

Peer reviewed article, submitted May 2026, accepted August 2026

Fluoride excretion of New Zealand school children: a nested cross-sectional study and comparison with recommended guidelines

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Abstract

Background and objectives: There is a lack of recent robust published data on the fluoride intake of the NZ paediatric population. Our objective was to measure 24-hour urinary fluoride excretion as a proxy for fluoride intake in NZ primary school children. Potential differences by gender and the percentage of children meeting the World Health Organization (WHO) optimal fluoride intake guideline (0.05 to 0.07 mg/kg of body weight (bw) per day) were also assessed. **Methods:** This cross-sectional analysis was nested in a larger study of children's sodium and potassium excretion. Children from five primary schools in areas with fluoridated water supplies in Auckland (n=4) and Dunedin (n=1) collected 24-hour urine samples in 2022/23, with 63 providing consent for additional urinary fluoride analysis. Samples were analysed using standard methods. Difference in fluoride intake by gender was tested using an independent sample t-test at two-sided 5% significance level. **Results:** Forty-four samples were considered complete and within laboratory reporting limits (n=27 boys, 13 girls, four not stating gender). Mean (SD) fluoride excretion was 0.019 (0.01) mg/kg of bw/day and there was no significant difference between girls and boys (mean difference (95% CI), 0.001 (-0.009, 0.006)). One child met the WHO optimal fluoride intake guideline. **Conclusions:** The mean fluoride intake of primary school children in our sample was lower than the WHO optimal intake guideline. Regular monitoring of children's total fluoride intake and the performance of water fluoridation in NZ in addition to a potential review of the NZ Guidelines for the Use of Fluorides and the water fluoridation target range (0.7 to 1.0 mg/L) are warranted.

Introduction

Adequate fluoride intake is essential for preventing dental caries; it hardens tooth enamel, prevents enamel dissolution by bacterial acid, and promotes remineralisation throughout the lifetime with the greatest benefits seen in the pre-eruptive stages of paediatric tooth formation (Bergman *et al.*, 2009; Royal Society of New Zealand, 2014). As such, dental caries are largely preventable in early life (Ministry of Health, 2023), but their effects are irreversible and cumulative if untreated through the lifespan (Royal Society of New Zealand, 2014).

Based on fluoride intake studies (Burt, 1992; McClure, 1943), the World Health Organization (WHO) optimal intake of fluoride for children is between 0.05 and 0.07 mg/kg of body weight (bw)/day, with intakes above 0.1 mg/kg bw/day known to increase the risk of enamel fluorosis (World Health Organization, 2014). Fluoride is present as a naturally occurring mineral in all human diets, with the main food sources being fish, black tea, and drinking water (Bergman *et al.*, 2009; World Health Organization, 2014), yet the fluoride concentration of most foods is low (National Health and Medical Research Council *et al.*, 2006). Fluoride supplements, topical fluorides applied during dentistry, and inadvertent ingestion of toothpaste, particularly in young children, also contribute to fluoride intake (Abuhaloob *et al.*, 2015; World Health Organization, 2014). However, the 2009 NZ Guidelines for the Use of Fluorides state that only those who have active caries in the past

three years and an individual assessment to identify them as 'high risk' should receive topical fluoride including varnishes, foams or gels, and mouthrinses (New Zealand Guidelines Group, 2009).

Consequently, adequate population-level fluoride is often best achieved through a combination of regular toothbrushing with fluoride containing toothpaste and community-based water fluoridation (Spencer *et al.*, 2018). While groundwater naturally contains fluoride, the amount present largely comes from geological processes and thus varies widely on a global scale, ranging from ~0.1 mg/L to over 10 mg/L (Shaji *et al.*, 2024). The WHO maximum safe limit for fluoride in drinking water is 1.5 mg/L (World Health Organization, 2004) meaning that some countries, including parts of China, Sri Lanka, and India require removal of fluoride to make drinking water safe (Shaji *et al.*, 2024). However, in most parts of Australia (Senevirathna *et al.*, 2023), the United Kingdom (The Academy of Medical Sciences, 2025), and in Aotearoa New Zealand (NZ) (Moore *et al.*, 2017), groundwater has a naturally lower level of fluoride (<0.2 mg/L) and requires fluoridation to reach the WHO recommended range for protective dental effects (0.5 to 1.0 mg/L) (Royal Society of New Zealand, 2014).

A national water fluoridation programme has been running in NZ since the 1950's (Ministry of Health, 2026b). However, historical adoption has been inconsistent, incomplete, and inequitable (Royal Society of New Zealand,



2014; Spencer *et al.*, 2018). Since the introduction of The Health (Fluoridation of Drinking Water) Amendment Act in 2021 when 14 local authorities were directed to fluoridate some or all of their water supplies, inequity in access for Māori and those in the highest level of deprivation appears to be improving (Chambers *et al.*, 2023; Ministry of Health, 2026b). Nonetheless, a 2022 analysis of 25 fluoridated water drinking supplies found a mean level of 0.66 mg/L, below the target for drinking water of between 0.7 and 1 mg/L (Chambers *et al.*, 2023; Ministry of Health, 2026b), and in September 2025, only 58% of the NZ population on registered drinking water supplies had access to fluoridated drinking water (Chambers *et al.*, 2025).

While NZ's water fluoridation programme has contributed to a general improvement in the oral health status of children over the past two decades (Hipgrave & Mason, 2022; Schluter & Lee, 2016), the rate of dental caries in NZ children remains high (Tustin *et al.*, 2024), and there are ethnic inequities contributed to by inequitable access to community water fluoridation (Chambers *et al.*, 2025) and oral health services (Hipgrave & Mason, 2022; Lacey *et al.*, 2021; Schluter & Lee, 2016). In 2024, 57% of 5-year-old children seen by community oral health services were caries-free (Health New Zealand, 2026), and data from the B4 School Check screening programme from 2010 to 2016 found that for children in unfluoridated areas, the adjusted odds of severe caries was significantly higher compared with children from fluoridated water areas (odds ratio, 1.21; 95% CI 1.17 to 1.24) (Schluter *et al.*, 2020). Hospitalisations for severe dental disease in NZ children aged 5 to 9 years have also more than doubled over the 20 years to 2023 (Cure Kids, 2023). Nonetheless, there is a lack of recent robust published data on the fluoride intake of the NZ paediatric population.

Direct assessment of fluoride intake is expensive and challenging (Kumah *et al.*, 2022). Following exposure or ingestion of fluoride, plasma fluoride rises immediately; however, it decreases again quickly and reverts to the original concentration within 3 to 6 hours (World Health Organization, 2014). Urinary fluoride is dependent on plasma fluoride concentration which varies throughout the day with dietary intake and tends to be skewed (World Health Organization, 2014). In children, 36 to 85% of dietary fluoride is excreted in the urine with older children excreting a higher percentage (Villa *et al.*, 2000). Further, urinary fluoride excretion is faster in individuals with higher fluid intakes and higher when the urine is more acidic, the latter being dependant on diet (World Health Organization, 2014). Despite these confounders, the WHO considers urinary fluoride excretion a useful assessment of fluoride exposure in young children (World Health Organization, 2014). Nonetheless, given the variation in fluoride excretion over the day, a spot or casual urine sample is not considered sufficient and the accepted biomarker is a 24-hour urine collection which 'levels out' variation in fluoride exposure across a 24-hour period (World Health Organization, 2014). Twenty-four hour urine collections are also considered suitable to identify insufficient or excessive excretion indicating suboptimal or excess fluoride intake, respectively (World Health Organization, 2014).

Our objective was to measure 24-hour urinary fluoride excretion as a proxy for fluoride intake in NZ primary school children. Potential differences by gender and the percentage of children meeting the WHO optimal fluoride intake guideline (0.05 to 0.07 mg/kg of bw per day (World Health Organization, 2014)) were also assessed.

Methods

Design and setting

This cross-sectional study was nested within SNaK+, a larger study involving five primary schools (four in Auckland and one in Dunedin, NZ) and 75 participating children aged 8 to 13 years of age who provided a 24-hour urine sample primarily to investigate children's sodium and potassium excretion (Eyles *et al.*, 2025). Ethical approval for the SNaK+ study including additional fluoride analyses was obtained from The Central Health and Disability Ethics Committee (20/CEN/85). A separate box on the consent form enabled participants to consent separately to urinary fluoride assessment.

Participants and recruitment

The study protocol and main findings for the SNaK+ study have been reported elsewhere (Eyles *et al.*, 2025). However, briefly, 75 participating children were recruited between July 2022 and February 2023. To reach high numbers of Māori as indigenous people, schools with the largest rolls and numbers of students from Māori whānau (families) were invited first. Inclusion criteria were aged 8 to 13 years old, not have a clinical condition that could impede sodium and potassium excretion, attend a recruited school, able to provide written informed assent (child) and consent (parent/caregiver), and able to speak and understand English language.

Outcomes

The main outcome of this study was 24-hour urinary fluoride excretion. Secondary outcomes were the percentage of children meeting the WHO optimal fluoride intake guideline and differences by gender. The rationale for investigating gender differences was that intake of fluoride-containing water is affected by thirst which in turn is generally related to activity level, body size, and body composition (Galagan & Vermillion, 1957), and these factors may differ in consistent ways between boys and girls (Iglesia *et al.*, 2015).

Collection of demographic information and outcome measures

Demographic information for participants and schools were collected via online surveys (Eyles *et al.*, 2025).

Anthropometric measures

Anthropometric measures including height, weight and waist circumference were measured at school by researchers trained in standard procedures recommended by the WHO (World Health Organization *et al.*, 2010). Height was measured to the nearest 0.1 cm using a portable stadiometer. Weight was measured to the nearest 0.1 kg on a flat surface using a calibrated electronic scale. According to WHO procedures, the average of two measures was used

unless the first two measures were >0.5 cm and 0.1 kg for height and weight respectively in which case the average of three measures was recorded (World Health Organization *et al.*, 2010).

Fluoride intake

Twenty-four-hour urine samples for this study were collected according to standard WHO recommended procedures for estimation of urinary salt excretion (World Health Organization *et al.*, 2010), which directly align with the WHO recommended procedures for urinary fluoride excretion (World Health Organization, 2014). Children were provided with collection kits, instruction sheets, a QR code to an instructional video on YouTube, and a record sheet for each toilet visit to note down missed collections and spillages (Eyles *et al.*, 2025). For practical purposes, children who received their collection kit on a Monday to Thursday started collecting urine immediately at school, and children who received their kit on a Friday collected their urine over the weekend. Children were asked to empty their bladder and discard this urine, writing the start time on their record sheet before collecting all urine for the next 24-hours. Urine samples were considered complete if the total volume was >300 mL, reported missed collections were ≤ 1 , collection time was > 20 hours and < 28 hours, and urinary creatinine excretion was >0.1 mmol/kg of bw per 24 hours (Remer *et al.*, 2002). Urinary creatinine validates the completeness of a 24-hour urine sample because it assesses creatinine clearance by the kidney, which is expected to be within a certain range for a child's body size, age and sex; therefore samples with missed collections and spillages result in an unusually low creatinine excretion (Remer *et al.*, 2002).

Aliquots of 1.5 mL of urine for each 24-hour sample were prepared, stored at -4 deg C and thawed for analysis. Samples were analysed in one batch using a ManTech (Herndon, VA) system comprising Automax 73 autosampler, and Autotitrator fitted with a Fluoride ion selective electrode (PCE-80-FL 1001). The instrument was calibrated within the range of 0.02–5 mg/L using commercially supplied fluoride standard solution (Inorganic Ventures, Christiansburg, VA), and samples were diluted 10-fold to bring them within this range. Where urine collection time was not exactly 24 hours but between 20- and 28-hours values were standardised to 24 hours.

Sample size and statistical analysis

A sample size calculation was not completed because fluoride excretion analyses were nested within the larger SNaK+ study (Eyles *et al.*, 2025).

All statistical analyses were undertaken using IBM SPSS Statistics version 30.0.0.0.

Fluoride excretion values for each participating child in g/m^3 were divided by body weight in kg and multiplied by the standardised excretion volume in L to give mg/kg bw/day (noting that g/m^3 values multiplied by 100 give mg/ m^3 values which must then be multiplied back by 1000 to provide mg/kg values).

All data were summarised using descriptive statistics. Continuous variables were explored for normality and

presented as mean (SD) values. Categorical variables were presented as frequencies and percentages. Demographic information was presented overall and by gender. Children's mean and individual fluoride excretion were compared with the accepted WHO values of between 0.05 and 0.07 mg/kg bw/day and below 0.1 mg/kg bw/day, (Levy *et al.*, 1995).

Difference in fluoride excretion by gender was tested using an independent sample t-test at a two-sided 5% significance level. The COVID-19 pandemic considerably impacted recruitment for the larger SNaK+ study and consequently the nested fluoride analysis described here (Eyles *et al.*, 2025). Therefore, although fluoride excretion may be expected to vary by a range of demographic characteristics in addition to gender, owing to the small sample size, further sub-group analyses were not possible.

Results

Recruitment and response

Of the 75 children who agreed to participate in the SNaK+ survey, 63 provided consent for urinary fluoride analysis (84% response rate).

Urine collection day, sample completeness, and final data for analysis

Fifty-four of the 63 consented samples (86%) were considered complete. Of complete samples, 10 were below the laboratory detection limit of ≥ 0.40 g/m^3 including one which had missing body weight data for calculating fluoride in mg/kg of bw per day. Therefore, final analyses were completed with 44/63 (70%) of total consented samples.

Demographics of participants

Table 1 shows the demographics of the 63 consenting children and the subset of 44 participating children included in the final analysis. Of the 44 children included in the final analysis, most identified as NZ European or Other ($n=37/44$ or 84%) followed by indigenous Māori ($n=7/44$ or 16%). Twenty seven of 44 participants (61%) reported their gender as boy, 13 (30%) as girl, and four participants (9%) did not report their gender. The overall mean (SD) age was 9.6 (1.5) years (range 6 to 12 years) and was similar for boys and girls. The overall mean (SD) height was 141 (10) cm, weight was 36.6 (11.3) kg, and waist circumference was 61.6 (14.1) cm. Boys were slightly taller and had a slightly larger waist circumference than girls (Table 1).

24-hour urinary fluoride excretion

Most participants in the final analysis ($n=33/44$ or 75%) collected their 24-hour urine sample on the weekend noting four participants (9%) did not report their urine collection day (Table 1). The mean (SD) volume collected per 24 hours was 878 (416) mL with a creatinine excretion of 684 (278) mg/24 hours (Table 2).

Figure 1 shows the distribution of urinary fluoride excretion in mg/kg of bw per day ($n=44$). Overall fluoride excretion was slightly skewed to the right with one outlier at 0.057 mg/kg of bw per day. The mean (SD) fluoride excretion was 0.019 (0.01), median (range) was 0.017 (0.052), minimum was 0.005, and maximum was 0.057 mg/kg of bw per day.



Table 1. Characteristics of participating children

	All children who gave consent for fluoride analysis						Subset of children with complete urine samples within the laboratory reporting value and with body weight data ^a					
	Girls (n=22)		Boys (n=35)		Total (n=63) ^b		Girls (n=13)		Boys (n=27)		Total (n=44) ^c	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Age (years) ^a	22	9.7 (1.4)	35	9.7 (1.4)	62	9.77 (1.4)	13	9.3 (1.5)	27	9.7 (1.5)	44	9.6 (1.5)
Height (cm)	22	140.7 (11.4)	33	142.0 (8.1)	61	142.1 (9.2)	13	137.7 (12.6)	25	142.4 (8.9)	43	141.2 (10.0)
Weight (kg)	22	38.6 (14.5)	35	35.8 (8.4)	62	37.3 (11.0)	13	36.5 (16.3)	27	36.2 (8.8)	45	36.6 (11.3)
Waist circumference (cm)	22	58.2 (22.6)	33	63.6 (8.8)	61	62.0 (15.5)	13	57.9 (22.1)	26	63.7 (9.2)	44	61.6 (14.1)
Ethnicity ^{d,e}	N	%	N	%	N	%	N	%	N	%	N	%
Māori	-	-	-	-	7	11	-	-	-	-	7	16%
New Zealand European or Other	20	91	32	91	56	89	11	85%	26	96%	37	84%
Urine sample collection day ^f	N	%	N	%	N	%	N	%	N	%	N	%
Weekday (at school)	-	-	-	-	9	14	-	-	-	-	7	16%
Weekend day (at home)	14	64	32	91	50	79	9	70%	22	81%	33	75%

^a10 samples were below the laboratory reporting limit of ≥ 0.40 g/m³ including one which had missing body weight data for calculating fluoride in mg/kg of bw per day.
^bSix participants who initially consented to fluoride analysis did not report their gender
^cFour participants in the final analysis not state their gender, and four participants did not report their urine collection day.
^dCell sizes <6 have been suppressed to protect anonymity of participants
^eParticipants were allocated to a single ethnic group in the following order of priority even if they identified with more than one ethnicity: Māori, Pacific, and European or Other. NZEO and Other were combined to protect anonymity of participants.
^fFour participants who initially consented to fluoride analysis and who were included in the final analysis did not report their urine collection day

Table 2. Twenty-four-hour urinary volume, creatinine, and fluoride excretion for the 44 children included in the final fluoride analysis

	Girls Mean (SD)	Boys Mean (SD)	Total ^b Mean (SD)	Difference by gender	
				Mean difference (95% CI) ^a	P-value
n	13	27	44		
Volume (mL/24 hours)	854 (499)	870 (366)	878 (416)	n/a	n/a
Creatinine (mg/24 hours)	705 (262)	634 (329)	684 (278)	n/a	n/a
Fluoride (mg/kg body weight/day)	0.020 (0.013)	0.018 (0.009)	0.019 (0.010)	0.001 (-0.009, 0.006)	0.685
Met optimal intake guideline (n (%))	1 (8%)	0 (0%)	1 (2%)	n/a	n/a

^a A two sample t-test was used to assess statistical significance between mean fluoride excretion for girls and boys (girls-boys). Pooled methods were used due to no evidence of unequal variance.
^b Four participants did not report their gender

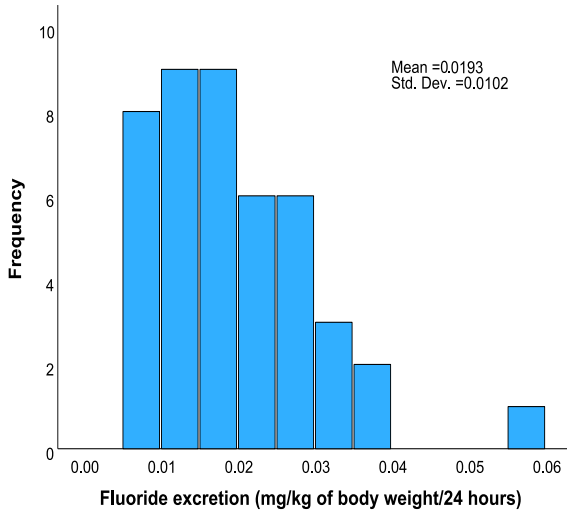


Figure 1. Distribution of fluoride excretion for 44 participants with complete 24-hour urine samples within the laboratory reporting limit and available body weight data

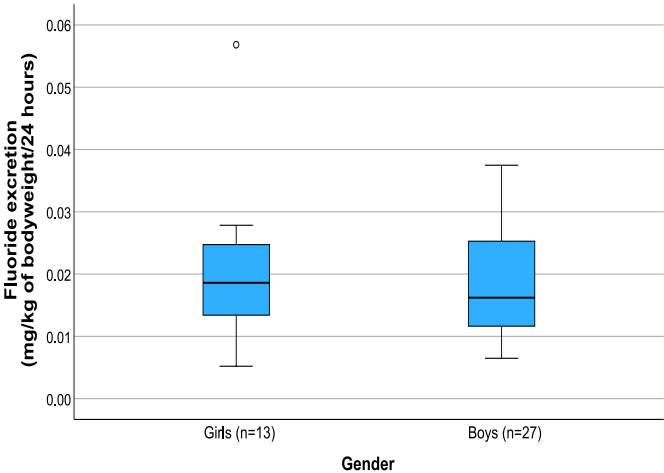


Figure 2. Box plot showing the distribution of fluoride excretion by gender (n=40)

Figure 2 shows the distribution of urinary fluoride excretion for girls and boys. Mean fluoride excretion was highest for girls (0.020 (0.013) mg/kg of bw per day) compared with boys (0.018 (0.009) mg/kg of bw per day). The mean difference in daily fluoride excretion between girls and boys was not statistically significant (0.001 (95% CI, -0.009, 0.006) mg/kg of bw per day; Table 2).

Percentage of children meeting the optimal fluoride intake guideline

One participant of 44 (2%) met the WHO optimal fluoride intake guideline; this participant identified as a girl with a fluoride excretion of 0.057 mg/kg of bw per day (Table 2 and Figure 2 outlier).

Discussion

The mean fluoride intake of our sample of 44 primary school children living in areas with reticulated fluoridated water supplies areas of Auckland and Dunedin was considerably lower than the WHO optimal fluoride intake guideline. The distribution of fluoride excretion showed that except for one child, all children had excretion values well below the WHO optimal intake guideline of 0.05 to 0.07 mg/kg of bw/day, with most ($n=38$ or 86%) excreting ≤ 0.03 mg of fluoride per kg of bw per day (Figure 2). There was no significant difference in fluoride excretion between girls and boys.

While there are limited robust international data on the fluoride intake of school children of a similar age to those in our sample, our findings are similar to 24-hour urine sample data from four- to six-year-old children living in Newcastle, a fluoridated area of North East England (mean (SD) fluoride excretion in our sample was 0.019 (0.01) mg/kg bw/day compared with 0.018 (0.009) mg/kg bw/day in the Newcastle sample ($n=61$) (Omid *et al.*, 2017)). The findings are similar despite the target level of fluoride in water in Newcastle being higher than that of Dunedin and Auckland (1 mg/L vs. 0.7 to 1 mg/L, respectively).

The true fluoridation level of drinking water consumed by children in the Auckland and Dunedin study schools during the time of urine collection is difficult to determine accurately, largely due to limited publicly available water quality monitoring data for Dunedin. However, evidence from Auckland Council's Watercare Organisation indicates that the highest average fluoride content of drinking water supplied to the areas where the three Auckland study schools are based (during the study period of July 2022 to February 2023 and including four months afterward) was 0.8 mg/L, with samples ranging from ~0.6 to 0.9 mg/L (Watercare, n.d.). In the context of the low fluoride excretion values for children in our study, these water fluoride monitoring results strongly indicate that closer monitoring and management of water fluoridation performance in NZ is required. There may also be scope to increase the fluoride water target level for further dental benefits for NZ school children while remaining within the WHO upper limit of <1.5 mg/L to prevent fluorosis (World Health Organization, 2004).

In addition to adequate and accessible community-based water fluoridation, fluoride intake is optimised by twice-daily toothbrushing with an age-appropriate amount of fluoridated toothpaste (Kanagaratnam & Schluter, 2022);

food sources of fluoride such as fish (McClure, 1953); and fluoride rinses, gels and tablets provided through dental care. It is a limitation that these behaviours were not captured in the current study. However, data from the NZ Health Survey (from 2022/23 to 2024/25) indicate that the toothbrushing habits of children aged 0 to 14 years in the Auckland and Dunedin study areas is likely to be similar to the national figure, and thus broadly generalisable to other NZ regions i.e., 0.68 (95% CI, 0.65 to 0.71) in Auckland and 0.59 (95% CI, 0.49 to 0.70) in Otago compared with the national average of 0.63 (95% CI, 0.60 to 0.66) (Ministry of Health, 2025, 2026a). With respect to dietary fluoride, we had planned to collect 24-hour dietary recalls but to reduce participant burden following a series of lockdown periods in NZ due to the COVID-19 pandemic, these were replaced with a series of dietary habits questions (Eyles *et al.*, 2025); one of these questions related to children's use of dietary supplements with no child reporting use of fluoride tablets, aligning with the NZ Ministry of Health Guidelines for the Use of Fluorides which only promote fluoride varnishes, foams or gels and fluoride mouthrinses, and not tablets (New Zealand Guidelines Group, 2009). There is a lack of published data on total dietary fluoride intakes in NZ children although for adults, dietary fluoride outside of that provided by toothpaste is low, and many NZ adults consume less than the Adequate Intake for caries protection (Cressey *et al.*, 2010). Therefore, while comprehensive assessment of total fluoride intake including fluoridated water, toothpaste, dental fluorides and diet is important, the lack of these data does not preclude action to improve NZ school children's exposure to fluoride, including a review of the current Guidelines for the Use of Fluorides (Ministry of Health, 2026b) to ensure optimal oral health outcomes for all NZ children.

Furthermore, while our analysis excluded 10 complete urine samples that had laboratory readings below the laboratory detection limit of ≥ 0.40 g/m³, including a value for these samples in the main analysis would have reduced the mean fluoride intake further below the WHO recommendations, thus strengthening our finding that the mean fluoride intake of children in our sample was considerably lower than the WHO optimal intake guideline. Taken together, this evidence indicates the need for equitable and complete access to fluoridated water and dental care for children to be made a priority in NZ.

A key strength of this study was the use of gold standard 24-hour urine collections as a biomarker and proxy measure of children's dietary fluoride intake. However, in generalising the findings some limitations must be considered, including the lack of total dietary fluoride data, small sample size and lack of sample diversity. While a larger sample may have resulted in less variation around the mean fluoride excretion, it is unlikely the overall message from the study findings would be different. The inclusion of children from cities in both the North and South Island of NZ provided some diversity, but our engagement and inclusion of low income and Māori communities was lower than ideal and thus caution must be applied in generalising to these important communities. Furthermore, findings should not be generalised to NZ children living in non-fluoridated water supplies.

In summary, the mean fluoride intake of primary school children in our sample, who were living in areas with reticulated fluoridated water supplies, was considerably lower than the WHO optimal intake guideline. Taken in context with the high level of dental caries in NZ school children and suboptimal and inequitable coverage of community water fluoridation and children's dental services, the implications of this study include the need for regular monitoring of children's total fluoride intakes; closer monitoring and performance management of water fluoridation in NZ; and the potential need to review both the current NZ Guidelines for the Use of Fluorides and the water fluoridation target range of 0.7 to 1.0 mg/L. Equitable and complete access to fluoridated water and fluoride provided through dental care are also critical. Together these actions will help to ensure the role of fluoride in reducing dental caries in NZ school children is optimised.

Author contributions

Conception and design of the study – HE, RMM, SS

Data collection – JR, KF

Data analysis and interpretation – HE, JF, RMM, SS

Drafting the article – HE, JF, RMM, SS

Critical revision of the article – HE, JF, RMM, SS, KF

Final approval of the version to be published – all authors

Ethical oversight

This study was approved by the Central Health and Disability Ethics Committee (HDEC) through the HDEC-Full Review pathway (Ethics ref#: 20/CEN/85).

Conflicts of interest

The authors declare no conflict of interest.

Funding acknowledgement

This work was supported by The Heart Foundation of New Zealand (grant #1843 – Senior Fellowship to HE and grant # 1821 – project grant to HE).

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