born. Otherwise, parent country of birth was classified as Australian-born. Household income was categorised into low, medium and high-income groups. The inclusion criteria for each group was as follows: low income was characterised as parents whose annual income was less than $60,000; medium income, between $60,000 and $120,000; and high income, over $120,000. Parent education was based upon parent's highest reported education level and categorised into three groups: school-level education, vocational training, and tertiary education. Classifications were applied based on whichever parent had the higher education level. For residential location, the Remoteness

Area Structure of the Australian Statistical Geography Standard (ASGS) (Australian Bureau of Statistics, 2016) was used to classify children's reported postcode as either major city, inner regional, outer regional, or remote/ very remote. Socioeconomic status was determined by applying participant residential addresses to the Socioeconomic Indexes for Areas (SEIFA) (Australian Bureau of Statistics, 2011), a measure which ranks Australian postcodes according to their relative socioeconomic advantage or disadvantage, with higher scores indicating more advantaged areas. These scores were then categorised into five 'SEIFA' groups to be used in analyses. Full demographic variables for the present sample are reported in the Results section.

2.2.2 Measurement of fluoride exposure

Lifetime fluoride exposure was obtained by utilising the Australian Research Centre for Population Oral Health database of postcode-specific fluoride levels in public water supplies (Spencer, Do, & Ha, 2018). This database collects information on both artificial and natural fluoride levels and has been regularly updated with information from health and water authorities since its development in 1990. In the previous NCOHS questionnaire, participants provided residential history from birth to the time of survey, as well as detailed information about the child's consumption of public water. Combined use of the information on postcode-specific fluoride concentration and participants' residential information allowed for the calculation of an individual-level percentage of lifetime exposure to fluoridated water (%LEFW), which was used in the present study as the measure for fluoride exposure in participants. This has been validated as a strong and extensive measure of lifetime exposure to fluoride (Slade et al., 1995).

2.2.3 Measurement of social and emotional wellbeing

To measure participants' social and emotional wellbeing, the Strengths and Difficulties Questionnaire (SDQ) was used, an extensively validated and widely used measure of psychopathology in children aged 4-17 years (Goodman, 2001; Miller-Lewis et al., 2014). The questionnaire includes 25 items assessing positive and negative developmental attributes of children on five subscales: conduct problems, hyperactivity-inattention, emotional problems, peer problems, and prosocial behaviour. The SDQ is scored using a 3-point Likert scale with 0 as 'not true', 1 as 'somewhat true', and 2 as 'certainly true'. A total difficulties score is generated by summing the four problem subscale scores. An impact supplement of an additional 7 questions was also added to the questionnaire to assess the chronicity, distress, burden, and interference with everyday life caused by perceived difficulties (Goodman, 1999). This additional component was included in the present study to allow us to assess the clinical relevance of any social or emotional difficulties identified.

The SDQ has proven to be useful in predicting psychiatric disorders in children from numerous countries (Goodman, Renfrew, & Mullick, 2000; Warnick, Bracken, & Kasl, 2008), and stands well against diagnostic interviews, long considered the gold standard of assessing emotional and social problems (Goodman, 2001). Previous studies have reported moderate to good internal consistency of the parent-report version used in the current study, with Cronbach's alphas ranging from 0.80-0.82 for total difficulties, 0.67-0.73 for emotional symptoms, 0.55-0.64 for conduct problems, 0.57-0.78 for peer problems, 0.80 for hyperactivity, and 0.65-0.75 for prosocial behaviour (Goodman, 2001; Muris, Meesters, & van Den Berg, 2003). It appears conduct and peer problems are often notably lower in reliability, and total difficulty score may be the most reliably useful value to use in analyses. The Cronbach's alphas for the current sample were somewhat better than what has previously

been reported. The total difficulty score, as well as the emotional problems and hyperactivity subscales, reached the benchmark of 0.70, with Cronbach's alphas of 0.70, 0.71 and 0.80, respectively. Consistent with the literature, conduct and peer problems were slightly lower, at 0.65 and 0.69. Studies have also confirmed the measure's sound test-retest reliability (Muris et al., 2003) (Goodman, 2001) and concurrent validity (Goodman, 1997; Goodman & Scott, 1999).

2.3 Ethical considerations

This study received approval from the University of Adelaide Human Research Ethics Committee (HREC) (Approval Number H-2019-020). The first page of the questionnaire received by participants included an information sheet outlining the purposes of the study, as well as a consent statement which stated that participation was voluntary and involvement in the study could be withdrawn at any time (Appendix A). Completion of the questionnaire was considered consent to participate in the study.

2.4 Procedure

Parents of participants from the NCOH study were sent an email containing an online version of the study questionnaire. If the email bounced back or participants did not respond, participants were sent a paper version of the questionnaire via the postal address obtained in the first study. If again this received no response, participants were contacted via telephone. Due to being part of a larger study, the questionnaire package had multiple parts containing several measures: (a) Child's Dental Behaviours and Practices; (b) Childhood Behaviour Problems; (c) Child's General Health and Daily Activities; (d) General Family Information; (e) Evaluation of Child's Dental Services. Part B included the SDQ, as well as an additional

measure assessing executive and cognitive functioning not reported here. The full questionnaire can be found in Appendix B.

2.5 Statistical analyses

Data was analysed using Statistical Package for the Social Sciences (SPSS, Version 24.0). Prior to data collection, a priori power analysis was conducted using G*Power to determine the sample size required to detect a meaningful effect. Results revealed a sample size of 776 would give sufficient power to detect the expected small effect ($f^2 = 0.02$) with alpha ($p<.05$) and power (0.80) levels set according to convention. Full results from this analysis can be seen in Appendix C. When designing the study, it was estimated that approximately 800 participants would be recruited, suggesting the study would have sufficient power to detect an effect. A multiple linear regression was used to test all hypotheses except Hypothesis 3, for which a logistic regression was used. Based upon a review of the literature and in consideration of the study population, the following variables were identified as confounders for the study and controlled for: sex, household income, parent education, Indigenous identity, parent country of birth, family composition (measured by the number of guardians living with the child), residential location and area-level socioeconomic status.

CHAPTER III

Results

3.1 Data Screening

3.1.1 Missing data

Prior to analysis, data were screened for missing values. As per standard methodology recommended by the SDQ developers, in cases where a subscale had two or less missing

items, substitution was conducted using each subscale mean from that participant (Youthinmind, 2019). Cases where all SDQ items were missing, or where there were too few items to complete mean substitution, were excluded from the study (N = 278). A total of 934 participants provided data without missing values and were included in statistical analysis, and 9 additional scores were included after mean substitution. This resulted in a final dataset of 943 participants.

3.1.2 Assumption testing

To determine suitability for the analyses, data was tested against the assumptions of tests prior to analysis. The Shapiro-Wilk test was used to assess normality of the data. %LEFW did not meet the assumption of normality, and analysis of the histogram revealed a bimodal distribution (see Figure 1). Analysis of SDQ total difficulty scores also revealed a non-normal distribution, however visual inspection of the histogram and descriptive statistics indicated it was very close to normal (see Figure 2). Being a large dataset, standard methodology suggests use of parametric statistics is acceptable provided the distribution appears close to normal (Allende-Alonso, Bouza-Herrera, Rizvi, & Sautto-Vallejo, 2019; Ghasemi & Zahediasl, 2012). Data was inspected for outliers using a Boxplot analysis, which indicated 17 cases lying far from the mean. After examination for invalid entries and errors, it was found that no scores exceeded the range of possible scores for the SDQ. Analysis of the Boxplot output also indicated that the outliers did not greatly alter the mean, due to the study's large sample size. As some high and low-end scores are expected within a community sample, and inclusion of these scores provided valuable information about the study population, no scores were removed from the analysis. Results from this Boxplot can be seen in Appendix D.

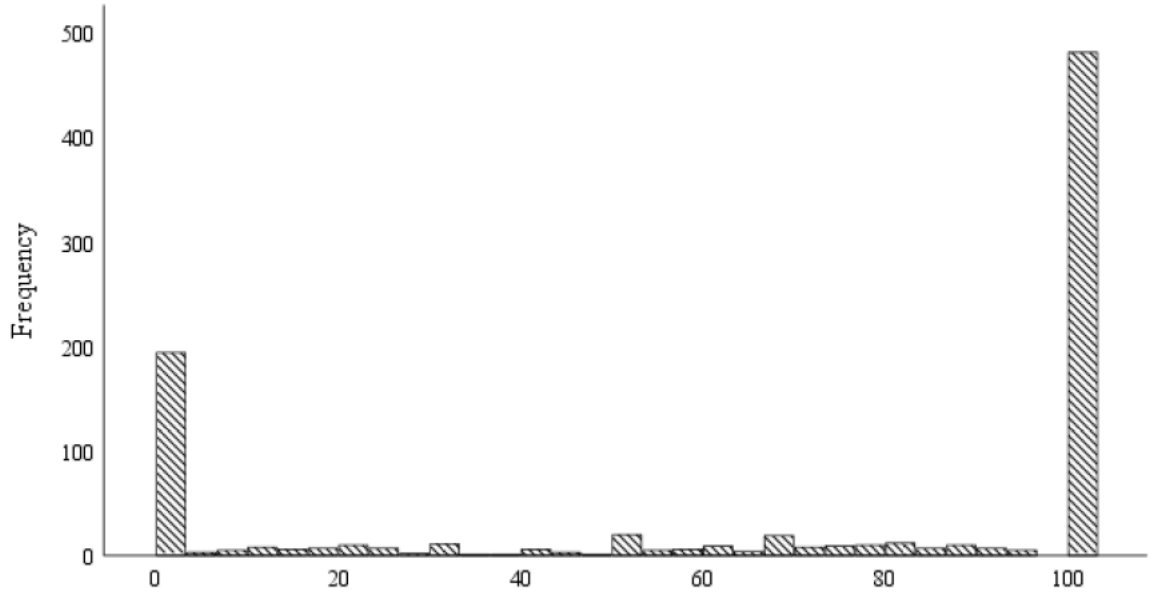


Figure 1. Bimodal distribution of participant lifetime exposure to fluoridated water

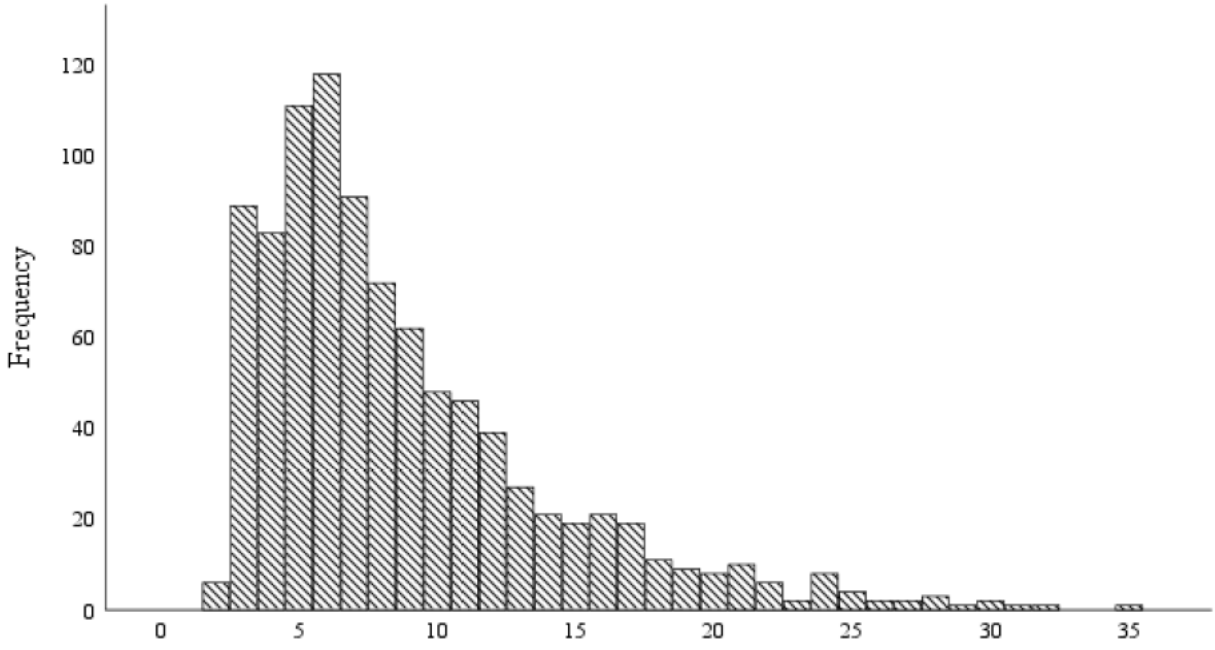


Figure 2. Distribution of participant SDQ total difficulty scores

3.2 Descriptive statistics

3.2.1 Demographic variables

Percentages and frequencies were generated to analyse the demographic information of the sample. The study population appeared to be largely made up of highly educated, middle and high-income individuals. Over half of participants resided in major cities (55.7%), most guardians were tertiary educated (75.4%), and almost all guardians reported their child as non-Indigenous (97.7%). Full demographic statistics for participants can be seen in Table 1, and a comparison to those excluded from the study can be seen in Table 2. The exclusion group had slightly more individuals from one-guardian (14.8%) and Australian-born (74.4%) households, and slightly less individuals educated beyond school level (86.5%). Apart from this, there appeared to be minimal differences between the two groups.

3.2.2 Lifetime exposure to fluoridated water

Analyses revealed that most participants had approximately 100% exposure to fluoride (54.8%), and the next largest group had no exposure (20.6%). As use of means in this case would not be meaningful due to the distribution being non-normal, the measure was split into three categories: <25% exposure, 25 to <100% exposure, and 100% exposure, as done in previous similar studies (Spencer, Do, Mueller, et al., 2018).

Table 1

Full participant demographic characteristics

	Factors	*N*	Percentage of Children (%)
Child's Demographic Characteristics			
Child Sex			
	Male	454	48.1%
	Female	477	50.6%
Child Indigenous Identity			
	Non-Indigenous	898	97.7%
	Indigenous	21	2.3%
Child Residential Location			
	Major City	513	55.7%
	Inner Regional	221	24.0%
	Outer Regional	153	16.6%
	Remote/Very Remote	34	3.7%
Parent/guardian Demographic Characteristics			
Parent Country of Birth			
	Australian-born	617	67.1%
	Overseas-born	302	32.9%
Parent Education Status			
	School-level Education	85	9.6%
	Vocational Training	133	15%
	Tertiary Education	667	75.4%
Household Demographic Characteristics			
Number of Guardians	One Guardian	83	9.0%
	Two Guardians	836	90.8%
Household Income			
	Low	157	17.7%
	Medium	379	42.7%
	High	351	39.6%
Socioeconomic Status (SEIFA)	1 (Lowest Advantage)	121	13.1%
	2	143	15.5%
	3	156	16.9%
	4	202	21.9%
	5 (Highest Advantage)	299	32.5%

Table 2

Comparison of key demographic variables between excluded and included participants

Factors		Study Sample	Excluded Participants
Sex	Male	48.1%	46.4%
	Female	50.6%	53.2%
Indigenous Identity	Non-Indigenous	97.7%	98.5%
	Indigenous	2.3%	1.5%
Residential Location	Major City	55.7%	57.6%
	Inner Regional	24.0%	21.4%
	Outer Regional	16.6%	18.8%
	Remote/Very Remote	3.7%	2.2%
Parent Country of Birth	Australian-born	67.1%	74.4%
	Overseas-born	32.9%	25.6%
Parent Education	School-level Education	9.6%	13.5%
	Vocational Training	15%	11.5%
	Tertiary Education	75.4%	75%
No. of Guardians	One Guardian	9.0%	14.8%
	Two Guardians	90.8%	85.2%
Household Income	Low	17.7%	22.9%
	Medium	42.7%	42.0%
	High	39.6%	35.1%

3.2.3 Social and emotional development

As per the statistical analysis plan, SDQ scores were generated into both continuous and categorical variables. To ensure the accurate generation of scores, certain items were reverse-coded, according to the syntax for the parent-report version provided by the SDQ developers (Youthinmind, 2019). Subscale and impact scores were calculated by summing scores on the relevant items, and total difficulty scores were calculated by summing each score on the emotional problems, conduct problems, hyperactivity and peer problems subscales (Youthinmind, 2019). Burden scores were created from participants' answers to the question "do the difficulties put a burden on you or the family as a whole?" and ranged from 1 to 4. To determine participants' classification into clinical categories, the three-tier clinical group structure proposed by Goodman and outlined on the sdqinfo website was used, which categorises participants into 'normal,'' 'borderline,' and 'abnormal,' based on their total difficulty score and scores on each subscale. This was chosen against the later proposed four-tier structure (Youthinmind, 2019), as it appears to be most commonly used in Australian samples (Fletcher, Tannock, & Bishop, 2001; Hayes, 2007; Kremer et al., 2015; Seward, Bayliss, Stallman, & Ohan, 2018) and has been shown to have few differences with Australian norms (Hayes, 2007).

Upon analysis, it was found that 84% of participants fell into the normal range on total difficulty scores, and only 9.5% fell into the abnormal category. This is consistent with the assumptions of the clinical categories by Goodman, whereby approximately 10% of any general population should fall within the abnormal category, and 85% within the normal category (Goodman, 2001). Means for total difficulty and each subscale score did not appear dissimilar to the Australian norms. A comparison based on sex and age groups can be seen in Table 3.

Table 3

SDQ means and standard deviations for study sample and Australian norms for sex and age groups.

	Males						**Females**					
	7-10 years		**11-13 years**		**14-17 years**		**7-10 years**		**11-13 years**		**14-17 years**	
SDQ Scores	Sample	Norms	Sample	Norms	Sample	Norms	Sample	Norms	Sample	Norms	Sample	Norms
Total Difficulty	8.73 (4.7)	9.9 (6.4)	9.01 (5.58)	7.8 (5.8)	9.27 (5.25)	8.5 (5.8)	8.36 (4.96)	7.7 (5.7)	8.77 (5.43)	7.5 (6.1)	8.16 (5.36)	7.8 (5.9)
Emotional	1.53 (1.55)	2.3 (2.1)	2.05 (2.36)	1.8 (1.8)	2.53 (2.37)	1.5 (1.9)	1.36 (1.45)	2.3 (2.0)	1.6 (1.84)	2.0 (2.1)	1.34 (1.88)	2.2 (2.1)
Conduct	1.00 (1.25)	1.8 (1.7)	1.16 (1.50)	1.2 (1.7)	1.09 (1.67)	1.7 (1.6)	1.5 (2.03)	1.3 (1.5)	1.16 (1.52)	1.3 (1.6)	1.00 (1.49)	1.5 (1.6)
Hyperactivity	4.00 (1.46)	4.1 (2.7)	4.05 (1.54)	3.2 (2.5)	3.87 (1.41)	3.5 (2.5)	4.5 (1.95)	2.6 (2.2)	4.35 (1.84)	2.5 (2.2)	4.03 (1.50)	2.5 (2.1)
Peer	2.2 (2.81)	1.8 (2.0)	1.76 (1.99)	1.6 (1.9)	1.78 (1.88)	1.8 (2.0)	1.00 (1.62)	1.5 (1.9)	1.62 (1.84)	1.6 (1.9)	1.79 (2.10)	1.5 (1.9)

3.3 Overall and subcategory social and emotional functioning

The first two study hypotheses predicted no relationship between fluoride exposure and both overall and subcategory social and emotional wellbeing. Both hypotheses were largely supported by results. Inspection of frequency tables suggested no obvious differences between fluoride exposure groups on total difficulty or subscale scores (see Table 4). A simultaneous multiple regression was used to assess Hypothesis 1, in which dummy variables representing the three fluoride exposure groups were entered with all covariates, and total difficulty score was entered as the dependent variable. Dummy variables were also used for household income, parent education, Indigenous identity, parent country of birth, number of guardians in household, residential location, socioeconomic status, and sex. Results indicated the model was significant and explained 3.6% of the variance in total difficulty scores, $F(17, 900) = 2.004$, $p = .009$. However, as expected, exposure to fluoride did not significantly contribute to the model. Full statistical information from this regression can be seen in Table 5. SDQ subscales were analysed the same way. Regression models for emotional problems, peer problems and hyperactivity were significant, however, exposure to fluoride did not significantly contribute to any of the models (see Table 6).

Table 4

SDQ total difficulty and subscale means and standard deviations for fluoride exposure groups

	Fluoride Exposure Group		
SDQ Scores	Minimal Exposure (<25%)	Partial Exposure (25-<100%)	Full Exposure (100%)
Total Difficulty	8.65 (5.23)	8.77 (5.58)	8.57 (5.18)
Emotional Problems	1.76 (2.13)	1.82 (2.24)	1.89 (2.19)
Peer Problems	1.78 (2.01)	1.75 (2.02)	1.60 (1.87)
Conduct Problems	1.11 (1.58)	1.07 (1.63)	1.11 (1.53)
Hyperactivity	4.00 (1.50)	4.13 (1.52)	3.98 (1.55)

Table 5

Simultaneous multiple regression analysis for variables predicting total difficulty scores

Predictor Variables	**B**	**SE**	**β**	**t**	***p***	**95% CI**	**R^2**	**Adj R**	***p***
Model							.036	.018	.009
Constant	11.90	0.86		13.86	.001	10.21, 13.58			
Fluoride Exposure									
Minimal (<25%)									
Partial (25-<100%)	0.07	0.55	0.01	0.13	.898	-1.02, 1.16			
Full (100%)	0.00	0.46	0.00	0.01	.996	-0.89, 0.90			
Household Income									
Low Income									
Medium Income	-0.43	0.53	-0.04	-0.81	.417	-1.48, 0.62			
High Income	-0.30	0.58	-0.03	-0.51	.608	-1.43, 0.84			
Parent Education									
School-level Education									
Vocational Training	2.03	1.20	0.06	1.70	.090	-0.32, 4.38			
Tertiary Education	-0.00	0.70	0.00	-0.00	.997	-1.38, 1.38			
Residential Location									
Major City									
Inner Regional	-1.10	0.60	-0.09	-1.83	.068	-2.27, 0.08			
Outer Regional	0.37	0.40	0.03	0.92	.359	-0.42, 1.15			
Remote/ Very Remote	0.34	0.35	0.03	0.96	.339	-0.36, 1.03			

(continued)

Parent Country of Birth						
Australian-born						
Overseas-born	-1.87	0.66	-0.10	-2.81	.005	-3.17, -0.56
Sex						
Male						
Female	0.38	0.49	0.03	0.77	.442	-0.59, 1.35
No. of Guardians						
One Guardian						
Two Guardians	-0.42	0.57	-0.03	-0.73	.468	-1.54, 0.71
Indigenous Identity						
Non-Indigenous						
Indigenous	-0.21	1.02	-0.01	-0.21	.837	-2.21, 1.79
Socioeconomic Status						
SEIFA 1						
SEIFA 2	-0.47	0.66	-0.03	-0.71	.476	-1.76, 0.82
SEIFA 3	-1.24	0.66	-0.09	-1.88	.061	-2.53, 0.06
SEIFA 4	-0.86	0.63	-0.07	-1.38	.167	-2.12, 0.37
SEIFA 5	-0.84	0.66	-0.07	-1.28	.200	-2.13, 0.45

Note. Reference groups for dummy variables were minimal fluoride (<25%), low income, school-level education, major city, Australian-born, male, one guardian, non-Indigenous, and SEIFA 1. SEIFA = Socioeconomic Indexes for Areas Group. Higher SEIFA group membership indicates greater socioeconomic advantage.

Table 6

Simultaneous multiple regression analyses for variables predicting SDQ subscale scores

	Emotional Problems				**Peer Problems**				**Hyperactivity**				**Conduct Problems**			
Predictor variables	*B*	*SE*	*β*	*p*	*B*	*SE*	*β*	*p*	*B*	*SE*	*β*	*p*	*B*	*SE*	*β*	*p*
Constant	2.32	0.35		.000	3.03	0.31		.000	5.06	0.25		.000	1.48	0.25		.000
Fluoride Exposure																
Minimal (<25%)																
Partial (25-<100%)	0.07	0.23	0.01	.765	0.02	0.20	0.00	.927	0.03	0.16	0.01	.868	-0.04	0.16	-0.01	.804
Full (100%)	0.19	0.19	0.04	.316	-0.13	0.17	-0.03	.454	-0.09	0.13	-0.03	.485	0.03	0.13	0.01	.798
Household Income																
Low Income																
Medium Income	-0.13	0.22	-0.03	.550	-0.21	0.20	-0.05	.275	-0.10	0.16	-0.03	.524	0.01	0.16	0.00	.973
High Income	-0.14	0.24	-0.03	.560	-0.34	0.21	-0.09	.104	0.04	0.17	0.01	.805	0.14	0.17	0.04	.420
Parent Education																
School-level Education																
Vocational Training	1.07	0.49	0.07	.028	0.28	0.44	0.02	.525	0.45	0.35	0.04	.198	0.21	0.35	0.02	.547
Tertiary Education	-0.07	0.29	-0.01	.814	0.04	0.26	0.01	.883	0.18	0.21	0.04	.391	-0.15	0.21	-0.03	.473
Residential Location																
Major City																
Inner Regional	-0.36	0.24	-0.08	.136	-0.35	0.22	-0.08	.109	-0.17	0.18	-0.05	.320	-0.21	0.18	-0.06	.243
Outer Regional	0.06	0.16	0.01	.725	0.00	0.15	0.00	.980	0.16	0.12	0.05	.163	0.14	0.12	0.04	.231
Remote/ Very Remote	0.77	0.14	0.17	.000	-0.08	0.13	-0.020	.564	-0.34	0.10	-0.11	.001	-0.02	0.10	-0.01	.864
Parent Country of Birth																
Australian-born																
Overseas-born	-0.50	0.27	-0.07	.064	-0.47	0.24	-0.07	.053	-0.63	0.19	-0.12	.001	-0.25	0.20	-0.05	.202

(continued)

Sex																
Male																
Female	0.21	0.20	0.04	.288	0.04	0.18	0.01	.816	0.08	0.14	0.02	.583	0.04	0.15	0.01	.762
No. of Guardians																
One Guardian																
Two Guardians	-0.02	0.23	-0.00	.940	-0.17	0.21	-0.03	.427	-0.19	0.17	-0.04	.264	-0.05	0.17	-0.01	.793
Indigenous Identity																
Non-Indigenous																
Indigenous	-0.18	0.42	-0.02	.664	-0.14	0.37	-0.01	.704	0.02	0.30	0.00	.942	0.09	0.30	0.01	.761
Socioeconomic Status																
SEIFA 1																
SEIFA 2	-0.20	0.27	-0.03	.447	-0.13	0.24	-0.02	.598	-0.11	0.19	-0.03	.572	-0.03	0.19	-0.01	.879
SEIFA 3	-0.26	0.27	-0.04	.334	-0.51	0.24	-0.10	.034	-0.31	0.19	-0.07	.110	-0.16	0.20	-0.04	.417
SEIFA 4	-0.27	0.26	-0.05	.290	-0.44	0.23	-0.09	.058	-0.18	0.19	-0.05	.335	0.02	0.19	0.00	.933
SEIFA 5	-0.20	0.27	-0.04	.450	-0.33	0.24	-0.08	.174	-0.16	0.19	-0.05	.418	-0.16	0.19	-0.05	.419
Model	R^2 = .052				R^2 = .040				R^2 = .041				R^2 = .009			
	$F(17, 900) = 2.876$, $p < .001$				$F(17, 900) = 2.228$, $p = .003$				$F(17, 900) = 2.266$, $p = .002$				$F(17, 900) = .466$, $p = .968$			

Note. Reference groups for dummy variables were minimal fluoride (<25%), low income, school-level education, major city, Australian-born, male, one guardian, non-Indigenous, and SEIFA 1. SEIFA = Socioeconomic Indexes for Areas Group. Higher SEIFA group membership indicates greater socioeconomic advantage.

3.4 Clinical groups of social and emotional functioning

Membership to the normal, borderline and abnormal groups appeared similar across categories of fluoride exposure, with slight differences in the partial exposure group (see Table 7). Analysis of frequencies revealed the most common group membership combination was full fluoride exposure and clinically normal functioning (46.9%). In order to ensure adequate control of confounders when assessing Hypothesis 3, participants were further grouped into 'normal' and 'clinically elevated' groups, by combining the 'borderline' and 'abnormal' categories, to suit logistic regression analysis. This categorisation has been used or recommended by previous studies (Rice et al., 2018; Theunissen, Vogels, Wolff, & Reijneveld, 2013), and is considered appropriate for research where false positives are less important than false negatives (Goodman, 1997). This is true for the present study, in that only a small effect, if any, was expected. A logistic regression was then conducted, but the model was not significant, $\chi 2(17) = 27.178$, $p = .056$. Full results can be seen in Table 8.

Table 7

Number and percentage of participants from fluoride exposure groups belonging to social and emotional clinical groups

Fluoride Exposure	**Clinical Groups**					
	Normal		Borderline		Abnormal	
	n	%	*n*	%	*n*	%
Minimal Exposure	200	85.8%	14	6.0%	19	8.2%
Partial Exposure	132	81.0%	15	9.2%	16	9.8%
Full Exposure	411	85.4%	26	5.4%	44	9.1%

Table 8

Logistic regression analysis for predictors of membership to clinically elevated categories

Predictor variables	*B*	*SE (B)*	*p*	*Exp (B)*	*95% CI*
Constant	-0.67	0.52	0.197	0.51	
Fluoride Exposure					
Minimal (<25%)					
Partial (25-<100%) (1)	0.42	0.29	0.15	1.53	0.86, 2.69
Full (100%) (2)	0.06	0.26	0.803	1.07	0.64, 1.77
Household income					
Low Income					
Medium Income (1)	0.02	0.3	0.946	1.02	0.57, 1.83
High Income (2)	-0.02	0.33	0.944	0.98	0.52, 1.86
Parent education					
School-level Education					
Vocational Training (1)	0.07	0.38	0.848	1.08	0.51, 2.25
Tertiary Education (2)	-0.378	0.34	0.273	0.69	0.35, 1.34
Residential location					
Major City					
Inner Regional (1)	0.12	0.27	0.649	1.13	0.67, 1.92
Outer Regional (2)	-0.51	0.34	0.139	0.6	0.31, 1.18
Remote/ Very Remote (3)	0.02	0.61	0.974	1.02	0.31, 3.40
Parent country of birth					
Australian-born					
Overseas-born (1)	0.12	0.22	0.601	1.12	0.73, 1.74
Sex					
Male					
Female (1)	0.25	0.2	0.202	1.29	0.87, 1.89
Number of guardians					
One Guardian					
Two Guardians (1)	-0.91	0.32	0.004	0.4	0.22, 0.75
Indigenous Identity					
Non-Indigenous					
Indigenous (1)	0.88	0.54	0.102	2.4	0.84, 6.88
Socioeconomic Status					
SEIFA 1					
SEIFA 2 (1)	0.07	0.36	0.853	1.07	0.53, 2.15
SEIFA 3 (2)	-0.4	0.37	0.283	0.67	0.33, 1.39
SEIFA 4 (3)	-0.3	0.35	0.393	0.74	0.38, 1.47
SEIFA 5 (4)	-0.36	0.37	0.337	0.7	0.34, 1.45

Note. Reference groups were minimal exposure (<25%), low income, school education, major city, Australian-born, male, one guardian, non-Indigenous and SEIFA 1. SEIFA = Socioeconomic Indexes for Areas Group. Higher SEIFA group membership indicates greater socioeconomic advantage.

3.5 Impact and burden of social and emotional difficulties

Impact and burden scores appeared similar across fluoride exposure groups, with the minimal fluoride group having a slightly lower impact score (see Table 9). Overall, 64.3% of participants answered that their child did not have difficulties in emotions, concentration, behaviour or being able to get along with others, resulting in an immediate impact and burden score of zero. For this reason, means were low across all groups. Two multiple regressions were conducted with fluoride exposure and covariates entered as predictor variables and impact and burden scores entered as dependent variables. The same dummy variables from the previous regressions were used. Both the impact and burden models were not significant. Full results from these regressions can be seen in Table 10.

Table 9

Means and standard deviations of impact and burden scores across %LEFW groups

	Fluoride Exposure		
SDQ Scales	**Minimal**	**Partial**	**Full**
Impact score	0.64 (1.59)	0.75 (1.91)	0.72 (1.69)
Burden score	0.42 (0.74)	0.53 (0.86)	0.44 (0.75)

Table 10

Simultaneous multiple regression analyses for variables predicting SDQ impact and burden scores

	Impact Scores					Burden Scores				
	B	*SE*	*β*	*p*	*95% CI*	*B*	*SE*	*β*	*p*	*95% CI*
Constant	1.41	0.29		.000	0.83, 1.98	0.70	0.13		.000	0.45, 0.96
Fluoride Exposure										
Minimal (<25%)										
Partial (25-<100%)	0.10	0.19	0.02	.583	-0.27, 0.47	0.08	0.08	0.04	.364	-0.09, 0.24
Full (100%)	0.10	0.16	0.03	.525	-0.21, 0.40	-0.01	0.07	-0.01	.891	-0.14, 0.13
Household Income										
Low Income										
Medium Income	-0.03	0.18	-0.01	.871	-0.39, 0.33	-0.07	0.08	-0.04	.402	-0.22, 0.09
High Income	-0.12	0.20	-0.03	.547	-0.50, 0.27	-0.05	0.09	-0.03	.544	-0.22, 0.12
Indigenous Identity										
Non-Indigenous										
Indigenous	0.18	0.41	0.02	.661	-0.62, 0.98	0.06	0.18	0.01	.749	-0.29, 0.41
Parent Education										
School-level Education										
Vocational Education	-0.27	0.24	-0.05	.258	-0.74, 0.20	0.00	0.11	0.00	.989	-0.21, 0.21
Tertiary Education	-0.32	0.20	-0.08	.113	-0.73, 0.08	-0.06	0.09	-0.04	.477	-0.24, 0.11
Parent Country of Birth										
Australian-born										
Overseas-born	0.06	0.14	0.01	.686	-0.21, 0.32	0.01	0.06	0.01	.843	-0.11, 0.13
Sex										
Male										
Female	-0.05	0.12	-0.02	.657	-0.29, 0.18	0.02	0.05	0.01	.671	-0.08, 0.13

(continued)

No. of Guardians										
One Guardian										
Two Guardians	-0.25	0.23	-0.04	.277	-0.69, 0.20	-0.17	0.10	-0.06	.095	-0.36, 0.03
Residential Location										
Major City										
Inner Regional	0.24	0.17	0.06	.150	-0.09, 0.57	0.08	0.07	0.04	.265	-0.06, 0.23
Outer Regional	-0.14	0.20	-0.03	.467	-0.53, 0.24	-0.03	0.09	-0.01	.741	-0.20, 0.14
Remote/ Very Remote	0.26	0.35	0.03	.458	-0.43, 0.94	0.14	0.15	0.03	.351	-0.16, 0.44
Socioeconomic Status										
SEIFA 1										
SEIFA 2	-0.10	0.22	-0.02	.666	-0.54, 0.34	-0.03	0.10	-0.01	.760	-0.22, 0.16
SEIFA 3	-0.37	0.23	-0.08	.104	-0.81, 0.08	-0.17	0.10	-0.08	.094	-0.36, 0.03
SEIFA 4	-0.24	0.22	-0.06	.258	-0.67, 0.18	-0.01	0.10	-0.01	.902	-0.20, 0.17
SEIFA 5	-0.26	0.22	-0.07	.253	-0.70, 0.18	0.00	0.10	0.00	.988	-0.19, 0.20
Model	$F(17, 900) = 0.985$, $p = .473$			$R^2 = 0.018$		$F(17, 900) = .952$, $p = .512$			$R^2 = 0.018$	

Note. Reference groups for dummy variables were minimal fluoride (<25%), low income, non-Indigenous, school-level education, Australian-born, male, one guardian, major city, and SEIFA 1. SEIFA = Socioeconomic Indexes for Areas Group. Higher SEIFA group membership indicates greater socioeconomic advantage.

CHAPTER IV

Discussion

4.1 Overview

The purpose of the present study was to investigate whether a relationship exists between lifetime exposure to fluoridated water and child social and emotional wellbeing. The study aimed to address some of the limitations of previous studies connecting fluoride exposure to adverse effects on child wellbeing and explore the largely new area of social and emotional factors within water fluoridation literature. The study hypotheses were largely supported, as no significant relationships were found between %LEFW and SDQ scores. The results of this study contribute to the literature in suggesting water fluoridation is not detrimental to childhood health, namely not impairing crucial emotional and behavioural functioning.

4.2 Summary of findings

Our first two study hypotheses referred to the effect of lifetime exposure to fluoridated water on overall social and emotional wellbeing, as well as the subcategories of functioning (measured in SDQ total difficulty and subscale scores). No significant relationship was found for both overall and subcategory aspects of social and emotional wellbeing. This is inconsistent with the small amount of previous research conducted in this area, which found that fluoride exposure was associated with anxious and depressive symptoms in mice (Liu et al., 2014; Li et al., 2019). These descriptions of emotional difficulty are most closely related to the emotional problems subscale of the SDQ, for which each of the three fluoride groups did not significantly contribute to variance in scores. Membership to the minimal fluoride exposure group was associated with the lowest total

difficulty score, however the partial (β = .01) and full (β = .04) exposure groups were only slightly higher (Table 6).

As previously discussed, other studies have found a relationship between fluoride exposure and the thyroid gland, with fluoride leading to depressive symptoms, but having a therapeutic effect on externalising problems (Galletti & Joyet, 1958; Peckham et al., 2015; Zachariassen & Flaten, 2009; Zohreh et al., 2018). The first again relates to the emotional problems subscale in the SDQ, while the latter is most relevant to the hyperactivity and conduct problems subscales. In the analyses, the model of predictors for conduct problems was not significant, and the hyperactivity model was significant, but fluoride exposure did not significantly contribute to the model. Despite this, the Beta values for hyperactivity did somewhat follow this trend in the literature in that membership to the full fluoride exposure group accounted for the greatest decrease in scores (β = -.03), albeit, this is a trivial effect.

There are significant differences in methodology which likely explain this discrepancy in results between the present study and those done previously. The two studies linking fluoride to behavioural changes via decreased hyperthyroidism (Galletti & Joyet, 1958; Zachariassen & Flaten, 2009) drew their conclusions based on animal samples, and measured much higher fluoride levels (5-10mg/L and 68mg/L) than those in Australian public water systems (0.6-1.1mg/L). This is a significant difference considering skeletal fluorosis is known to occur when fluoride concentrations reach 3.0mg/L (WHO, 2017). The two studies linking fluoride to hypothyroidism did measure lower fluoride levels (0.3-0.7mg/L and 0-0.5mg/L) but did not directly explore any emotional or behavioural outcomes (Peckham et al., 2015; Zohreh et al., 2018). Bearing in mind this previous research, and the research connecting high fluoride exposure to cognitive deficits, it is probable that exposure to fluoride in high concentrations does cause issues in emotional functioning to some extent.

However, there remains no evidence that the levels of fluoride present in Australian water systems would be likely to cause emotional problems in children, nor are they likely to prevent conduct or hyperactivity problems.

Our third hypothesis referred to the effect of fluoride exposure on total difficulty scores as measured by the proportion of participants belonging to clinical risk categories based on Goodman's cut-off values (Youthinmind, 2019). Very slight differences between groups could be seen from inspection of frequencies, with the partial exposure group having a slightly greater proportion of participants in the borderline and abnormal category, and slightly less in the normal category. A logistic regression revealed that these differences were not statistically significant when confounders were controlled for. Consistent with the trend in frequencies between groups, individuals in the partial exposure group had a 1.53 greater probability of belonging to the clinically elevated group than those in the minimal exposure group. Those in the full exposure group had the next greatest probability, with an odds ratio of 1.07, however these differences were not significant. The present study appears to be the first to explore clinical risk categories in the context of fluoride exposure, however since the emotional problems subscale generally has the highest correlation with total difficulty scores (r = 0.80 in the present sample), it could be said that these results are again inconsistent with previous research in that they do not indicate fluoride exposure (within recommended concentrations) increases overall difficulties in social and emotional functioning.

Hypotheses 4 and 5 referred specifically to the impact and subsequent burden of reported social and emotional difficulties. The minimal fluoride exposure group had a slightly lower impact score than the other two exposure groups, however neither regression models produced significant results, suggesting the difficulties experienced by those with less fluoride exposure do not necessarily have less impact on their day to day lives. The impact

and burden variables were developed to bring a more comprehensive understanding of social and emotional difficulties and thus may be most meaningful when analysed in accordance with, or to better understand, clear trends in total difficulty scores. Since analyses did not find an association between membership to fluoride exposure groups and total difficulty scores, it is not surprising that there were also no strong trends in the impact or burden of those difficulties.

4.3 Strengths and limitations

4.3.1 Non-inferiority testing

Due to the time limitations of the project, the test of non-inferiority was not used to assess the null hypotheses. This is a significant limitation as, while no statistically significant difference was found between fluoride exposure groups, and we therefore cannot reject the null hypothesis that fluoride exposure has no effect on emotional and behavioural functioning, we also cannot accept this hypothesis solely on the basis of not reaching significance. These results do not provide definite evidence that those with full fluoride exposure are not unacceptably inferior than those with low exposure (i.e. that there is definitely no adverse effect of exposure to fluoride on social and emotional wellbeing). Therefore, any conclusions drawn from these results must be considered in light of this limitation and not be overstated, and future research should be conducted in consideration of this. Recommendations for future research will be discussed in greater detail further below.

4.3.2 Use of %LEFW as measure for exposure to fluoride

Despite being unable to confirm its hypotheses, the study largely completed its aims. As intended, the study corrected several limitations of previous research conducted which made claims regarding the danger of water fluoridation on child health. The measure used for

exposure to fluoride in the present study greatly improved upon many of those previously used; not only did the study focus on long-term exposure (rather than fluoride levels in the body), it also did not assume stable fluoride concentrations or participant residency overtime. While this measure did not capture all possible exposures to fluoride (e.g. teas and certain foods), it is understood that fluoridated water is often the primary source of fluoride in Australia. Maintaining focus on water fluoridation also makes the results and conclusions more directly applicable to public health policy, as public water fluoridation has often been the key concern of studies suggesting fluoride may have negative neurological effects. It should also be noted that the measure of fluoride exposure used in the study was obtained from the 2012-2014 NCOHS and is thus somewhat out of date, however, being a long-term measure, it likely still adequately reflects patterns of exposure in most participants. Being nationally representative, the study included a large number (N=194) of participants who had never had access to fluoridated water (i.e. whose fluoride exposure was 0%), as well as those who had always had this exposure (i.e. fluoride exposure of 100%, N=481). This bimodal distribution reflects common differences in fluoride exposure found in previous studies (Spencer, Do, & Ha, 2018). This representation of different exposure groups is a significant strength of the study, as its implications are relevant and applicable to all Australian states and public water fluoridation policies.

4.3.3 Sample size and representativeness

As was its aim, this study has contributed arguably the most nationally representative sample in this field of research, including participants from both regional and metropolitan areas, state and private schools, and from a variation of socioeconomic statuses and household circumstances. Unlike most previous studies in this area, the study also had a large sample size, giving ample power (.995 in a post-hoc analysis, see Appendix C) to detect the

small effects seen in analyses. Previous studies have often not known whether non-significant results were due to lack of power or truly reflective of there being no relationship between fluoride and child functioning. Meta-analyses in this area have thus recommended researchers ensure adequate sample sizes prior to analysis, which is a significant strength of the present study.

The study is representative in its wide inclusion of demographic factors, however, common to community samples, the present sample did not have equal weighing across demographic groups. Of those involved in the study, 55.7% resided in a city, and most were from middle (42.7%) and high (39.6%) income households. This is not surprising, as it is difficult to obtain a completely random sample when recruiting from the public, and voluntary community samples are often largely comprised of individuals with higher education and sufficient resources required to participate (Cobb, Singer, & Davis, 2014; Ten Klooster, Smit, & Pieterse, 2017). The present sample was comprised largely of majority groups, with only 2.3% of participants identifying as Indigenous, only 9.6% having not gone beyond school-level education, and 17.7% falling into the low socioeconomic status group. Having primarily high-income, highly educated individuals involved in the study may have affected the generalizability of its findings, in that, while fluoride exposure may not impact social and emotional difficulties in those from areas of relative advantage, this relationship may look differently for those of different income, education and Indigenous groups.

Our population was made up of the first responders (those who replied within approximately a month) of a larger study, and thus although the study's sample was representative, it was also most likely made up of the most diligent and conscientious of participants. These participants may have been more likely to practice appropriate oral health behaviours or come from more favourable backgrounds, which may have affected their SDQ

scores and hidden a relationship between SDQ scores and fluoride exposure. Despite the sample being not entirely representative, this is still a notable improvement on the previous literature, which often used convenience samples, comparing two or three specific towns and attempting to control for confounders by keeping socioeconomic status the same.

4.3.4 Use of SDQ as measure for social and emotional wellbeing

The usefulness and applicability of the study conclusions is largely reliant upon the validity of the SDQ as a diagnostic tool for social and emotional difficulties. Use of the SDQ in this way was both a strength and limitation of the study. Use of reliable, valid, and widely-used measures to assess child functioning has not previously been done in this area of research yet is a noteworthy improvement in the present study. However, while the SDQ is a well-established measure, it is not the gold standard of assessing social and emotional wellbeing. One-on-one diagnostic interviews have long been accepted as this gold standard (Goodman, 2001; Goodman et al., 2000; Vaz et al., 2016), however considering the study's large, nation-wide population, and the time limitations of the project, use of this measure would have been impractical, and the study was not resourced efficiently to individually assess every child via clinical interview.

As discussed earlier, research shows a good relationship between the SDQ and clinical interviews. This has been established in a number of international samples (Becker, Woerner, Hasselhorn, Banaschewski, & Rothenberger, 2004; Samad, Hollis, Prince, & Goodman, 2005; Vugteveen, De Bildt, Hartman, & Timmerman, 2018), as well as a general Australian sample (Hawes & Dadds, 2004), which reported moderate correlations between SDQ total difficulty scores and clinical interviews (r=.57). The common conclusion regarding these validations is that the measure is useful as a screening tool for noticing social, emotional and behavioural difficulties, but should not replace a formal clinical diagnosis.

Considering the aim of the study was to recognise patterns in social or emotional difficulties across fluoride exposure groups, and not to necessarily identify individual clinical issues, the SDQ proved valuable for its intended use. Use of the SDQ allowed us to explore the largely unexplored research area within a small timeframe, and this study remains one of the only studies to date to have assessed social and emotional wellbeing as an outcome of fluoride exposure in humans.

Limitations also lie more specifically in use of the parent-informant version of the SDQ. While questioning parents is the most efficient way of collecting information about children's emotional and social problems, there is considerable evidence suggesting biases and inaccuracies can occur when informants provide information about children based on their own perceptions and experiences with them (Achenbach, 2009). Previous research has shown that parents are more accurate when reporting on externalising problems, and less accurate when rating internalising problems, due to internalising symptoms being difficult to see (Duhig, Renk, Epstein, & Phares, 2000). Parents experiencing depression, anxiety or stress themselves also tend to rate their children higher on emotional problems than independent raters (De Los Reyes & Kazdin, 2005). It is a known weakness that the subscales of the SDQ-P are not as internally consistent as the total difficulty scores (Kersten et al., 2016). This was true within the present sample, with both conduct and peer problems scales not reaching the benchmark of 0.70. Considering these limitations, the best way of obtaining information about a child's behavioural and emotional difficulties is through a combination of observation and interaction with the child themselves, as well as obtaining information from teachers and both guardians (Achenbach, 2009).

Along with having items to identify difficulties, the SDQ asked for additional comments from parents, through which they could express further information regarding their

child or the questionnaire. Review of this section revealed a pattern in which several participants commented on how the emotional difficulties they reported seeing in their child were most likely due to puberty or being a teenager, and that the items in the questionnaire appeared to be more relevant to younger children than to adolescents. Similar to its other psychometric properties, validity for the parent-informant adolescent version of the SDQ has generally been reported as moderate to good (Bekker, Bruck, & Sciberras, 2016; He, Burstein, Schmitz, & Merikangas, 2013; Kovacs & Sharp, 2014), and each version of the SDQ is worded differently as to tailor items to the relevant age group. This is therefore a surprising theme in participants and suggests there may be an issue with the face validity in this version of the test. Lack of face validity may have impacted how thoroughly or truthfully guardians answered the questionnaire and contributed to the attrition rates of the study, thus impacting final results.

As discussed, the parent version of the SDQ has been widely validated in Australian and other Western samples, however there have been questions regarding its validity in families with non-English speaking backgrounds (Kersten et al., 2016). Issues have also been found in its use with Indigenous Australian populations, in particular, the peer problems scale perceiving certain behaviours as problematic which are actually not considered to be an issue within that cultural context (Williamson et al., 2014). Approximately one-third of the study sample (32.9%) reported that one or both parents were not born in Australia. This means that a considerable amount of the children in the sample may have grown up in non-Western backgrounds, and as there have been concerns surrounding its validity in non-Western countries (Coghill, Kou, & Du, 2008; Riso et al., 2010), it may be that the SDQ did not provide an accurate indication of emotional and social difficulties for the participants from these backgrounds.

4.3.5 Attrition rates

As the study required participants to complete a relatively long questionnaire including questions on oral health, cognitive wellbeing, and the SDQ, many participants did not complete the entire questionnaire. In fact, a total of 279 participants dropped out before completing the section of the form containing the SDQ. Comparison of demographic variables between completers and those who dropped out of the study suggests minimal differences between those who completed the SDQ and those who did not. Of those who dropped out, there were slightly more with only one guardian (14.8%), and slightly less individuals educated beyond school level (86.5%), than in the final sample (9% and 90.4% respectively). This makes sense, as those from one guardian households and those with less education may have less time and resources to complete the study than those with two guardians or higher education. Apart from this, demographic patterns appeared similar across the two groups. As this study relied on following up participants from a study conducted five years ago, attrition rates from the original study were most likely also a factor in the final participant group recruited.

4.3.6 Control of confounders

In consideration of previous research, the present study developed and successfully controlled for a number of confounders relevant to the present Australian sample. This is a notable improvement to previous studies; whereby very significant confounders were often not considered, and it could not be concluded whether any effects found were due to the lack of control for these. While the study had data on a range of key confounders, it was not completely comprehensive, and did not control for all factors which could influence social and emotional functioning. For example, parent education, income and socioeconomic status,

were controlled for in the present study, but there are also other factors within the home which have been known to impact a child's functioning (Pachter, Auinger, Palmer, & Weitzman, 2006). One study exploring the effect of fluoride exposure on intelligence accounted for this by also controlling for home environment (Green et al., 2019). It was also recommended that future studies control for parent IQ. Similarly, considering the potential for bias when using parent-report questionnaires, the present study would have benefitted from the assessment and control of parents' emotional and behavioural functioning as well as children's.

4.4 Implications for policy and future research

As discussed, there have been considerable concerns regarding water fluoridation in several recent studies. The effectiveness of water fluoridation has long been confirmed, however this study addressed these questions regarding simultaneous adverse effects on child development, suggesting water fluoridation is of much greater benefit than risk to public health. The study therefore provides support for each state-wide policy of water fluoridation in Australia by suggesting the social and emotional wellbeing of children is not significantly affected by regular exposure to fluoride at its current concentration level in public water supplies. While these results do not point toward national policy change, it does suggest that introducing these policies into the smaller towns and cities in Australia which still do not have fluoridated water (several of which are in Queensland) would not be of detriment to children's wellbeing and thus should be considered by local governments. Sound literature which suggests those with full exposure to fluoridated water are not functionally inferior is beneficial in that it prevents the need for a large-scale evaluation of water fluoridation. Were this to be a necessity, there would be significant economic implications, as this would extend also to fluoride levels in numerous foods, drinks and dental products.

Due to a lack of high-quality research, meta-analyses to date have not reached consensus regarding the relationship between early fluoride exposure and child functioning (Choi et al., 2012; Tang, Du, Ma, Jiang, & Zhou, 2008). This study has followed the recommendations of previous systematic reviews by contributing high-quality research which has addressed several previous criticisms of work in this area, while exploring the relatively new research interest of fluoride in relation to social and emotional difficulties in children. However, the study's methodology and results suggest certain factors should be considered for future research to improve and further explore this area of literature. To confirm the inferences about the null hypothesis, future research should involve testing the equivalence, or at least non-inferiority, of exposure groups, so as to assess whether those with consistent exposure to fluoride from drinking water are equivalent, or not inferior, in social and emotional functioning to those without this exposure (Lakens, 2017; Schumi & Wittes, 2011). Either conclusion would provide support for maintaining Australian public water fluoridation policies.

Rationale for the present study was largely related to weak methodology in previous studies linking fluoride exposure to child development, with several of these focussing on cognitive deficits and IQ. While this study suggests it is probable that low level fluoride exposure has no effect on social and emotional development, the SDQ does not measure cognitive functioning, and thus we are unable to make broad conclusions as to whether exposure to fluoride has no adverse effect on overall child development. Further research is required to explore this relationship with a representative sample and sound measures of lifetime exposure to fluoridated water at practically relevant concentrations. As the SDQ only reached moderate levels of internal consistency in the study sample, future research may also

benefit from use of a psychopathology measure closer to the gold standard. Studies with greater time and resources should consider use of clinical interviews to achieve this.

Overall, these results are relevant to Australian public water policies, and the conclusions are drawn with a reliance on controlling for confounders relevant to those residing in Australia. These confounding variables may be significantly different in other countries, in particular those which have high levels of other harmful chemicals in the environment (NHMRC, 2017). As water fluoridation has been raised as a concern in research primarily from other countries, namely China (Choi et al., 2015; Cui et al., 2018; Yu et al., 2018) and India (Das & Mondal, 2016; Khan et al., 2015; Mondal, Dutta, & Gupta, 2016; Razdan et al., 2017), international studies similar to the present should be conducted to assess the impact of water fluoridation in concentrations specific to other countries' policies, controlling for confounders relevant to those countries, with use of representative international samples.

4.4 Conclusions

This study has contributed valuable research to the literature, suggesting exposure to fluoride (at the concentrations found in Australian public water supplies) does not have a significant negative or positive effect on child social and emotional wellbeing. The results of the study suggest further research is required to replicate these findings in other representative samples. Tests of equivalence or non-inferiority are encouraged to confirm these conclusions.

References

Achenbach, T. (1966). The classification of children's psychiatric symptoms: A factor analytic study. *Psychological Monographs, 80*.

Achenbach, T. (2009). Some Needed Changes in DSM-V: But What About Children? *Clinical Psychology: Science and Practice, 16*(1), 50-53. doi:10.1111/j.1468-2850.2009.01142.x

Allende-Alonso, S., Bouza-Herrera, C. N., Rizvi, S. E. H., & Sautto-Vallejo, J. M. (2019). Big data and the central limit theorem: A statistical legend. *Investigacion Operacional, 40*(1), 112.

Allgood-Merten, B., Lewinsohn, P. M., & Hops, H. (1990). Sex Differences and Adolescent Depression. *Journal of Abnormal Psychology, 99*(1), 55-63. doi:10.1037/0021-843X.99.1.55

Armfield, J. M., Spencer, A. J., Roberts-Thomson, K. F., & Plastow, K. (2013). Water fluoridation and the association of sugar-sweetened beverage consumption and dental caries in Australian children. *American Journal of Public Health, 103*(3), 494. doi:10.2105/AJPH.2012.300889

Arnold, D., Ortiz, C., Curry, J., Stowe, R. M., Goldstein, N., Fisher, P., . . . Yershova, K. (1999). Promoting academic success and preventing disruptive behavior disorders through community partnership. *Journal of Community Psychology, 27*(5), 589-598.

Australian Bureau of Statistics. (2011). *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA)*. Australia

Australian Bureau of Statistics. (2016). Australian Statistical Geography Standard (ASGS). Retrieved from

https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1270.0.55.001~July%202016~Main%20Features~Overview~1

Australian Institute of Health and Welfare. (2012). *Social and emotional wellbeing: Development of a Children's Headline Indicator*. Canberra: AIHW

Awofeso, N. (2012). Ethics of Artificial Water Fluoridation in Australia. *Public Health Ethics, 5*(2), 161-172. doi:10.1093/phe/phs016

Bayer, J., Ukoumunne, O. C., Mathers, M., Wake, M., Abdi, N., & Hiscock, H. (2012). Development of children's internalising and externalising problems from infancy to five years of age. *Australian and New Zealand Journal of Psychiatry, 46*(7), 659-668. doi:10.1177/0004867412450076

Becker, A., Woerner, W., Hasselhorn, M., Banaschewski, T., & Rothenberger, A. (2004). Validation of the parent and teacher SDQ in a clinical sample. *European Child & Adolescent Psychiatry, 13*(2), ii11-ii16. doi:10.1007/s00787-004-2003-5

Bekker, J., Bruck, D., & Sciberras, E. (2016). Congruent Validity of the Strengths and Difficulties Questionnaire to Screen for Comorbidities in Children With ADHD. *Journal of Attention Disorders, 20*(10), 879-888. doi:10.1177/1087054713496462

Bogren, L. Y. (1997). Expressed emotion, family burden, and quality of life in parents with schizophrenic children. *Nordic Journal of Psychiatry, 51*(4), 229-233. doi:10.3109/08039489709090713

Bozic, N. (2013). Developing a strength-based approach to educational psychology practice: A multiple case study. *Educational and Child Psychology, 30*(4), 18-29.

Bryan, J., Osendarp, S., Hughes, D., Calvaresi, E., Baghurst, K., & Klinken, J. (2004). Nutrients for Cognitive Development in School-aged Children. *Nutrition Reviews, 62*(8), 295-306. doi:10.1111/j.1753-4887.2004.tb00055.x

Cate, J. M. T. (1999). Current concepts on the theories of the mechanism of action of fluoride. *Acta Odontologica Scandinavica, 57*(6), 325-329. doi:10.1080/000163599428562

Choi, A. L., Sun, G., Zhang, Y., & Grandjean, P. (2012). Developmental Fluoride Neurotoxicity: A Systematic Review and Meta-Analysis. *Environmental Health Perspectives*. doi:10.1289/ehp.1104912

Choi, A. L., Zhang, Y., Sun, G., Bellinger, D. C., Wang, K., Yang, X. J., . . . Grandjean, P. (2015). Association of lifetime exposure to fluoride and cognitive functions in Chinese children: A pilot study. *Neurotoxicology and Teratology, 47*, 96-101. doi:10.1016/j.ntt.2014.11.001

Clarkson, J. J., Hardwick, K., Barmes, D., & Richardson, L. M. (2000). International Collaborative Research on Fluoride. *Journal of Dental Research, 79*(4), 893-904. doi:10.1177/00220345000790040301

Cobb, E. M., Singer, D. C., & Davis, M. M. (2014). Public Interest in Medical Research Participation: Differences by Volunteer Status and Study Type. *Clinical and Translational Science, 7*(2), 145-149. doi:10.1111/cts.12142

Coghill, D., Kou, J., & Du, Y. (2008). The validity, reliability and normative scores of the parent, teacher and self report versions of the Strengths and Difficulties Questionnaire in China. *Child and Adolescent Psychiatry and Mental Health, 2*(1), 8. doi:10.1186/1753-2000-2-8

Costello, E. J., Egger, H., & Angold, A. (2005). 10-Year Research Update Review: The Epidemiology of Child and Adolescent Psychiatric Disorders: I. Methods and Public Health Burden. *Journal of the American Academy of Child & Adolescent Psychiatry, 44*, 972-986. doi:10.1097/01.chi.0000172552.41596.6f

Crijnen, A. A. M., Achenbach, T. M., & Verhulst, F. C. (1997). Comparisons of Problems Reported by Parents of Children in 12 Cultures: Total Problems, Externalizing, and Internalizing. *Journal of the American Academy of Child & Adolescent Psychiatry, 36*(9), 1269-1277. doi:10.1097/00004583-199709000-00020

Cui, Y., Zhang, B., Ma, J., Wang, Y., Zhao, L., Hou, C., . . . Liu, H. (2018). Dopamine receptor D2 gene polymorphism, urine fluoride, and intelligence impairment of children in China: A school-based cross-sectional study. *Ecotoxicology and Environmental Safety, 165*, 270-277. doi:10.1016/j.ecoenv.2018.09.018

Das, K., & Mondal, N. (2016). Dental fluorosis and urinary fluoride concentration as a reflection of fluoride exposure and its impact on IQ level and BMI of children of Laxmisagar, Simlapal Block of Bankura District, W.B., India. *An International Journal Devoted to Progress in the Use of Monitoring Data in Assessing Environmental Risks to Man and the Environment, 188*(4), 1-14. doi:10.1007/s10661-016-5219-1

De Los Reyes, A., & Kazdin, A. E. (2005). Informant Discrepancies in the Assessment of Childhood Psychopathology: A Critical Review, Theoretical Framework, and Recommendations for Further Study. *Psychological Bulletin, 131*(4), 483-509. doi:10.1037/0033-2909.131.4.483

Dearing, E., McCartney, K., & Taylor, B. A. (2006). Within-Child Associations Between Family Income and Externalizing and Internalizing Problems. *Developmental Psychology, 42*(2), 237-252. doi:10.1037/0012-1649.42.2.237

Denham, S. A., Wyatt, T. M., Bassett, H. H., Echeverria, D., & Knox, S. S. (2009). Assessing social-emotional development in children from a longitudinal perspective.(Longitudinal Assessment in Children). *Journal of Epidemiology & Community Health, 63*(1), I37.

Ding, Y., Yanhuigao, H., Sun, H., Han, W., Wang, X., Ji, X., . . . Sun, D. (2011). The relationships between low levels of urine fluoride on children's intelligence, dental fluorosis in endemic fluorosis areas in Hulunbuir, Inner Mongolia, China. *Journal of Hazardous Materials, 186*(2-3), 1942-1946. doi:10.1016/j.jhazmat.2010.12.097

Do, L. G., & Spencer, A. J. (2007a). Decline in the prevalence of dental fluorosis among South Australian children. *Community Dentistry and Oral Epidemiology, 35*(4), 282-291. doi:10.1111/j.1600-0528.2007.00314.x

Do, L. G., & Spencer, A. J. (2007b). Risk-Benefit Balance in the Use of Fluoride among Young Children. *Journal of Dental Research, 86*(8), 723-728. doi:10.1177/154405910708600807

Do, L. G., & Spencer, A. J. (2016). *Oral health of Australian children: The National Child Oral Health Study 2012-14*: University of Adelaide Press.

Du, L., Wan, C. W., Cao, X., & Liu, J. (2008). The effect of fluorine on the developing human brain. *Fluoride, 41*(4), 327-330.

Duhig, A. M., Renk, K., Epstein, M. K., & Phares, V. (2000). Interparental Agreement on Internalizing, Externalizing, and Total Behavior Problems: A Meta-analysis. *Clinical Psychology: Science and Practice, 7*(4), 435-453. doi:10.1093/clipsy.7.4.435

Fawell, J., Bailey, K., & Chilton, J. (2006). *Fluoride in Drinking-water*. Albany: Albany: World Health Organization.

Fletcher, J., Tannock, R., & Bishop, D. V. M. (2001). Utility of brief teacher rating scales to identify children with educational problems. *Australian Journal of Psychology, 53*(2), 63-71. doi:10.1080/00049530108255125

Galletti, P. M., & Joyet, G. (1958). Effect of fluorine on thyroidal iodine metabolism in hyperthyroidism. *Journal of Clinical Endocrinology and Metabolism, 18*(10), 1102-1110. doi:10.1210/jcem-18-10-1102

Garmezy, N. (1991). Resiliency and Vulnerability to Adverse Developmental Outcomes Associated With Poverty. *American Behavioral Scientist, 34*(4), 416-430. doi:10.1177/0002764291034004003

Ghasemi, A., & Zahediasl, S. (2012). Normality Tests for Statistical Analysis: A Guide for Non-Statisticians. *International Journal of Endocrinology and Metabolism, 10*(2), 486-489. doi:10.5812/ijem.3505

Goodman, R. (1994). A Modified Version of the Rutter Parent Questionnaire Including Extra Items on Children's Strengths: A Research Note. *Journal of Child Psychology and Psychiatry, 35*(8), 1483-1494. doi:10.1111/j.1469-7610.1994.tb01289.x

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: A Research Note. *Journal of Child Psychology and Psychiatry, 38*(5), 581-586. doi:10.1111/j.1469-7610.1997.tb01545.x

Goodman, R. (1999). The Extended Version of the Strengths and Difficulties Questionnaire as a Guide to Child Psychiatric Caseness and Consequent Burden. *Journal of Child Psychology and Psychiatry, 40*(5), 791-799. doi:10.1111/1469-7610.00494

Goodman, R. (2001). Psychometric Properties of the Strengths and Difficulties Questionnaire. *Journal of the American Academy of Child & Adolescent Psychiatry, 40*(11), 1337-1345. doi:10.1097/00004583-200111000-00015

Goodman, R., Renfrew, D., & Mullick, M. (2000). Predicting type of psychiatric disorder from Strengths and Difficulties Questionnaire (SDQ) scores in child mental health clinics in London and Dhaka.(Author abstract). *European Child & Adolescent Psychiatry, 9*(2), 129. doi:10.1007/s007870050008

Goodman, R., & Scott, S. (1999). Comparing the Strengths and Difficulties Questionnaire and the Child Behavior Checklist: Is Small Beautiful? *An official publication of the*

International Society for Research in Child and Adolescent Psychopathology, 27(1), 17-24. doi:10.1023/A:1022658222914

Grandjean, P., & Landrigan, P. J. (2014). Neurobehavioural effects of developmental toxicity. *Lancet Neurology, 13*(3), 330-338. doi:10.1016/S1474-4422(13)70278-3

Green, R., Lanphear, B., Hornung, R., Flora, D., Martinez-Mier, E. A., Neufeld, R., . . . Till, C. (2019). Association Between Maternal Fluoride Exposure During Pregnancy and IQ Scores in Offspring in Canada. *JAMA pediatrics*. doi:10.1001/jamapediatrics.2019.1729

Greenberg, M. T., Domitrovich, C., & Bumbarger, B. (2001). The Prevention of Mental Disorders in School-Aged Children: Current State of the Field. *Prevention & Treatment, 4*(1). doi:10.1037/1522-3736.4.1.41a

Grembowski, D. (1988). Measuring length of exposure to fluoridated water. *Community Dentistry and Oral Epidemiology, 16*(3), 131-134. doi:10.1111/j.1600-0528.1988.tb00559.x

Gussy, M. G., Waters, E. G., Walsh, O., & Kilpatrick, N. M. (2006). Early childhood caries: Current evidence for aetiology and prevention. *Journal of Paediatrics and Child Health, 42*(1-2), 37-43. doi:10.1111/j.1440-1754.2006.00777.x

Hage, M. P., & Azar, S. T. (2012). The Link between Thyroid Function and Depression. *Journal of Thyroid Research, 2012*(2012). doi:10.1155/2012/590648

Hawes, D. J., & Dadds, M. R. (2004). Australian Data and Psychometric Properties of the Strengths and Difficulties Questionnaire. *Australian and New Zealand Journal of Psychiatry, 38*(8), 644-651. doi:10.1080/j.1440-1614.2004.01427.x

Hayes, L. (2007). Problem Behaviours in Early Primary School Children: Australian Normative Data using the Strengths and Difficulties Questionnaire. *Australian and*

New Zealand Journal of Psychiatry, 41(3), 231-238. doi:10.1080/00048670601172715

He, H., Cheng, Z., & Liu, W. (2008). Effects of fluorine on the human fetus. *Fluoride, 41*(4), 321-326.

He, J.-P., Burstein, M., Schmitz, A., & Merikangas, K. (2013). The Strengths and Difficulties Questionnaire (SDQ): the Factor Structure and Scale Validation in U.S. Adolescents. *An official publication of the International Society for Research in Child and Adolescent Psychopathology, 41*(4), 583-595. doi:10.1007/s10802-012-9696-6

Health Protection Unit. (2013). *Water Fluoridation Code of Practice*. Queensland: Health Protection Unit

Queensland Health. (2008). *Tooth decay: Health Teeth for Life fact sheet*. Queensland: Queensland Government

Hinshaw, S. P. (1987). On the Distinction Between Attentional Deficits/Hyperactivity and Conduct Problems/Aggression in Child Psychopathology. *Psychological Bulletin, 101*(3), 443-463. doi:10.1037/0033-2909.101.3.443

Hong, F., Cao, Y., Yang, D., & Wang, H. (2008). Research on the effects of fluoride on child intellectual development under different environmental conditions. *Fluoride, 41*(2), 156-160.

International Programme on Chemical Safety. (2002). *Fluorides*. Geneva: World Health Organization

Jack, B., Ayson, M., Lewis, S., Irving, A., Agresta, B., Ko, H., & Stoklosa, A. (2016). *Health Effects of Water Fluoridation: Evidence Evaluation Report*. Canberra

Jetti, R., Raghuveer, C., & Mallikarjuna, R. C. (2016). Protective effect of ascorbic acid and Ginkgo biloba against learning and memory deficits caused by fluoride. *Toxicology and Industrial Health, 32*(1), 183-187. doi:10.1177/0748233713498460

Kanduti, D., Sterbenk, P., & Artnik, B. (2016). Fluoride: A review of use and effects on health. *Materia Socio-Medica, 28*(2), 133-137. doi:10.5455/msm.2016.28.133-137

Karimzade, S., Aghaei, M., & Mahvi, A. (2014). Investigation of intelligence quotient in 9-12-year-old children exposed to high- and low-drinking water fluoride in west azerbaijan province, iran. *Fluoride, 47*(1), 9-14.

Kersten, P., Dudley, M., Nayar, S., Elder, H., Robertson, H., Tauroa, R., & McPherson, K. (2016). Cross-cultural acceptability and utility of the strengths and difficulties questionnaire: views of families. *BMC Psychiatry, 16*(1). doi:10.1186/s12888-016-1063-7

Khan, S. A., Singh, R. K., Navit, S., Chadha, D., Johri, N., Navit, P., . . . Bahuguna, R. (2015). Relationship Between Dental Fluorosis and Intelligence Quotient of School Going Children In and Around Lucknow District: A Cross-Sectional Study. *Journal of Clinical and Diagnostic Research : JCDR, 9*(11), ZC10. doi:10.7860/JCDR/2015/15518.6726

Knock, J., Kline, E., Schiffman, J., Maynard, A., & Reeves, G. (2011). Burdens and difficulties experienced by caregivers of children and adolescents with schizophrenia-spectrum disorders: a qualitative study. *Early Intervention in Psychiatry, 5*(4), 349-354. doi:10.1111/j.1751-7893.2011.00305.x

Koh, R., Pukallus, M. L., Newman, B., Foley, M., Walsh, L. J., & Seow, W. K. (2015). Effects of Water Fluoridation on Caries Experience in the Primary Dentition in a High Caries Risk Community in Queensland, Australia. *Caries Research, 49*(2), 184-191. doi:10.1159/000369864

Kovacs, S., & Sharp, C. (2014). Criterion validity of the Strengths and Difficulties Questionnaire (SDQ) with inpatient adolescents. *Psychiatry Research, 219*(3), 651-657. doi:10.1016/j.psychres.2014.06.019

Kremer, P., de Silva, A., Cleary, J., Santoro, G., Weston, K., Steele, E., . . . Waters, E. (2015). Normative data for the Strengths and Difficulties Questionnaire for young children in Australia. *Journal of Paediatrics and Child Health, 51*(10), 970. doi:10.1111/jpc.12897

Laird, R. D., Jordan, K. Y., Dodge, K. A., Pettit, G. S., & Bates, J. E. (2001). Peer rejection in childhood, involvement with antisocial peers in early adolescence, and the development of externalizing behavior problems. *Development and Psychopathology, 13*(2), 337-354. doi:10.1017/S0954579401002085

Lakens, D. (2017). Equivalence Tests: A Practical Primer for t Tests, Correlations, and Meta-Analyses. *Social Psychological and Personality Science, 8*(4), 355-362. doi:10.1177/1948550617697177

Li, X., Zhang, J., Niu, R., Manthari, R. K., Yang, K., & Wang, J. (2019). Effect of fluoride exposure on anxiety- and depression-like behavior in mouse. *Chemosphere, 215*, 454-460. doi:10.1016/j.chemosphere.2018.10.070

Li, X. S., Zhi, J. L., & Gao, R. O. (1995). Effect of fluoride exposure on intelligence in children. *Fluoride - Quarterly Reports, 28*(4), 189-192.

Liu, F., Ma, J., Zhang, H., Liu, P., Liu, Y.-P., Xing, B., & Dang, Y.-H. (2014). Fluoride exposure during development affects both cognition and emotion in mice. *Physiology & Behavior, 124*, 1-7. doi:10.1016/j.physbeh.2013.10.027

Malin, A. J., Riddell, J., McCague, H., & Till, C. (2018). Fluoride exposure and thyroid function among adults living in Canada: Effect modification by iodine status. *Environment International, 121*, 667-674. doi:10.1016/j.envint.2018.09.026

Masten, A. S., Best, K. M., & Garmezy, N. (1990). Resilience and development: Contributions from the study of children who overcome adversity. *Development and Psychopathology, 2*(4), 425-444. doi:10.1017/S0954579400005812

McClelland, M. M., Morrison, F. J., & Holmes, D. L. (2000). Children at Risk for Early Academic Problems: The Role of Learning-Related Social Skills. *Early Childhood Research Quarterly, 15*(3), 307-329. doi:10.1016/S0885-2006(00)00069-7

Mesman, J., Bongers, I. L., & Koot, H. M. (2001). Preschool Developmental Pathways to Preadolescent Internalizing and Externalizing Problems. *Journal of Child Psychology and Psychiatry, 42*(5), 679-689. doi:10.1017/S0021963001007351

Miller-Lewis, L. R., Sawyer, A. C. P., Searle, A. K., Mittinty, M. N., Sawyer, M. G., & Lynch, J. W. (2014). Student-teacher relationship trajectories and mental health problems in young children. *BMC Psychology, 2*(1). doi:10.1186/s40359-014-0027-2

Mondal, D., Dutta, G., & Gupta, S. (2016). Inferring the fluoride hydrogeochemistry and effect of consuming fluoride-contaminated drinking water on human health in some endemic areas of Birbhum district, West Bengal. *Official Journal of the Society for Environmental Geochemistry and Health, 38*(2), 557-576. doi:10.1007/s10653-015-9743-7

Muris, P., Meesters, C., & van Den Berg, F. (2003). The Strengths and Difficulties Questionnaire (SDQ)--further evidence for its reliability and validity in a community sample of Dutch children and adolescents. *European Child & Adolescent Psychiatry, 12*(1), 1.

Murray, J. J. (1986). *Appropriate use of fluorides for human health*.

National Health and Medical Research Council. (2007). *A systematic review of the efficacy and safety of fluoridation*.

National Health and Medical Research Council. (2017). *Water Fluoridation and Human Health in Australia*.

Pachter, L. M., Auinger, P., Palmer, R., & Weitzman, M. (2006). Do parenting and the home environment, maternal depression, neighborhood, and chronic poverty affect child

behavioral problems differently in different racial-ethnic groups? (Disease/Disorder overview). *Pediatrics, 117*(4), 1329. doi:10.1542/peds.2005-1784

Pahl, K. M., & Barrett, P. M. (2007). The Development of Social-emotional Competence in Preschool-aged Children: An Introduction to the Fun FRIENDS Program. *Australian Journal of Guidance and Counselling, 17*(1), 81-90. doi:10.1375/ajgc.17.1.81

Peckham, S., & Awofeso, N. (2014). Water Fluoridation: A Critical Review of the Physiological Effects of Ingested Fluoride as a Public Health Intervention. *The Scientific World Journal, 2014*. doi:10.1155/2014/293019

Peckham, S., Lowery, D., & Spencer, S. (2015). Are fluoride levels in drinking water associated with hypothyroidism prevalence in England? A large observational study of GP practice data and fluoride levels in drinking water. *Journal of Epidemiology and Community Health, 69*(7), 619. doi:10.1136/jech-2014-204971

Razdan, P., Patthi, B., Kumar, J. K., Agnihotri, N., Chaudhari, P., & Prasad, M. (2017). Effect of Fluoride Concentration in Drinking Water on Intelligence Quotient of 12-14-Year-Old Children in Mathura District: A Cross-Sectional Study. *Journal of International Society of Preventive & Community Dentistry, 7*(5), 252. doi:10.4103/jispcd.JISPCD_201_17

Reiss, F. (2013). Socioeconomic inequalities and mental health problems in children and adolescents: A systematic review. *Social Science & Medicine, 90,* 24-31. doi:10.1016/j.socscimed.2013.04.026

Rice, L. J., Emerson, E., Gray, K. M., Howlin, P., Tonge, B. J., Warner, G. L., & Einfeld, S. L. (2018). Concurrence of the strengths and difficulties questionnaire and developmental behaviour checklist among children with an intellectual disability. *Journal of Intellectual Disability Research : JIDR, 62*(2), 150. doi:10.1111/jir.12426

Riso, D. D., Salcuni, S., Chessa, D., Raudino, A., Lis, A., & AltoΓË, G. (2010). The Strengths and Difficulties Questionnaire (SDQ). Early evidence of its reliability and validity in a community sample of Italian children. *Personality and Individual Differences, 49*(6), 570-575. doi:10.1016/j.paid.2010.05.005

Roelofs, J., Meesters, C., ter Huurne, M., Bamelis, L., & Muris, P. (2006). On the Links Between Attachment Style, Parental Rearing Behaviors, and Internalizing and Externalizing Problems in Non-Clinical Children. *Journal of Child and Family Studies, 15*(3), 319-332. doi:10.1007/s10826-006-9025-1

Rogers, J. G. (2011). *Evidence-based oral health promotion resource*. Melbourne: Prevention and Population Health Branch

Rugg-Gunn, A. J., & Do, L. (2012). Effectiveness of water fluoridation in caries prevention. *Community Dentistry and Oral Epidemiology, 40*, 55-64. doi:10.1111/j.1600-0528.2012.00721.x

Sachdev, J., Bansal, K., & Chopra, R. (2016). Effect of Comprehensive Dental Rehabilitation on Growth Parameters in Pediatric Patients with Severe Early Childhood Caries. *International Journal of Clinical Pediatric Dentistry, 9*(1), 15-20. doi:10.5005/jp-journals-10005-1326

Samad, L., Hollis, C., Prince, M., & Goodman, R. (2005). Child and adolescent psychopathology in a developing country: testing the validity of the Strengths and Difficulties Questionnaire (Urdu version). *International Journal of Methods in Psychiatric Research, 14*(3), 158-166. doi:10.1002/mpr.3

Schumi, J., & Wittes, J. (2011). Through the looking glass: understanding non-inferiority. *Trials, 12*(1). doi:10.1186/1745-6215-12-106

Sebastian, S., & Sunitha, S. (2015). A cross-sectional study to assess the intelligence quotient (IQ) of school going children aged 10-12 years in villages of Mysore district, India

with different fluoride levels. *Journal of Indian Society of Pedodontics and Preventive Dentistry, 33*(4), 307-311. doi:10.4103/0970-4388.165682

Seward, R. J., Bayliss, D. M., Stallman, H. M., & Ohan, J. L. (2018). Psychometric Properties and Norms for the Strengths and Difficulties Questionnaire Administered Online in an Australian Sample. *Australian Psychologist, 53*(2), 116-124. doi:10.1111/ap.12325

Shores, R., & Wehby, J. (1999). Analyzing the classroom social behavior of students with EBD. *Journal of Emotional and Behavioral Disorders, 7*(4), 194-199.

Slade, G. D., Davies, M. J., Spencer, A. J., & Stewart, J. F. (1995). Associations Between Exposure to Fluoridated Drinking Water and Dental Caries Experience among Children in Two Australian States. *Journal of Public Health Dentistry, 55*(4), 218-228. doi:10.1111/j.1752-7325.1995.tb02373.x

Spencer, A. J. (2006). The use of fluorides in Australia: guidelines. *Australian Dental Journal, 51*(2), 195-199. doi:10.1111/j.1834-7819.2006.tb00427.x

Spencer, A. J. & Do, L. G. (2008). Changing risk factors for fluorosis among South Australian children. *Community Dentistry and Oral Epidemiology, 36*(3), 210-218. doi:10.1111/j.1600-0528.2007.00389.x

Spencer, A. J., Do, L. G., & Ha, D. H. (2018). Contemporary evidence on the effectiveness of water fluoridation in the prevention of childhood caries. *Community Dentistry and Oral Epidemiology, 46*(4), 407-415. doi:10.1111/cdoe.12384

Spencer, A. J., Do, L. G., Mueller, U., Baines, J., Foley, M., & Peres, M. A. (2018). Understanding Optimum Fluoride Intake from Population-Level Evidence. *Advances in Dental Research, 29*(2), 144-156. doi:10.1177/0022034517750592

Tang, Q.-q., Du, J., Ma, H.-h., Jiang, S.-j., & Zhou, X.-j. (2008). Fluoride and Children's Intelligence: A Meta-analysis. *Biological Trace Element Research, 126*(1), 115-120. doi:10.1007/s12011-008-8204-x

Taylor, J. L., & Seltzer, M. M. (2011). Changes in the mother-child relationship during the transition to adulthood for youth with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 41*(10), 1397. doi:10.1007/s10803-010-1166-9

Ten Klooster, P., Smit, C., & Pieterse, M. (2017). The impact of non-response bias due to sampling in public health studies: A comparison of voluntary versus mandatory recruitment in a Dutch national survey on adolescent health. *BMC Public Health, 17*(1). doi:10.1186/s12889-017-4189-8

Theunissen, M. H. C., Vogels, A. G. C., Wolff, M. S. d., & Reijneveld, S. A. (2013). Characteristics of the strengths and difficulties questionnaire in preschool children.(Report). *Pediatrics, 131*(2), e446. doi:10.1542/peds.2012-0089

Thompson, R. A., & Calkins, S. D. (1996). The double-edged sword: Emotional regulation for children at risk. *Development and Psychopathology, 8*(1), 163-182. doi:10.1017/S0954579400007021

Valdez Jiménez, L., López Guzmán, O. D., Cervantes-Flores, M., Costilla-Salazar, R., Calderón Hernández, J., Alcaraz-Contreras, Y., & Rocha-Amador, D. O. (2016). In utero exposure to fluoride through drinking water and cognitive development delay in children. *Neurotoxicology, 259*, S206-S206. doi:10.1016/j.toxlet.2016.07.493

Vandenbos, G. R. (Ed.) (2015). Washington: Washington: American Psychological Association.

Vaz, S., Cordier, R., Boyes, M., Parsons, R., Joosten, A., Ciccarelli, M., . . . Christiansen, H. (2016). Is Using the Strengths and Difficulties Questionnaire in a Community Sample

the Optimal Way to Assess Mental Health Functioning? *PLOS ONE, 11*(1). doi:10.1371/journal.pone.0144039

Viswanathan, G., Jaswanth, A., Gopalakrishnan, S., Siva Ilango, S., & Aditya, G. (2009). Determining the optimal fluoride concentration in drinking water for fluoride endemic regions in South India. *Science of the Total Environment, 407*(20), 5298-5307. doi:10.1016/j.scitotenv.2009.06.028

Vugteveen, J., De Bildt, A., Hartman, C., & Timmerman, M. (2018). Using the Dutch multi-informant Strengths and Difficulties Questionnaire (SDQ) to predict adolescent psychiatric diagnoses. *European Child & Adolescent Psychiatry, 27*(10), 1347-1359. doi:10.1007/s00787-018-1127-y

Warnick, E. M., Bracken, M. B., & Kasl, S. (2008). Screening Efficiency of the Child Behavior Checklist and Strengths and Difficulties Questionnaire: A Systematic Review. *Child and Adolescent Mental Health, 13*(3), 140-147. doi:10.1111/j.1475-3588.2007.00461.x

Watling, D. (2015). Children's judgements of social withdrawal behaviours. *British Journal of Developmental Psychology, 33*(2), 180-182. doi:10.1111/bjdp.12088

Weiss, B. (2000). Vulnerability of children and the developing brain to neurotoxic hazards. *Environmental Health Perspectives, 108 Suppl 3*(Suppl 3), 375.

Williamson, A., McElduff, P., Dadds, M., D' Este, C., Redman, S., Raphael, B., . . . Eades, S. (2014). The Construct Validity of the Strengths and Difficulties Questionnaire for Aboriginal Children Living in Urban New South Wales, Australia: Validity of the SDQ for urban Aboriginal children. *Australian Psychologist, 49*(3), 163-170. doi:10.1111/ap.12045

World Health Organization. (2002). *Fluorides*.

World Health Organization. (2017). Guidelines for drinking-water quality, 4th edition, incorporating the 1st addendum.

World Health Organization. (2019). Water-related diseases: Fluorosis. Retrieved from https://www.who.int/water_sanitation_health/diseases-risks/diseases/fluorosis/en/

Youthinmind. (2019). SDQ: Information for researchers and professionals about the Strengths & Difficulties Questionnaires. Retrieved from sdqinfo.com

Yu, X., Chen, J., Li, Y., Liu, H., Hou, C., Zeng, Q., . . . Wang, A. (2018). Threshold effects of moderately excessive fluoride exposure on children's health: A potential association between dental fluorosis and loss of excellent intelligence. *Environment International, 118*, 116-124. doi:10.1016/j.envint.2018.05.042

Yu, Y., Yang, W., Dong, Z., Wan, C., Zhang, J., Liu, J., . . . Lu, B. (2008). Neurotransmitter and receptor changes in the brains of fetuses from areas of endemic fluorosis. *Fluoride, 41*(2), 134-138.

Zachariassen, K. E., & Flaten, T. P. (2009). Is fluoride-induced hyperthyroidism a cause of psychosis among East African immigrants to Scandinavia?(Report). *Medical Hypotheses, 72*(5), 501. doi:10.1016/j.mehy.2008.11.039

Zahn-Waxler, C., Klimes-Dougan, B., & Slattery, M. J. (2000). Internalizing problems of childhood and adolescence: Prospects, pitfalls, and progress in understanding the development of anxiety and depression. *Development and Psychopathology, 12*, 443-466. doi:10.1017/S0954579400003102

Zeman, J., Shipman, K., & Suveg, C. (2002). Anger and Sadness Regulation: Predictions to Internalizing and Externalizing Symptoms in Children. *Journal of Clinical Child & Adolescent Psychology, 31*(3), 393-398. doi:10.1207/S15374424JCCP3103_11

Zhang, Z., Xu, X. L., Shen, X., & Xua, X. (2008). Effect of fluoride exposure on synaptic structure of brain areas related to learning-memory in mice. *Fluoride, 41*(2), 139-143.

Zheng, X., Sun, Y., Ke, L., Ouyang, W., & Zhang, Z. (2016). Molecular mechanism of brain impairment caused by drinking-acquired fluorosis and selenium intervention. *Environmental Toxicology and Pharmacology, 43*, 134-139. doi:10.1016/j.etap.2016.02.017

Zohreh, K., Masoud, M., Amir Hossein, M., Mehdi, M., Reyhane, A., Hossein, F., & Mohammad Hassan, E. (2018). Impact of Drinking Water Fluoride on Human Thyroid Hormones: A Case- Control Study. *Scientific Reports, 8*(1), 1-7. doi:10.1038/s41598-018-20696-4

Appendices

Appendix A: Participant information sheet and consent form

THE UNIVERSITY of ADELAIDE

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.

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]

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 H-2019-020). 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 B: 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]
or email: toothforhealth@adelaide.edu.au

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

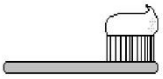
A3 How long does YOUR CHILD usually brush his/her teeth

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

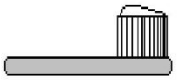
A4 What type of toothpaste is usually used for YOUR CHILD?

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

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

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

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

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

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

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)

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

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_____)

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		Usual main source of water? *(Tick one box only for each location)*	Filter that removes fluoride? *(reverse osmosis or distillation)*
		From	To		
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

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

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] during business hours or email [redacted]

[redacted]

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

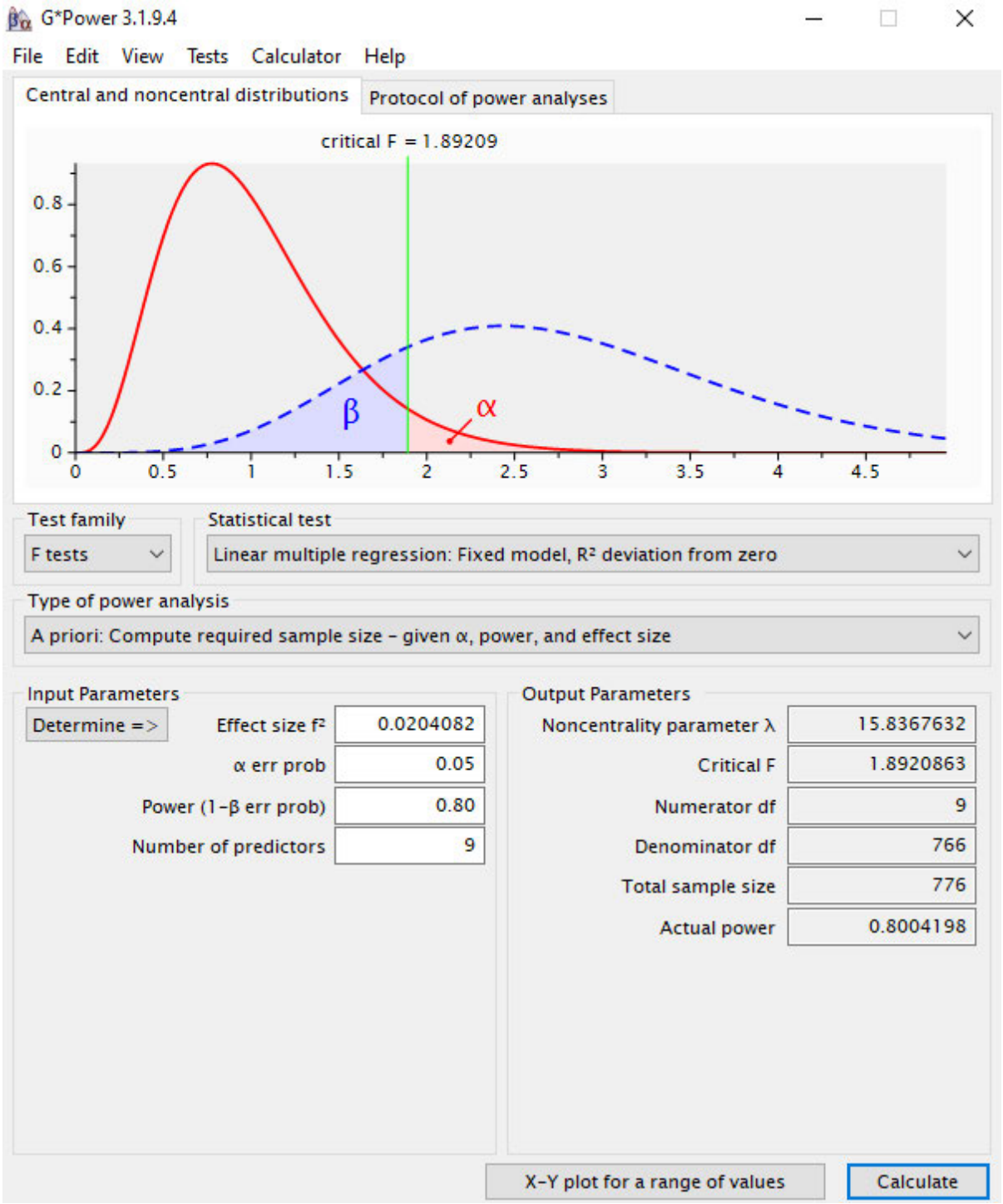
.....

.....

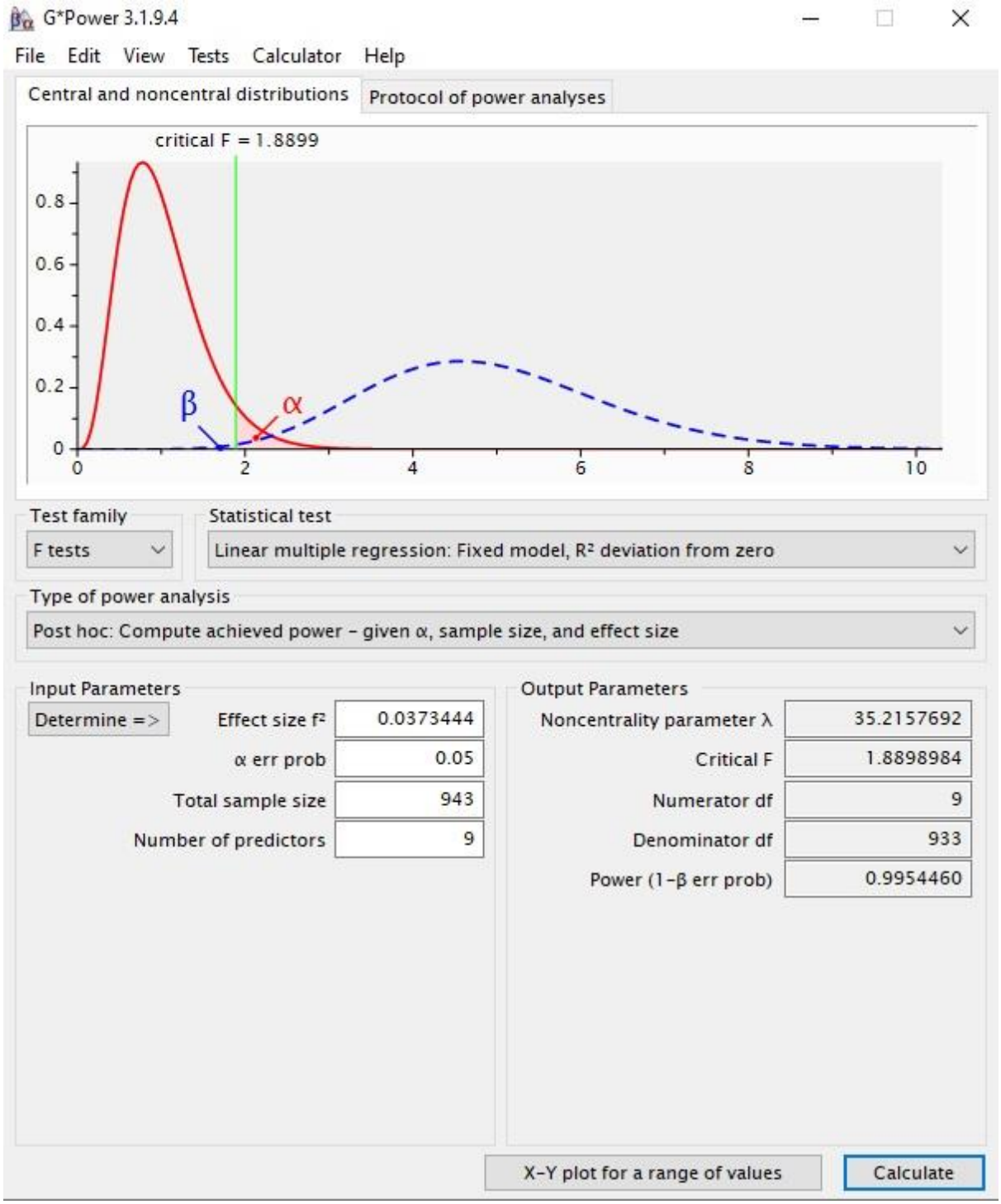
.....

Appendix C: Power analysis results

Priori power analysis



Post-hoc power analysis



Appendix D: Boxplot results

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
pebdtot	943	100.0%	0	0.0%	943	100.0%

Descriptives

			Statistic	Std. Error
pebdtot	Mean		8.7741	.17427
	95% Confidence Interval for Mean	Lower Bound	8.4321	
		Upper Bound	9.1161	
	5% Trimmed Mean		8.2462	
	Median		7.0000	
	Variance		28.638	
	Std. Deviation		5.35144	
	Minimum		2.00	
	Maximum		35.00	
	Range		33.00	
	Interquartile Range		6.00	
	Skewness		1.516	.080
	Kurtosis		2.562	.159

Extreme Values

			Case Number	ncohsid	Value
pebdtot	Highest	1	574	13418TAS	35.00
		2	604	1432006SA	32.00
		3	745	3008047VIC	31.00
		4	505	1172014SA	30.00
		5	900	6016018WA	30.00
	Lowest	1	930	8074015SA	2.00
		2	690	2021006VIC	2.00
		3	323	10530ACT	2.00
		4	301	10474ACT	2.00
		5	183	1007007VIC	2.00[a]

a. Only a partial list of cases with the value 2.00 are shown in the table of lower extremes.

pebdtot Stem-and-Leaf Plot

Frequency Stem & Leaf

6.00 2 . 000
89.00 3 . 00000000000000000000000000000000000000000000000000
83.00 4 . 00000000000000000000000000000000000000000000
111.00 5 . 000000000000000000000000000000000000000000000000000000000000000
118.00 6 . 0000000000000000000000000000000000000000000000000000000000000000000000
91.00 7 . 000000000000000000000000000000000000000000000000
72.00 8 . 000000000000000000000000000000000000
62.00 9 . 00000000000000000000000000000000
48.00 10 . 000000000000000000000000
46.00 11 . 000000000000000000000
39.00 12 . 000000000000000000
27.00 13 . 000000000000
21.00 14 . 0000000000
19.00 15 . 000000000
21.00 16 . 0000000000
19.00 17 . 000000000
11.00 18 . 00000
9.00 19 . 0000
8.00 20 . 0000
43.00 Extremes (>=21.0)

Stem width: 1.00
Each leaf: 2 case(s)