The Fluoride IQ studies

There are now 78 out of 87 IQ studies reporting lowered IQ from exposure to elevated levels of fluoride. Since 2017 we learned that the fluoride level of 0.7 mg/L, the "optimal" level used in U.S. and Canadian drinking water fluoridation projects, can create neurodevelopmental harm to the fetus, bottle-fed infant, and child. The fetus and bottle-fed infant were never considered in any risk assessment for water fluoridation by any regulatory agency in any fluoridating country.

Subpage :

The 78 Fluoride-IQ studies

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The 78 human studies listed below reported an association of exposure to elevated levels of fluoride and lowered IQ. These studies are based on IQ/cognitive examinations of 29,130 children (75 studies) and 689 adults (3 studies).
Location of the Studies: China (47), India (14), Iran (4), Mexico (4), Canada (4), Egypt (1), Kenya (1), Pakistan (1), Sudan (1), Indonesia (1).
Sources of Fluoride Exposure in the IQ Studies:
• 68 studies: drinking water,
• 9 studies: coal burning,
• 1 study: salt fluoridation (Mexico, Cantoral et al., 2021).

NOTE: *The IQ study #67 by Xu 2020 was retracted by the publisher on Nov 8, 2022. We have adjusted the number of each study to reflect that change. On Nov 9, 2022, another IQ study by Saeed et al. was published, for a total of 76 studies. (EC)*

The 78 IQ Studies:

IQ Study #78 (Xia, 2023)

Citation:	Xia Y, Xu Y, Shi M, Liu S, Liu S, Wang H, Dai C, Ye Y, Liu M, Shang L, Wang Y, Wang P. **Effects of High-Water Fluoride Exposure on IQ Levels in School-Age Children: A Cross-Sectional Study in Jiangsu, China**. *Exposure and Health*, September 23, 2023.

Location:	Jiangsu Province, China.The high fluoride group (HF) communities were Wangxiaowu Village of Zhaozhuang Town in Feng County, Jiangzhuang Village of Wuduan Town in Pei County, and Zhangzhuang Village of Zhangzhuang Town in Pei County, where the water fluoride levels were greater than 1.0 mg/L.For the control group, with normal fluoride water, namely, Shizhai Village of Shizhai Town in Feng County, Huzhai Village of Huzhai Town in Pei County, and Kongzhuang Village of Yangtun Town in Pei County. Less than 1.0 mg/L.
Size of Study:	721 children
Age of Subjects:	8–12 years old who had lived locally for more than 5 years.
Type of IQ Test:	Raven Intelligence Test version 2 (CRT-RC2).
Source of Fluoride Exposure:	Drinking Water
Water Fluoride Levels:	The control community: lower than 1.0 mg/L, The high fluoride community; above 1.0 mg/L
Urinary Fluoride Levels:	The urinary fluoride concentration (UF) was abnormally distributed; the median [min, max] of High Fluoride and CONTROL were 2.63 [0.57, 8.84] mg/L and 0.98 [0.33, 3.59] mg/L, respectively.
Dental Fluorosis:	The results showed that children with dental fluorosis had lower IQ scores than those who without it, and IQ scores decreased gradually with the increase in the severity of dental fluorosis. These findings suggest that the effects of high-water fluoride exposure on children's teeth and IQ were in the same direction in our study.
Results:	Significant IQ decreases were connected to changes in urine fluoride levels.The High Fluoride (HF) group had the lower average IQ score, and there were statistical differences in IQ scores among the groups ($P < 0.001$). Children with dental fluorosis had lower IQ scores than those without it, and there were statistical differences ($P < 0.001$).Children with different grades of dental fluorosis had different IQ scores, and the differences were statistically significant ($P = 0.018$). The mean IQ score for children with excessive urinary fluoride was lower than that for children with normal urinary fluoride ($P = 0.002$).
Conclusions:	In conclusion, excessive exposure to high-fluorine water was inversely associated with children's intelligence. The impairment of excellent intelligence by the occurrence of dental fluorosis and excessive urinary fluoride further confirms the damage of fluoride on the intelligence quotient. Therefore, it is necessary to continue monitoring children's urine fluoride levels and take effective actions to reduce fluoride intake in children.
Funding:	This study was supported by the National Science and Technology Major Project (Grant No. 2022YFC3700105), and Jiangsu Province Association of Endemic Diseases Scientific Research Project on Schistosomiasis, Parasitic Diseases, and Endemic Diseases (Grant No. X201824, Grant No. X202119, Grant No. X202115).

IQ Study #77 (Hall 2022) – online Feb 9, 2023, before the print version of Dec 27, 2022.

Citation:	Hall M, Lanphear B, Chevrier J, Hornung R, Green R, Goodman C, Ayotte P, Martinez-Mier EA, Zoeller RT, Till C. Fluoride exposure and hypothyroidism in a Canadian pregnancy cohort. *Science of The Total Environment*. Online Febuary 9, 2023, before the print version of December 27, 2022.
Location:	From ten cities across Canada, seven of which add fluoride to drinking water (Toronto, Hamilton, Ottawa, Sudbury, Halifax, Edmonton, Winnipeg) and three of which do not (Vancouver, Montreal, Kingston).

Size of Study:	601 children. “Owing to limited resources, in-person IQ testing was offered in six study sites (Toronto, Hamilton, Halifax, Vancouver, Kingston, and Montreal). Of 1207 eligible women, 808 consented to participate in this follow-up study; of these, 610 (76 %) agreed to child neurodevelopmental testing and 601 completed IQ testing in entirety… In a subsample of 466 mother-child pairs, we used linear regression to explore the association between maternal hypothyroidism and child Full-Scale IQ (FSIQ) at ages 3-to-4 years and tested for effect modification by child sex…”
Age of Subjects:	3-4 years
Type of IQ Test:	The authors “used Full-Scale IQ (FSIQ), a measure of global intellectual and cognitive functioning, as the primary outcome. Verbal (VIQ) and Performance IQ (PIQ) were used in supplementary analyses.”
Results:	“Among women with normal TPOAb [maternal thyroid peroxidase antibody levels] the risk of primary hypothyroidism increased with both increasing water fluoride and fluoride intake (aOR water fluoride concentration: 2.85; 95%CI: 1.25, 6.50; aOR fluoride intake: 1.75; 95%CI: 1.27, 2.41). Children born to women with primary hypothyroidism had lower FSIQ scores compared to children of euthyroid women, especially among boys (B coefficient: -8.42; 95 % CI: -15.33, -1.50).”
Conclusions:	According to the authors: “To our knowledge, this is the first study to investigate the relationships between maternal fluoride exposure and thyroid function in a prospective pregnancy cohort receiving optimally fluoridated water. Our findings indicate that higher levels of fluoride exposure in pregnant women were associated with increased risk of hypothyroidism, supporting our hypothesis that fluoride exposure may disrupt thyroid function. Thyroid dysfunction in pregnancy may be one mechanism underlying the previously found association between fluoride exposure in pregnancy and offspring FSIQ in the MIREC cohort (Green et al., 2019), particularly among women with male children, though further research is warranted. Our findings are of public health significance given the large number of people exposed to fluoride in drinking water and the vital role of thyroid hormones in neurodevelopment.”
Funding:	National Institute of Environmental Health Science [grant numbers R21ES027044, 2016–2019; R01ES030365, 2020–2025], and the Maternal-Infant Research on Environmental Chemicals Study was funded by the Chemicals Management Plan at Health Canada, the Ontario Ministry of the Environment, and the Canadian Institute for Health Research (CIHR) [grant number MOP-81285, 2006]. This work was also supported by a CIHR scholarship awarded to M.H.

IQ Study #76 (Saeed 2022)

Citation:	Saeed M, Rehman MYA, Farooqi A, Malik RN. 2022. Arsenic and fluoride co-exposure through drinking water and their impacts on intelligence and oxidative stress among rural school-aged children of Lahore and Kasur districts, Pakistan. *Environmental Geochemistry and Health*, 44(11):3929-3951.
Location of Study:	Lahore and Kasur districts, Pakistan.
Size of Study:	148 children from the exposed and control group were recruited in the current study from endemic rural areas of Lahore and Kasur districts
Age of Subjects:	5 to 16 years old
Type of IQ Test:	“The non-verbal IQ test was optimized based on the Wechsler scale of intelligence (WISC-IV) to determine impacts on the development of cognitive abilities. The children’s IQ scores were ranked into the following groups according to the Wechsler scale of children intelligence (WISC-IV): < 70(Retarded level), 70–79 (Borderline), 80–89 (Low Average), 90–110 (Average), 111–119 (High Average), 120–129 (Above Average) and C 130 (Superior) (Wechsler, 2003). For the IQ test, assistance from a trained person was obtained to supervise the assessment of IQ in children. The raw scores obtained from the test were transformed into standardized values (z-scores) by linear transformation using SPSS 21.0 for a better comparison of test scores across study groups. Then, the z-scores were converted into IQ scores by using the following equation where M and SD represent the mean and standard deviation of the new distribution, respectively (Brock, 2018).”
F^- and As in water	“In this study, comparative analysis revealed a significant difference in water content of F^- and As between the exposed and control group (P\0.000) (Table 1). In control, the mean F^- concentration was measured 0.15 mg/L (0–0.5 mg/L), which was many folds lower compared to the mean F^- value of 5.64 mg/L (0.10–15.80 mg/L) among the exposed group. Similarly, the mean As concentration was measured 180 lg/L (ND-1000 lg/L) in the exposed area, which was higher as compared to the control area where As concentrations were below detection limit of field kits.”

Results:	"In the present study, comparative analysis between exposed and control subjects exhibited an increasing trend of dental fluorosis with a significant difference ($P < 0.000$) as presented in (Table 1). Comparatively, the cases of dental fluorosis (mild to severe level) were much higher in the exposed group than in the control group. It was found out that dental fluorosis was dependent on gender, As and F^- in urine ($R2 = 0.57$, $P = 0.000$; Table 3) while independent of economic status and parent education… … A non-significant difference was observed in age and gender [male] distribution between the control and exposed groups according to x^2 analysis."There was no significant difference perceived in IQ score between the exposed and control group (Table 1).However, the control group showed a slightly higher IQ score (100.93 ± 13.1) as compared to the exposed group with an IQ score of 97.26 ± 15.39 (Table 1). However, it was observed that cases of low IQ level (low average to retarded) were higher in the exposed group compared to the controls (Table S4). Furthermore, IQ level was dependent on age, gender, parent education as well as F^- in urine ($R2 = 0.49$, $P = 0.000$; Table 3) while independent from As exposure in the present study… The use of urinary F^- and dental fluorosis as a biomarker of F^- appears to be a valid tool in the estimation of F^- exposure. The urinary F^- also showed a negative correlation with Ca ($R2 = -0.722$, P\0.001). The higher concentration of Ca^{2+} in the control group can be another reason for lower dental fluorosis prevalence. The reduction in Ca^{2+} due to the presence of F^- can be linked with F^- toxicity on dental growth and intellectual impairment in children.
Conclusions:	"it was revealed that variations in dental fluorosis and IQ levels were more significantly associated with F^- exposure compared to As. Additionally, it was also observed that the induction of oxidative stress was more positively correlated with urinary F^- and dental fluorosis. Based on the results (Table 2,3, and 4), it was concluded that F^- was more negatively associated with the health effects on school children as compared to As."

IQ Study #75 (Goodman 2022)

Citation:	Goodman CV, Hall M, Green R, Chevrier J, Ayotte P, Matinez-Mier EA, McGuckin T, Krzeczkowski J, Flora D, Hornung R, Lanphear B, Till C. 2022. Iodine Status Modifies the Association between Fluoride Exposure in Pregnancy and Preschool Boys' Intelligence. Nutrients.
Location of Study:	Canadian Maternal–Infant Research on Environmental Chemicals (MIREC) study
Size of Study:	366 mother–child dyads
Age of Subjects:	3 – 4 years
Type of IQ Test:	The Wechsler Preschool and Primary Scale of Intelligence-III with Canadian age-standardized norms (mean = 100, SD = 15).
Results:	We found a significant three-way interaction between **MUFCRE [maternal urinary fluoride creatinine]**, **MUICCRE [maternal urinary iodine concentration]**, and sex while controlling for relevant covariates ($p = 0.019$; see Table 3 and Figure 2). The two-way MUICCRE by MUFCRE interaction was significant for boys ($p = 0.042$), but not girls ($p = 0.190$). For boys whose mothers had a low MUICCRE, every 0.5 mg/g increase in MUFCRE was associated with a 4.65-point lower **FSIQ [full-scale intelligence]** score (95% CI: ?7.67, ?1.62; $p = 0.003$). For boys whose mothers had adequate MUICCRE, every 0.5 mg/g increase in MUFCRE was associated with a 2.95-point lower FSIQ score (95% CI: ?4.77, ?1.13; $p = 0.002$). In contrast, MUFCRE was marginally associated with FSIQ for girls whose mothers had low MUICCRE ($B = 2.48$; 95% CI: ?0.31, 5.26; $p = 0.081$) and was not significantly associated with FSIQ for girls whose mothers had adequate MUICCRE ($B = 1.31$, 95%; CI: ?0.41, 3.03; $p = 0.135$).
Conclusions:	This is the first prospective epidemiological study to estimate the interplay between prenatal fluoride exposure and maternal iodine status in relation to child IQ in boys and girls. Our findings indicate that the association between prenatal fluoride exposure and fullscale intelligence previously identified in this cohort [6] was exacerbated by low maternal iodine in pregnancy among boys. These results, which were found among mother-child pairs living in fluoridated and non-fluoridated communities in Canada, underscore the importance of sufficient iodine intake in pregnancy to minimize the neurotoxicity of fluoride in boys.
Funding:	This research was funded by National Institute of Environmental Health Science, grant numbers R21ES027044, 2016–2019; R01ES030365, 2020–2025 and the Maternal-Infant Research on Environmental Chemicals Study was funded by the Chemicals Management Plan at Health Canada, the Ontario Ministry of the Environment, and the Canadian Institute for Health Research, grant number MOP-81285, 2006).

IQ Study #74 (Feng 2022)

Citation:	Feng Z, An N, Yu F, Ma J, Li N, Du Y, Guo M, Xu K, Hou X, Li Z, Zhou G, Ba Y. 2022. Do methylenetetrahydrofolate dehydrogenase, cyclohydrolase, and formyltetrahydrofolate synthetase 1 polymorphisms modify changes in intelligence of school-age children in areas of endemic fluorosis? Chinese Medical Journal, July 18.
Location of Study:	Tongxu County, Henan Province,
Size of Study:	694 children
Age of Subjects:	Aged 8 to 12 years
Water Fluoride:	Endemic drinking water-borne fluorosis area
Source of Fluoride exposure:	Water
Type of IQ Test:	Combined Raven's Test
Results:	In the high fluoride group, children's IQ scores decreased by 2.502 when the UF_{Cr} [urinary fluoridde creatinine] level increased by 1.0 mg/L (B = -2.502, 95% confidence interval [CI]:—4.411, —0.593), and the possibility for having "excellent" intelligence decreased by 46.3% (odds ratio = 0.537, 95% CI: 0.290, 0.994).Children with the GG genotype showed increased IQ scores than those with the AA genotype of rs11627387 locus in the high fluoride group (P< 0.05). Interactions between fluoride exposure and *MTHFD1* polymorphisms on intelligence were observed (Pinteraction < 0.05).
Conclusions:	Our findings suggest that excessive fluoride exposure may have adverse effects on children's intelligence, and changes in children's intelligence may be associated with the interaction between fluoride and *MTHFD1* polymorphisms.
Funding:	National Natural Science Foundation of China (Nos. 81972981, 82003401, and 81673116) and Key Projects of Colleges and Universities of Henan Education Department (21A330006).

IQ Study #73 (Yani 2021)

Citation:	Yani SI, Seweng A, Mallongi A, Nur R, Abdullah MT, Salmah U, Sirajuddin S, Basir-Cyio M, Mahfudz, Anshary A. 2021. The influence of fluoride in drinking water on the incidence of fluorosis and intelligence of elementary school students in Palu City. *Gaceta Sanitaria* 35(Supplement 2):S159-S163.
Location of Study:	Palu City, Indonesia.
Size of Study:	100 students
Age of Subjects:	6–12 years old
Water fluoride:	in Talise Sub-Village with a water fluoride level of 1.6 ppm and Birobuli Sub-Village with a water fluoride level of 0.10 ppm.
Source of fluoride exposure:	Drinking water
Type of IQ Test:	Raven's Coloured Progressive Matrices

Results:	"From a total of 40 students who suffered from fluorosis, 62.5% of them had high IQ scores. Meanwhile, for students who did not suffer from fluorosis, 96.6% of them had high IQ. Based on the statistical test results, the *p*-value obtained was 0.001 < 0.05, which means that Ho is rejected, or it can be concluded that: there is an influence of Fluorosis status with student intelligence."
Conclusions:	"There is a relationship between Fluoride level in well water and the incidence of fluorosis in students, where the incidence of fluorosis was higher in the high fluorine area than in the low fluorine area. "The intelligence of children who suffered from fluorosis is lower than the intelligence of children who do not suffer from fluorosis. "The level of intelligence of students who live in the high-fluorine area is lower than students who live in low fluorine area."

IQ Study #72 (Ren 2021)

Citation:	Ren C, Zhang P, Yao XY, Li HH, Chen R, Zhang CY, Geng DQ. 2021. The cognitive impairment and risk factors of the older people living in high fluorosis areas: DKK1 need attention. *BMC Public Health* 21:2237. December 9.
Location of Study:	China
Size of Study:	444 adults
Age of Subjects:	3 groups: 60–69 years of age, 70–80 years of age and older than 80 years of age.
Water fluoride:	272 subjects from the high fluoride drinking water community (water fluoride concentration > 2 mg/L) of Feng County, Xuzhou City, Jiangsu Province, and nd a total of 172 subjects, from the normal fluoride drinking water community (water fluoride concentration < 0.8 mg/L) of Suining County, Xuzhou City, Jiangsu Province,
Source of fluoride exposure:	Drinking water
Type of IQ test:	"The Montreal Cognitive Assessment-Basic (MoCA-B) and AD-8 were used to investigate the cognitive functions of the subjects. The MoCA-B had excellent validity in screening for mild cognitive impairment in poorly educated older adults regardless of literacy [25]. The AD-8 is an 8-item informant-based questionnaire, which was designed to detect changes in the fields of memory, orientation, judgement and executive function [26]."
Results:	"• The blood fluoride concentration, mRNA level of DKK1 and ratio of abnormal cognitive function of subjects in high fluorine drinking water areas were higher than those in normal areas."• The level of SOD of subjects in high fluorine drinking water was low compared with those in normal areas…"• The mRNA level of DKK1 and the level of cognitive function showed a positive correlation and DKK1 was one of five risk factors involved in cognitive impairment of older people living in high fluorosis areas."
Conclusions:	"The cognitive functions could be impaired in the older people living in high fluoride drinking water areas, and DKK1 may as a potential intervention point of this brain damage process need attention."
Funding:	This study was supported by Natural Science Foundation of Jiangsu Province (BK20151159), Shandong Provincial Key Research & Development Project (2017GSF218043), National Natural Science Foundation of China (81501185), Jiangsu Provincial Medical Youth Talent (QNRC2016369) and Xuzhou Medical Talents Project and Xuzhou technological and scientific project (KC14SH050).

IQ Study #71 (Wang 2021)

Citation:	Wang S, Zhao Q, Li G, Wang M, Liu H, Yu X, Chen J, Li P, Dong L, Zhou G, Cui Y, Wang M, Liu L, Wang A. 2021. The cholinergic system, intelligence, and dental fluorosis in school-aged children with low-to-moderate fluoride exposure. *Ecotoxicology and Environmental Safety*. November 20. *Supplementary data associated with this article can be found in the online version at doi:10.1016/j.e*

Location of Study:	Rural areas in Tianjin, China: three historical high fluoride areas and four non-endemic areas.
Size of Study:	709 children
Age of Subjects:	6.70 –13.0
Source of Fluoride Exposure:	Drinking water
Type of IQ Test:	Combined Raven's Test-The Rural in China (CRT-RC2) (Liu et al., 2009).
Results:	"Compared with children in the first quartile, those in fourth quartile the risk of either developing DF or IQ < 120 increased by 19% and 20% for water and urinary fluoride. The risk of having both increased by 58% and 62% in third and fourth quartile for water fluoride, 52% and 65% for urinary fluoride. Water fluoride concentrations were positively associated with AChE and negatively associated with ChAT and ACh, trends were same for urinary fluoride except for ACh. The risk of either developing DF or having non-high intelligence rose by 22% (95%CI: 1.07%, 1.38%) for the fourth quartile than those in the first quartile of AChE, for having the both, the risk was 1.27 (95%CI: 1.07, 1.50), 1.37 (95%CI: 1.17, 1.62) and 1.44 (95%CI: 1.23, 1.68) in second, third and fourth quartiles. The mediation proportion by AChE between water fluoride and either developing DF or IQ < 120 was 15.7%. For both to exist, the proportion was 6.7% and 7.2% for water and urinary fluoride. Our findings suggest low-to-moderate fluoride exposure was associated with dysfunction of cholinergic system for children. AChE may partly mediate the prevalence of DF and lower probability of having superior and above intelligence."
Conclusions:	"In conclusion, our study showed that low-to-moderate fluoride exposure was associated with the alteration of cholinergic system, DF [dental fluorosis] and IQ, and AChE partly mediated the elevated prevalence of DF and the lower probability of developing superior and above intelligence caused by fluoride."
Funding	"This work was supported by grants from the National Natural Science Foundation of China (Grants No. 82073515 and No. 81773388), and the State Key Program of National Natural Science of China (Grant No. 81430076)."

IQ Study #70 (Cantoral 2021)

Citation:	Cantoral A, Téllez-Rojo MM, Malin AJ, Schnaas L, Osorio-Valencia E, Mercado A, Martínez-Mier EA, Wright RO, Till C. 2021. Dietary fluoride intake during pregnancy and neurodevelopment in toddlers: a prospective study in the Progress Cohort. *NeuroToxicology*. August 31.
Location of Study:	Mexico City
Size of Study:	"103 mother-infant pairs: 72 (70%) completed neurodevelopmental testing at both 12 and 24 months, whereas 31 (30%) completed testing at either the 12 or 24 months visit (see Supplemental Figure 1 for flowchart of included participants)."
Age of Subjects:	12 months and 24 months
Source of Fluoride Exposure:	The study was performed in Mexico where salt is fluoridated. According to the authors,"The practice of adding salt to a meal was reported by 27% of the participants… "To our knowledge, this is the first prospective and longitudinal study to examine associations between maternal fluoride intake from food and beverages during pregnancy and offspring neurodevelopment. Our findings are consistent with two other prospective cohort studies from Mexico that measured urinary fluoride levels in pregnancy."
Type of IQ Test:	"We assessed developmental functioning of infants and toddlers at 12 and 24 months using the Spanish version of the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) (Bayley 2006)…"T-test or Fisher´s exact tests were used to test differences between boys and girls."
Results:	"In the mixed-effects longitudinal model, we observed a statistically significant negative association between dietary fluoride intake in pregnancy and cognitive score (averaged across both time points) in boys, but not girls (interaction p value = 0.07) (Table 4). Specifically, a 0.5 mg increase in dietary fluoride intake during the third trimester and across pregnancy (i.e. trimesters 2 and 3) was associated with a 3.10-point (95% CI: -5.67, -0.53) and 3.46-point (95% CI: -6.23, -0.70) lower cogn ively.

	Although the effect estimates were in the expected direction, maternal fluoride intake was not significantly associated with language or motor scores, nor was there a significant fluoride intake by sex interaction for these outcomes. The adjusted margin effects and 95% confidence intervals of the cognitive scores according to fluoride intake in pregnancy and sex are presented in Figure 1.'
Conclusions:	"In this prospective cohort study, higher exposure to fluoride from food and beverage consumption in pregnancy was associated with reduced cognitive outcome, but not with language and motor outcome in male offspring over the first two years of life. Given the ubiquity of fluoride in food and beverages, it will be important to develop recommendations for how vulnerable populations, such as pregnant women, may limit dietary fluoride intake to minimize potential adverse health risks of the unborn fetus."
Funding:	This research was funded by the National Institutes of Health (NIH)/National Institute of Environmental Health Science (NIEHS) (grant numbers: P30ES023515, R01ES014930, R01ES021357, R24ES028522, R21ES027044).

IQ Study #69 (Yu 2021)

Citation:	Yu X, Xia L, Zhang S, Zhou G, Li Y, Liu H, Hou C, Zhao Q, Dong L, Cui Y, Zeng Q, Wang A, Liu L. 2021. Fluoride exposure and children's intelligence: Gene-environment interaction based on SNP-set, gene and pathway analysis, using a case-control design based on a cross-sectional study. *Environment International* 155:106681.
Location of Study:	The rural areas of Baodi district, Tianjin, China. The study areas were divided into historical high fluoride areas and normal fluoride areas. None of the study sites was exposed to excessive neurotoxins including lead, arsenic and mercury, or in the endemic areas of iodine deficiency based on the surveillance data from the local CDC
Size of Study:	952 resident children
Age of Subjects:	7 to 13 years old
Water Fluoride:	0.70 mg/L (0.40–1.00) to 1.00 mg/L (0.50–1.90)
Urine, Hair and Nail Fluoride Test:	**Urine fluoride:** 0.33 mg/L (0.13–0.81) **to** 0.60 mg/L (0.16–2.22) **Hair fluoride:** 8.26 *u*g/g (5.72–10.48) **to** 14.39 *u*g/g (10.25–20.56) **Nail fluoride:** 11.71 *u*g/g ((8.53–14.64) **to** 19.76 *u*g/g (14.16–27.32)
Type of IQ Test:	The second edition of Combined Raven's Test – The Rural in China (CRT-RC2)
Results:	The probability of high intelligence was inversely correlated with fluoride contents in water, urine, hair and nail (all $P < 0.001$). The SNP-set based on rs3788319, rs1879417, rs57377675, rs11556505 and rs7187776 was related to high intelligence ($P = 0.001$) alone and by interaction with water, urinary and hair fluoride ($P = 0.030$, 0.040, 0.010), separately. In gene level, *CLU* and *TOMM40* interacted with hair fluoride (both $P = 0.017$) on intelligence. In pathway level, Alzheimer disease pathway, metabolic pathway, signal transduction pathway, sphingolipid signaling pathway and PI3K-AKT signaling pathway interacted with fluoride on intelligence in men.
Conclusions:	Our study suggests that fluoride is inversely associated with intelligence. Moreover, the interactions of fluoride with mitochondrial function-related SNP-set, genes and pathways may also be involved in high intelligence loss.
Discussion:	In this population-based study, we explored gene-fluoride interactions on intelligence systematically and comprehensively…Our study has several strengths. Using four fluoride exposure indicators including water fluoride, urinary fluoride, hair fluoride and nail fluoride, which reflect the external and internal, and short-term and long-term exposures, makes the evaluation of fluoride exposures more comprehensive and reliable. Besides, due to the relatively rare studies on low-to-moderate level fluoride exposure in hair and nail, our results also enrich the epidemiological evidence across different fluoride indicators and levels. Compared to previous studies which mainly focused on the effect of single SNP or gene on intelligence and its interaction with fluoride exposures, our study is the first one to explore the interactions between SNP-set and fluoride on intelligence loss. Besides, this is the first study that evaluated the gene-fluoride interactions at gene and pathway levels by using the ARTP method. Furthermore, selection bias in this study is relatively small given the comparable characteristics between the included and excluded children, along with 94.6% response rate in the multistage random sampling step.
Funding:	This work was supported by the State Key Program of National Natural Science Foundation of China (Grant No. 81430076) for Aiguo Wang, and the National Program for Support of Top-notch Young Professionals and Health commission of Hubei Province scientific research project (Grant No.WJ2019H308) for Li Liu.

IQ Study #68 (Zhao 2021)

Citation:	Zhao L, Yu C, Lv J, Cui Y, Wang Y, Hou C, Yu J, Guo B, Liu H, Li L. 2021. Fluoride exposure, dopamine relative gene polymorphism and intelligence: A cross-sectional study in China. *Ecotoxicology and Environmental Safety* 209:111826. [Epub ahead of print].
Location of Study:	Endemic and non-endemic fluorosis areas in Tianjin, China
Size of Study:	567 children
Age of Subjects:	6–11 years old
Water Fluoride Level:	"We used urinary fluoride to represent the fluoride exposure from drinking water, which ignored the bias of short-term fluoride intake from diet."
Urine Fluoride Levels:	Child urine fluoride levels of 1.5 mg/L were estimated to have a -6.5 IQ points* loss compared to children with urine fluoride levels of 0.5 mg/L. (See Special Note by Chris Neurqth below)
Type of IQ Test:	The Combined Raven's Test (modified in China)
Results:	This was a cross-sectional study to explore the role of DA [dopamine] relative genes in the health effect of low-moderate fluoride exposure in drinking water. According to the authors, "Our study has several strengths. So far as we know, this is the first epidemiological study to uncover the effect modification of DAT1 and MAOA gene polymorphism in the relationship between fluoride exposure and IQ, and the first study to analyze the high-dimensional interaction among fluoride exposure and the four DA relative genes. Our findings suggest a novel clue for the neuro-toxicological mechanism of fluoride."
Conclusions:	"Our study suggests DA [dopamine] relative genes may modify the association between fluoride and intelligence, and a potential interaction among fluoride exposure and DA relative genes on IQ…. In the present study, we found that fluoride exposure is inversely related to children's IQ scores, while DA related genes polymorphism (ANKK1 Taq1A, COMT Val 158 Met, DAT1 40 bp VNTR and MAOA uVNTR) may show modifying effects on the association between urinary fluoride and IQ scores. UF, ANKK1 Taq1A, COMT Val 158 Met and MAOA uVNTR showed a high-dimensional interaction on IQ… We further examined the roles of DA related genes in the relationship between fluoride exposure and found that the linear association performed differently in COMT and ANKK1 genotype subgroups…"
Special Note:	**From Chris Neurath:** *This "paper reports effect sizes as 'IQ points per unit of logarithm of urine fluoride concentration'. These units have been converted to express the effect size for a 1 mg/L increase in urine fluoride concentration from 0.5 to 1.5 mg/L which covers the range of exposures found in the majority of the study children. The paper does not specify whether base 10 or base *e* (natural) logarithms were used and FAN received no response to inquiries to the authors on this question. However, other papers on fluoride and IQ by some of the same authors have used natural logarithms so we have assumed the same for this paper when converting effect sizes to more easily understood units."
Funding:	This work was supported by the National Natural Science Foundation of China (Grant No. 81573107, 81372934).

IQ Study #67 (Prabhakar-2020)

Note: This study was available on PubMed in January 2022

Citation:	Prabhakar A, Abdulkhayarkutty K, Cheruvallil SV, Sudhakaran P. 2020. **Effect of Endemic Fluorosis on Cognitive Function of School Children in Alappuzha District, Kerala: A Cross Sectional Study**. *Annals of Indian Acade* 5-

	720. November 6.
Location of Study:	Alappuzha district, Kerala, India
Size of Study:	120 children
Age of Subjects:	8-10 years
Source of Fluoride:	Drinking water
Water Fluoride Level:	"All the 60 children had urine fluoride level > 1 mg/mL and drinking water fluoride level >1 ppm."
Urine Fluoride Levels:	"All the 60 children had urine fluoride level > 1 mg/mL and drinking water fluoride level >1 ppm."
Type of IQ Test:	Raven's Standard Progressive Matrices and MISIC digit span subtest were used to assess the cognitive function
Results:	"There were 60 children each in fluorosis and control groups. The mean age of the children was 8.95 ± 0.50. Only 15% of the children with fluorosis scored Grade I and II Raven's SPM grades (Intellectually superior/above the average) versus 30% in the control group. None of the children without fluorosis scored Grade V (intellectually impaired) category versus 20% in the fluorosis group. The mean digit span was significantly higher in the control group. A strong positive correlation between severity of dental fluorosis and Raven's SPM grades was found (Spearman's correlation coefficient = 0.740)."
Conclusions:	"Fluorosis is associated with impaired cognition in children. There is a positive correlation between severity of dental fluorosis and the grade of cognitive impairment."

The IQ study #67: Xu 2020 has been retracted by the publisher on November 8, 2022

IQ Study #66 (Lou 2020)

Citation:	Lou D, Luo Y, Liu J, Zheng D, Ma R, Chen F, Yu Y, Guan Z. 2020. **Refinement Impairments of Verbal-Performance Intelligent Quotient in Children Exposed to Fluoride Produced by Coal Burning**. *Biological Trace Element Research*. May 3.
Location of Study:	in coal-burning fluorosis area of Dafang County, Guizhou Province, China
Size of Study:	99 children. 55 in dental fluorosis group (none with moderate or severe dental fluorosis, but all with mild) and 44 students without dental fluorosis.
Age of Subjects:	8–12 years

Source of Fluoride:	"This area belongs to the alpine region, and the winter rainfall days from December to March accounted for 80%, causing heavy moisture. Thus, traditionally, people use cooking stoves with indoor smoke by burning the coal to bake food and to keep warm their bodies, causing ingestion of smoke through the respiratory tract. The volatilized fluorine released by burning coal is inhaled by humans through the air, or the baked food that adsorbs the burning coal is ingested by humans, leading to fluorosis. Thus, it is referred to as coal-burning pollution fluorosis"
Water Fluoride Level:	An aside. "By comparing the previous investigations conducted in Guizhou Province, the level of fluorosis and IQ for children helped by the government of Guizhou Province showed improvement [31]. In China, except for Guizhou, the survey data of other regions showed that the IQ level in children drinking water in fluorosis areas after treatment of defluorination of water also showed significant improvement, especially the levels of severe IQ [38, 39]."
Type of IQ Test:	Wechsler Intelligence Scale for Children Revised in China (WISC-CR)
Results:	To explore the relationship between total intelligence quotient (**IQ**), verbal intelligence quotient (**VIQ**), performance intelligence quotient (**PIQ**)VIQ, which is the manifestation of learning memory, language understanding, and language thinking ability. The results showed that VIQ in children of fluorosis group was impaired and the common sense and other items demonstrated statistically significant difference. In the scale, common sense was **reduced by 1.2 times**, with the smallest reduction degree. Similarly, arithmetic and vocabulary were **reduced by nearly 2 times**, while understanding was **reduced by nearly 3 times**. The test for common sense includes general knowledge. The more interest and curiosity present, the more knowledge can be obtained. The common sense of children with fluorosis showed declination, and this might be related to the brain organic damage caused by early fluorine intake, resulting in children's lack of interest in things and less general knowledge… In the children's vocabulary, calculation and similarities were **decreased by nearly 2 times**, indicating that their overall knowledge content and processing ability were weak… Compared with common sense test, influence by culture and education is less, and the comprehensive understanding level of children with dental fluorosis is **most significantly reduced, i.e., by about three times.** This clearly reflects the damage of fluoride on children's language development, vocabulary learning, and other comprehensive understanding abilities. The impairment of VIQ shows that the **IQ impairment in children with fluorosis** mainly loses the ability of learning language, forming concept, abstract thinking, analysis, and generalization [24, 25, 37].The results showed no significant difference between fluorosis group and control group ($P > 0.05$). Statistical significance was observed in the test of building blocks and decoding in the dental fluorosis group ($P < 0.05$), but not in other items ($P > 0.05$).
Conclusions:	"In conclusion, we believe that reducing fluoride intake with the assistance of the government can reduce fluorosis as well as the severity of intellectual impairment caused by fluorosis. Fluorosis in children can cause IQ impairment, especially the VIQ that is represented by language learning and vocabulary comprehension. During the period of fluorosis in children, language learning, vocabulary, and other interventions should be enhanced to improve the ability to acquire complementary skills."
Funding:	This work was financed by grants from the Natural Science Foundation of China (81460483).

IQ Study #65 (Till 2020)

Citation:	Till C, Green R, Flora D, Hornung R, Martinez-Miller EA, Blazer M, Farmus L, Ayotte P, Muckle G, Lanphear B. 2020. **Fluoride exposue from infant formula and child IQ in a Canadian birth cohort**. *Environment International* 134:105315. (Published in November 2019)
Location of Study:	In fluoridated and non-fluoridated cities in Canada.
Size of Study:	398 mother-child pairs
Age of Subjects:	Fetus and Infants up to 3-4 year-olds
Source of Fluoride:	Fluoride in drinking water for (1) Fetal fluoride exposure and (2) breast-fed versus formula-fed from both fluoridated and non-fluoridated cities.
Water Fluoride Level:	Thirty-eight percent of mother-child pairs lived in fluoridated communities, with the optimal fluoride level of 0.7 mg/L.
Urinary fluoride:	The authors "used maternal urinary fluoride (MUF) adjusted for specific gravity as a proxy of fetal fluoride exposure. MUF, which was derived by averaging three spot samples collected across all three trimesters of pregnancy".

Type of IQ Test:	Wechsler Primary and Preschool Scale of Intelligence-III at 3–4 years. Outcomes included Full Scale IQ (FSIQ), a measure of global intellectual functioning, Verbal IQ (VIQ), a measure of verbal reasoning, and Performance IQ (PIQ), a measure of non-verbal reasoning and visual-motor coordination skills.
Results:	Thirty-eight percent of mother-child dyads [pairs] lived in fluoridated communities. An increase of 0.5 mg/L in water fluoride concentration (approximately equaling the difference between fluoridated and non-fluoridated regions) corresponded to a 9.3- and 6.2-point decrement in Performance IQ among formula-fed (95% CI: -13.77, -4.76) and breast-fed children (95% CI: -10.45, -1.94). The association between water fluoride concentration and Performance IQ remained significant after controlling for fetal fluoride exposure among formula-fed (B = -7.93, 95% CI: -12.84, -3.01) and breastfed children (B = -6.30, 95% CI: -10.92, -1.68). A 0.5 mg increase in fluoride intake from infant formula corresponded to an 8.8-point decrement in Performance IQ (95% CI: -14.18, -3.34) and this association remained significant after controlling for fetal fluoride exposure (B = -7.62, 95% CI: -13.64, -1.60).
Conclusions:	In summary, fluoride intake among infants younger than 6 months may exceed the tolerable upper limits if they are fed exclusively with formula reconstituted with fluoridated tap water. After adjusting for fetal exposure, we found that fluoride exposure during infancy predicts diminished non-verbal intelligence in children. In the absence of any benefit from fluoride consumption in the first six months, it is prudent to limit fluoride exposure by using non-fluoridated water or water with lower fluoride content as a formula diluent.
Funding for Study:	This study was funded by a grant from the U.S. National Institute of Environmental Health Sciences (NIEHS) (grant #R21ES027044). The MIREC Study [from which the women were chosen] was supported by the Chemicals Management Plan at Health Canada, the Ontario Ministry of the Environment, and the Canadian Institutes for Health Research (grant #MOP-81285).

IQ Study #64 (Wang 2019)

Citation:	Wang M, Liu L, Li H, LI Y, Liu H, Hou C, Zeng Q, Li P, Zhao Q, Dong L, Zhou G, Yu X, Liu L, Guan Q, Zhang S, Wang A. 2019. **Thyroid function, intelligence, and low-moderate fluoride exposure among Chinese school-age children**. *Environment International* 134:105229. [Epub ahead of print].
Location of Study:	From endemic and non-endemic fluorosis areas in Tianjin, China.
Size of Study:	571 children randomly selected from endemic and non-endemic fluorosis areas in Tianjin. Children who were not long- term residents of the area were eliminated. Further, children who had congenital or acquired diseases affecting intelligence, or a history of cerebral trauma and neurological disorders, or those with a positive screening test history (like hepatitis B virus infection, Treponema palladium infection and Down's syndrome) and adverse exposures (smoking and drinking) during maternal pregnancy were excluded from the analyses.
Age of Subjects:	7–13 years
Source of Fluoride:	Drinking water
Water Fluoride Level:	About half of the children are in the district where water fluoride concentrations were within the Standards for Drinking Water Quality in China of 1 mg/L, while the other half had significantly higher fluoride concentrations than the screening guideline of 1 mg/L. The water fluoride concentration ranged from 0.20 mg/L to 3.9 mg/L, with a mean value of 1.39 ± 1.01 mg/L.
Urinary fluoride levels:	The mean (±SD) urinary fluoride was 1.28 ± 1.3 mg/L, with the range from 0.01 mg/L to 5.54 mg/L.
Thyroid hormone levels	The median THs levels in the serum were 1.33 ng/mL for TT_3, 6.8 g/dL for TT_4, 3.28 pg/mL for FT_3, 1.12 ng/dL for FT_4, and 2.28 uIU/mL for TSH.
Type of IQ Test:	A Combined Raven's Test for Rural China (CRT-RC2) was taken to evaluate the IQ of each child. Additionally, we utilized logistic regression model to examine the associations between fluoride, THs (Thyroid hormones) and different levels of intelligence, in which the IQ scores were categorized into five degrees as follows: marginal (70–89), normal (90–109), high normal (110–119), superior (120–129) and excellent (130), and the normal group was assigned as the control. Moreover, multivariate linear regression models were constructed to assess the associations between quartiles of water fluoride or urinary fluoride and THs and IQ scores, as well as associations between quartiles of THs and IQ scores. Trends tests were assessed by using the median value in each quartile as a continuous variable in the linear regression models

Results:	Fluoride exposure was inversely related to IQ scores for water fluoride and for urinary fluoride. The study detected a significant modification effect by TSH on the association between urinary fluoride and IQ scores, without mediation by THs.Adjusted estimates (95% *CI*) for the associations between fluoride exposure and IQ scores were a decrease of 1.587) points (95% *CI:* 2.607, 0.568, *P*= 0.002) and 1.214 points (95% *CI:* 1.987, 0.442), *P* = 0.002) in every 1mg/L increase of water and urinary fluoride concentration, respectively (Table 4). The similar relationship between IQ scores and fluoride exposure were observed in boys and girls, respectively. However, the modification effects by gender were not significant (Table 4).
Conclusions:	The study suggests low-moderate fluoride exposure is associated with alterations in childhood thyroid function that may modify the association between fluoride and intelligence.In the current work, results demonstrated clearly that, across the full range of water and urinary fluoride concentrations and using a measure to focus on children's IQ scores, higher fluoride levels were associated with lower IQ scores.
Funding for Study:	This work was supported by grants from the State Key Program of National Natural Science of China (Grant No. 81430076), the National Natural Science Foundation of China (Grants No. 81502785 and No. 81773388) and the Fundamental Research Funds for the Central Universities (HUST 2016YXMS221 and HUST 2015ZDTD052).

IQ Study #63 (Green-2019)

Citation:	Green R, Lanphear B, Hornung R, Flora D, Martinez-Mier EA, Neufeld R, Ayotte P, Muckle G, Till C. 2019. **Association Between Maternal Fluoride ExposureDuring Pregnancy and IQ Scores in Offspring in Canada.** *JAMA Pediatrics*. Published August 19.
Location of Study:	**CANADA.** 6 major cities.
Size of Study:	512 mother-child pairs
Age of Subjects:	Between the ages 3 and 4 years at testing
Source of Fluoride:	Self-reported maternal daily fluoride intake from water and beverage consumption available for 400 pregnant women. the design of our study compares water fluoride level and IQ score
Water Fluoride Level:	0.7 mg/L in fluoridated communities
Type of IQ Test:	Wechsler Preschool and Primary Scale of Intelligence, ThirdEdition. Full Scale IQ (FSIQ), a measure of global intellectual functioning, was the primary outcome. We also assessed verbal IQ (VIQ), representing verbal reasoning and comprehension, and performance IQ (PIQ), representing nonverbal reasoning, spatial processing, and visual-motor skills.
Results:	Data on Maternal urinary fluoride (MUF_{SG}) concentrations, IQ scores, and complete covariates were available for 512 mother-child pairs; data on maternal fluoride intake and children's IQ were available for 400 of 601mother-child pairs. Women living in areas with fluoridated tap water (n = 141) compared with nonfluoridated water (n = 228) had significantly higher mean (SD) MUF_{SG} concentration. A 1-mg/L increase in MUF_{SG} was associated with a 4.49-point lower IQ score (95% CI, -8.38 to -0.60) in boys, but there was no statistically significant association with IQ scores in girls (B= 2.40; 95% CI, -2.53 to 7.33). A 1-mg higher daily intake of fluoride among pregnant women was associated with a 3.66 lower IQ score (95% CI, -7.16 to -0.14) in boys and girls. Children had mean (SD) Full Scale IQ scores of 107.16 (13.26), range 52-143, with girls showing significantly higher mean (SD) scores than boys: 109.56 (11.96) vs 104.61(14.09); P= .001. There was a significant interaction (P= .02) between child sex and MUF_{SG} (6.89; 95% CI, 0.96-12.82) indicating a differential association between boys and girls.
Conclusions:	"In this study, maternal exposure to higher levels of fluoride during pregnancy was associated with lower IQ scores in children aged 3 to 4 years. These findings indicate the possible need to reduce fluoride intake during pregnancy."
Funding for Study:	This study was funded by a grant from the U.S. National Institute of Environmental Health Sciences (grant R21ES027044).The Maternal-Infant Research on Environment Chemicals Study (from which the women were chosen) was supported by the Chemicals Management Plan at Health Canada, the Ontario Ministry of the Environment, and the Canadian Institutes for Health Research.

IQ Study #62: (Cui-2018)

Citation:	Cui Y, Zhang B, Ma J, Wang Y, Zhao L, Hou C, Yu J, Zhao Y, Zhang Z, Nie J, Gao T, Zhou G, 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,* Sept 11;165:270-277.
Location of Study:	**CHINA.** Tianjin. Four schools in both historical endemic and non-endemic areas of fluorosis.
Size of Study:	323 children. Urine fluoride levels and age-specific IQ scores in children were measured at the enrollment.
Age of Subjects:	7–12 years old.
Source of Fluoride:	Drinking water
Water Fluoride Level:	Endemic fluorosis area = 1.52–2.49 mg/L. Nonendemic fluorosis area 0.20–1.00 mg/L.
Type of IQ Test:	Combined Raven's Test – The Rural in China (CRT-RC) method, which is based on the Raven's Standard Progressive Matrices (SPM) and the Color Progressive Matrices (CPM) and was widely adopted in China with modifications.
Results:	• the relationship between urine fluoride levels and IQ scores was significant after adjusting for child age, mother's education, family member smoking, stress, and anger. • Urine fluoride was inversely associated with IQ. • DRD2 Taq 1A polymorphism was not related to IQ in children exposed to high fluoride. • Urine fluoride had a stronger association with IQ in children with TT genotype. • The threshold of urine fluoride affecting IQ in children with TT genotype existed.
Conclusions:	Strengths of our study include using urine fluoride as an internal exposure index and thus minimizing the measurement error of exposure, adjusting up to 30 potential confounding covariates including child age and gene polymorphismin regressing IQ on urine fluoride in children, and careful modeling with applications of cross-validation, bootstrap techniques, and sensitivity analysis.In the overall participants, by LOWESS, the IQ decreased in a roughly linear manner as the log-urine fluoride increased (Fig. 1A).The authors also determined a safety threshold of urine fluoride on intelligence impairment in the subgroup TT as 1.73 mg/L urine fluoride with a 95% CI of (1.51 mg/L, 1.97 mg/L).
Funding for Study:	This work was supported by the National Nature Science Foundation of China (Grant nos. 81573107 and 81372934), Scientific and Technological Project of Tianjin Medicine in 2014 (Grant no. 14KG120) and Scientific and Technological Project of Tianjin Centers for Disease Control and Prevention (Grant no. CDCKY1501).

IQ Study #61: (El Sehmawy-2018)

Citation:	El Sehmawy AAEW, Hammouda SM, Ibrahim GE, Barghash SS, Elamir RY. 2018. **Relationship between Drinking Water Fluoride and Intelligence Quotient in Egyptian School Children.** *Occupational Medicine & Health Affairs,* Aug 13: 6:3.
Location of Study:	**EGYPT.** Beheira Governorate. Two different towns (urban) and four village (rural), the towns are Italy Elbaroud Center and two villages that belong to it, the second town is Shubra Khit Center and two villages that belong to it.
Size of Study:	1,000 children, 495 (49.5%) female and 405 (50.5%) male

Age of Subjects:	4.6 – 11 years old
Source of Fluoride:	Drinking water
Water Fluoride Level:	1.903 ± 1.06 mg/L; 0.330-0.377 mg/L *.the mean arsenic and cadmium levels in tap drinking water was (0.005 ± 0.004 mg/L) and (0.002 ±0.001 mg/L) for arsenic and cadmium respectively which are below the recommended WHO and the Egyptian level for all.*
Type of IQ Test:	The Draw-A-Person (DAP) test is a valuable instrument for the assessment of IQ, not only because it is easy to administer, but also for its multiple uses [25]. The children's drawings reflect their intellectual development, not just their visual-motor skills, therefore DAP test is useful for assessing children IQ between the age of 4 and 13 [26].
Results:	In this study there's a highly significant decrease in average IQ level in group of children with high fluoride level more than 1.5 mg /dL than the group of children with low fluoride level less than 1.5 mg /dL with the mean IQ was (96.25 ± 19.63) and (103.11 ± 28.00) for both groups respectively with p value ($p<0.001$), the graphical representation of the observation is shown in Figure 2.
Conclusions:	A real relationship between fluoride exposure and intelligence with the average IQ of high fluoride group was lower than those with lower fluoride level.
Funding for Study:	No source identified.

IQ Study #60: (Induswe-2018)

Citation:	Induswe B, Opinya G, Khasakhala LI, Owino R. 2018. **The Auditory Working Memory of 13-15-Year-Old Adolescents Using Water with Varying Fluoride Concentrations from Selected Public Primary Schools in North Kajiado Sub County.** *American Journal of Medicine and Medical Science*s, Jan; 8(0):274-290.
Location of Study:	**KENYA.** Kajiado North Subcounty in North Kajiado in the Great rift valley.
Size of Study:	269 school children; 178 (66.2%) female; 91 (33.8%) male.
Age of Subjects:	13-15 years
Source of Fluoride:	Drinking water
Water Fluoride Level:	15 (5.58%) had F level between 0-0.5mg/l; 52 (19.33%) had F level between 0.6-0.8 mg/l;38 (14.12%) had F between 0.9-1 mg/l; 41 (15.24%) had F level between 1.1-1.8 mg/l; 44 (16.36%) had F between 1.9-2.5 mg/l; 79 (29.37%) had F above 2.5mg/l.
Type of IQ Test:	Wechsler intelligence scale for Children V (WISC-V) subtest
Results:	A comparison of the AWM (Auditory Working Memory) of children from low (105.40±23.6) and high (99.52±23.2) fluoride schools and medium with high fluoride school had significant differences. The AWM for the children whose household water had low fluoride had higher AWMI 122.58±19.9 compared to those whose household had high fluoride in the with ANOVA F (2, 266) = 17.968, p?.0001 and Tukey HSD for low and medium (m=-5.919, se=3.146, p=.145, low and high fluoride, (m=-18.559. se=3.124, p?.001; medium and high (m=-12.640, se= 3.32, p?.001 at 95% CL.
Conclusions:	In conclusion, low fluoride in the water seemed to enhance the AWM (Auditory Working Memory). However, the AWM declined with an increase in the fluoride concentration in water.

Funding for Study:	No source identified.

IQ Study #59: (Mustafa-2018)

Citation:	Mustafa DE, Younis UM, Elhag SA. (2018). **The relationship between the fluoride levels in drinking water and the schooling performance of children in rural areas of Khartoum State, Sudan.** *Fluoride* 51(2):102–113.
Location of Study:	**SUDAN.** 16 rural areas in Khartoum state. These villages depend on groundwater as the main source of drinking water because of the lack of a central water supply. The main activities in these villages are agriculture and animal breeding. The villages lack any industrial and mining activities and are located away from high traffic roads.
Size of Study:	775 primary students, 315 boys and 460 girls from 27 schools.
Age of Subjects:	NA
Source of Fluoride:	Ground water
Water Fluoride Level:	The range for the F level was 0.14–2.07 mg/L in the dry season and0.01–1.34 mg/L in the rainy season (Table 1).Although the F level not extremely high, frequent water drinking may occur due to several factors such as the rural human activities, arid conditions, and high temperatures. In addition, food products also contribute to the F intake as the people in these areas consume their own crops. These crops may possibly accumulate F to considerable levels.
Type of IQ Test:	Using the Khartoum Ministry of Education's method, the schooling performance for the boys' and girls' primary schools in the 16 areas where the F samples were taken and were assessed by calculating the average score and high score prevalence… Generally, the schooling performance in these rural areas was poor compared to urban areas. There were also significant dropout rates in these rural areas, which could reflect even lower schooling performances.
Results:	Negative correlation coefficients were found for the average score for all the subjects and for the overall score, with the result being statistically significant in five out of the eight subjects and in the overall score (Tables 4 and 5)…. significant correlations undoubtedly exit between the drinking water F level and the schooling performances in all the subjects except for one, technology, which might be due to the nature of the subject.
Conclusions:	In summary, the results of this study suggest that there may be an association between the fluoride level in drinking water and the schooling performance of children. This result may be applicable to children in other areas with conditions similar to those of the study areas. Consequently, the upper permissible drinking water fluoride level needs to be revised downwards to minimize the effect of fluoride on children neurodevelopment
Funding for study:	The Department of Research, Ministry of Higher Education and Scientific Research, Sudan.

IQ Study #58: (Pang-2018)

Citation:	Pang H, Yu L, Lai X, Chen Q. 2018. **Relation Between Intelligence and COMT Gene Polymorphism in Children Aged 8-12 in the Endemic Fluorosis Area and Non-Endemic Fluorosis Area.** *Chinese Journal of Control of Endemic Diseases* 32(2):151-152. Study in Chinese translated into English.
Location of Study:	**CHINA.** The areas for population sampling were divided into a non-endemic fluorosis area where the prevalence of dental fluorosis in local children aged 8-12 is less than 30%, and an endemic fluorosis area where the prevalence of dental fluorosis in local children aged 8-12 is greater than 30%.
Size of Study:	268 children: 134 children each from endemic fluorosis area and non-endemic fluorosis areas.

Age of Subjects:	8 -12 years of age
Source of Fluoride:	Endemic fluorosis area and non-endemic fluorosis areas.
Water Fluoride Level:	NA
Type of IQ Test:	Combined Raven's Test (CRT)
Results:	This study found that in COMT gene polymorphism, there was no difference between children in the endemic fluorosis area and those in the non-endemic fluorosis area ($P > 0.05$). It was found that alleles of the COMT gene were codominantly inherited, and the activity of different genotypes of the COMT gene expressed in vivo was somewhat different. This study also found that there were great differences in terms of the level of intelligence between children with Val/Val or Met/Val and children with Met/Met, and such differences were statistically significant ($P < 0.05$): children with the highly active COMT Val/Val genotype had significantly higher intelligence than those with the Met/Met COMT genotype or the Met/Val COMT genotype, and intelligence in children with any of the three genotypes in the endemic fluorosis area was lower than that in the non-endemic fluorosis area, indicating that the highly active COMT Val/Val genotype has a protective effect on children's intelligence development.
Conclusions:	This study found that there was a great difference in the level of intelligence between children in the endemic fluorosis area and those in the non-endemic fluorosis area and such difference was statistically significant ($P < 0.05$).The rate of mental retardation (IQ < 69) in children in the endemic fluorosis area was significantly higher than that in the non-endemic fluorosis area, and the difference was statistically significant ($P < 0.05$).
Funding for Study:	No mention

IQ STUDY

#57: (Chang-2017)

Citation:	Chang A, Shi Y, Sun H, Zhang L. 2017. Analysis on the Effect of Coal-Burning Fluorosis on the Physical Development and Intelligence Development of Newborns Delivered by Pregnant Women with Coal-Burning Fluorosis. *Chinese Journal of Control of Endemic Diseases* 32(8):872-873.
Location of Study:	**CHINA**: mothers in coal-burning fluorosis areas compared to control
Size of Study:	118 newborns
Age of Subjects:	68 newborns to 12 months of age
Source of Fluoride:	Coal-burning fluorosis areas
Water Fluoride Level:	NA
Type of IQ Test:	Mental development index (MDI) and psychomotor development index (PDI) (assessed using the Standardized Scale for the Intelligence Development of Children formulated by the Children Development Center of China [CDCC])
Results:	The body weight, body length, head circumference, chest circumference, upper arm circumference and top arm length of newborns in the observation group were all significantly lower than those in the control group, and their differences were statistically significant ($P < 0.05$). At 3, 6, 9 and 12 months after birth, the grades of body weight development and body-length development of infants in the control group were significantly higher than those in the observation group ($P < 0.05$); both the MDI and the PDI of infants in the observation group were significantly lower than those in the control group ($P < 0.05$).T al

	attention on the stay of mother during pregnancy, source of drinking water since conception, the socioeconomic status of all the three villages which were same in both endemic and control areas.
Conclusions:	Comparison of the mental development index (MDI) and psychomotor development index (PDI) (assessed using the Standardized Scale for the Intelligence Development of Children formulated by the Children Development Center of China [CDCC]) of newborns in the two groups at 3, 6, 9 and 12 months after birth showed that both the MDI and the PDI in the observation group were significantly lower than those in the control group (P< 0.05), which suggests that maternal fluorosis have a significant impact on the intelligence development of newborns.

IQ Study #56: (Jin-2017)

Citation:	Jin T, Wang Z, Wei Y, Wu Y, Han T, Zhang H. (2017). **Investigation of Intelligence Levels of Children of 8 to 12 Years of Age in Coal Burning-Related Endemic Fluorosis Areas.** *Journal of Environment and Health* 34(3):229-231.
Location of Study:	**CHINA.** Cichong Elementary School in the coal burning-related endemic fluorosis area of Liupanshui City in Guizhou Province; and Minzu Elementary School of Guian District's Dangwu Township, a non-coal burning area, as the control group
Size of Study:	284 children: 167 were from the endemic area and 117 were the control.
Age of Subjects:	8 – 12 years
Source of Fluoride:	Coal Burning-Related Endemic Fluorosis Areas
Water Fluoride Level:	NA
Type of IQ Test:	Raven's Standard Progressive Matrices (RSPM)
Results:	we found that except for the intelligence levels of 12-year-old children in the control area being higher than that of those in the endemic area, there were no statistically significant differences among any of the other age groups. The differences of intelligence level among children in the endemic area with different dental fluorosis severities also showed no statistical significance. However, there was a negative correlation between age and intelligence level in children of the endemic area, which is in direct opposition to the usual situation of the intellectual development of school-aged children in general. The reason for this is that the dental fluorosis patients in our investigation were mainly concentrated in the suspected fluorosis group, and patients with other levels of severity only made up 50% of the total number of patients, with only six child patients with moderate dental fluorosis and no child patients with severe clinical fluorosis. The degree of fluorosis severity in the patients included in this investigation was not high, so a dosage-effect relationship might not have been able to be formed. In addition, the factors that influence the intelligence level of children are multivariate, and the mechanisms are complex, with fluorosis possibly only being one of many factors.
Conclusions:	The intelligence of the 12-year-old group in the endemic area was lower than that of the control area, with the difference having statistical significance (Z = 3.244, P = 0.001).
Funding for Study:	No mention

IQ Study #55: (Razdan-2017)

Citation:	Razdan P, Patthi B, Kumar JK, Agnihotri N, Chaudhan 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):252-258.
Location of Study:	**INDIA.** Mathura district, Uttar Pradesh.

Size of Study:	219: 75 from low F area, 75 medium F area, and 69 from high F area. Identical numbers of male and female children were included.
Age of Subjects:	12-14 year olds
Source of Fluoride:	Drinking water
Water Fluoride Level:	Charora (Group A) had low fluoride (0.60 ppm) village, Farah (Group B) had medium fluoride level (1.70 ppm), and Raya (Group C) had the highest concentration of fluoride in water used for consumption (4.99 ppm).
Type of IQ Test:	SPM Test by John C Raven (1998)
Results:	Appraisal of the IQ levels among the three groups (low-, medium-, and high-fluoride areas) showed a statistically significant difference ($P = 0.05$). None of the children in the low-fluoride region were intellectually compromised when compared to 15 (20%) in the high-fluoride region and 4 (5.3%) in the medium-fluoride areas [Table 1]. In addition, no subject in the low fluoride area had below average IQ in contrast to 35 (46.7%) in the high and 10 (13.3%) in the medium-fluoride areas. Similarly, no one in medium and high fluoride area had either above average or superior IQ when compared to 38 (55.1%) and 9 (13%) children having above average and superior IQ in low-fluoride area, respectively.None of the children in the low-fluoride region had dental fluorosis as compared to 8 (10.7%), 45 (60.0%), and 22 (29.3%) children in the high-fluoride area who had mild, moderate, and severe dental fluorosis, respectively.
Conclusions:	Concentration of Fluoride in the ingested water was significantly associated with the IQ of children.Outcome measures revealed that exposure to higher levels of F determined by dental fluorosis status of child inferred higher IQ deficit.
Funding for Study:	There was no financial support nor sponsorship for this study.

IQ Study #54: (Yu-2018)

Citation:	Yu X, Chen J, Li Y, Liu H, et al. (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*, Jun 2; 118:116-124.
Location of Study:	**CHINA.** In endemic and non-endemic fluorosis areas in Tianjin.
Size of Study:	2,886 resident children
Age of Subjects:	7 to 13 years
Source of Fluoride:	Drinking water
Water Fluoride Level:	The water fluoride concentration ranged from 0.20 mg/L to 1.00 mg/L, with a mean value of 0.50 ± 0.27 mg/L in the normal fluoride exposure group, and from 1.10 mg/L to 3.90 mg/L, with a mean value of 2.00 ± 0.75 mg/L in the high-fluoride exposure group (Table 1).
Type of IQ Test:	We examined the dose-response effects of low-to-moderate fluoride exposure on dental fluorosis (DF) and intelligence quotient (IQ), and evaluated the potential relationships between DF grades and intelligence levels using piecewise linear regression and multiple logistic regression, respectively.IQ scores were measured using the second edition of Combined Raven's Test–The Rural in China (CRT-RC2) (Liu et al., 2009) for children aged 7 to 13 years. The CRT-RC2 is a validated test for basic cognitive abilities, and has been widely adopted in China after modifications, as it is non-verbal and less affected by language, and cultural and ethnic differences (Sun et al., 2015).Dean's fluorosis index (WHO criteria) (Molina-Frechero et al., 2015) was used to estimate the prevalence and severity of DF. Each participant was examined by two qualified and independent experts, who had rich experience on examination of dental fluorosis… The final diagnosis was made only when judgments from the two experts were in agreement; if not, a third expert would join in and offer suggestion. For repeatability, 10% of participants were double checked and the Kappa value was 0.82.

Results:	The adjusted odds ratios (ORs) of DF were 2.24 (95% confidence interval [CI]: 2.02 to 2.48) for every 0.1 mg/L increment in the water fluoride concentration in the range of 0.80 to 1.50 mg/L, and 2.61 (95% CI: 2.32 to 2.93) for every 0.5 mg/L increment in the urinary fluoride level up to 1.80 mg/L. Every 0.5 mg/L increment in the water fluoride level was associated with a reduction of 4.29 in the IQ score (95% CI: -8.09 to -0.48) in the range of 3.40 to 3.90 mg/L, and a decreased probability of developing excellent intelligence (IQ ?130, OR = 0.60, 95% CI: 0.47 to 0.77) in the range of 0.20-1.40 mg/L, respectively. Every 0.5 mg/L increment in the urinary fluoride level was related to a decrease of 2.67 in the IQ scores (95% CI: -4.67 to -0.68) between 1.60 mg/L to 2.50 mg/L. Excellent intelligence decreased by 51% in children with higher urinary fluoride, and by 30% with each degree increment of DF.
Conclusions:	In conclusion, chronic exposure to excessive fluoride, even at a moderate level, was inversely associated with children's dental health and intelligence scores, especially excellent intelligence performance, with threshold and saturation effects observed in the dose-response relationships. Additionally, DF severity is positively associated with the loss of high intelligence, and may be useful for the identification of individuals with the loss of excellent intelligence. Thus, it is important to monitor water quality, and supply fluoride-free drinking water to safeguard children's health.
Funding for Study:	This study was supported by the State Key Program of National Natural Science of China (Grant No. 81430076) and the Fundamental Research Funds for the Central Universities (HUST 2015ZDTD052 and HUST 2016YXMS221).

IQ Study #53: (Bashash-2017)

Citation:	Bashash M, Thomas D, Hu H, Martinez-Mier EA, Sanchez BN, Basu N, Peterson KE, Ettinger AS, Wright R, Zhang Z, Liu Y, Schnaas L, Mercado-García A, Téllez-Rojo MM, Hernández-Avila M. 2017. **Prenatal Fluoride Exposure and Cognitive Outcomes in Children at 4 and 6–12 Years of Age in Mexico.** *Environmental Health Perspectives*, Sept 19;125(9):097017.
Location of Study:	**MEXICO.** Participants from the Early Life Exposures in Mexico to Environmental Toxicants (ELEMENT) project.
Size of Study:	299 mother–child pairs, of whom 287 and 211 had data for the General Cognitive Index and IQ analyses, respectively.
Age of Subjects:	Tests of cognitive function in the offspring at age 4 and 6–12 years.
Source of Fluoride:	Fluoridated salt (at 250?ppm) and to varying degrees of naturally occurring fluoride in drinking water.
Water Fluoride Level:	Natural water fluoride levels in Mexico City may range from 0.15 to 1.38 mg/L
Type of IQ Test:	"At age 4 y, neurocognitive outcomes were measured using a standardized version of McCarthy Scales of Children's Abilities. For children 6–12 y old a Spanish-version of the Wechsler Abbreviated Scale of Intelligence."
Results:	"In multivariate models we found that an increase in maternal urine fluoride of 0.5mg/L (approximately the IQR) predicted 3.15 (95% CI: 5.42, 0.87) and 2.50 (95% CI 4.12, 0.59) lower offspring GCI and IQ scores, respectively."
Conclusions:	"In this study, higher prenatal fluoride exposure, in the general range of exposures reported for other general population samples of pregnant women and nonpregnant adults, was associated with lower scores on tests of cognitive function in the offspring at age 4 and 6–12 y."
Funding for study:	This study was supported by the U.S. National Institutes of Health (NIH; grants R01ES021446 and R01-ES007821); the National Institute of Environmental Health Sciences/the U.S. Environmental Protection Agency (NIEHS/EPA; grant P01ES022844), the NIEHS (grant P42-ES05947 and NIEHS Center Grant P30ES017885), and by the National Institute of Public Health/Ministry of Health of Mexico. The American British Cowdray Hospital provided facilities used for this research.

IQ Study #52: (Valdez Jiménez-2017)

Citation:	Valdez Jiménez L, López Guzmán OD, Cervantes Flores M, Costilla-Salazar R, Calderón Hernández J, Alcaraz Contreras Y, Rocha-Amador DO. 2017. **In utero exposure to fluoride and cognitive development delay in infants.** *Neurotoxicology* Mar;59:65-70.
Location of Study:	**MEXICO.** Durango City and Lagos de Moreno, Jalisco. Both are endemic hydro-fluorosis areas.
Size of Study:	"65 mother-infant pairs recruited from 2013 to 2014. Inclusion criteria were: 12 weeks of gestation, with no history of thyroid disease, without clinically diagnosed diabetes, and a minimum 5 years of residence in the study area."
Age of Subjects:	"The average age of children assessed was 8 months (3–15 months) and almost 70% were girls." The average age of the mothers was 22.4 ±4.0.
Source of Fluoride:	The study was performed in an endemic hydrofuorosis area. According to the authors: 'in Mexico F in water remains as the main source of F exposure. In endemic hydrofuorosis areas of Mexico only non-fluorinated salt is distributed according to the NOM-040-SSA1-1993."
Water Fluoride Level:	F levels in tap water mean concentrations for each trimester were: 2.6 ±1.1 mg/l, 3.1 ±1.1 mg/l and 3.7 ±1.0 mg/l respectively. It is worthy to note that over 81.5% of the samples of tap water were above 1.5 mg/l (NOM-127- SSA1-1994) with the highest value of 12.5 mg/.33.8% of women reported drink tap water and 78.4% use it for cooking. The practice of use tap water for drink or cooking is crucial because exposure to F could be increased when the infant change to bottle feeding and starts solid foods. Regarding, bottled water it is important to mention that we have analyzed several brands of this water and 65% of the samples exceeded the 0.7 mg/l value (NOM-041-SSA1-1993) and 22.9% had values over 1.5 mg/l (NOM-127-SSA1-1994) data not shown.
Type of IQ Test:	"Neurodevelopment was assessed with the Bayley Scales of Infant Development II (BSDI-II) (Bayley, 1993). This test has good reliability and validity; it is applied to evaluate developmental delay in children between 3 months to 5 years in Mexico by the SSA (CNPSS, 2013). The Mental Development Index scale (MDI) of the Bayley test evaluate aspects of functioning such as eye-hand coordination, manipulation, understanding of object relation, imitation and early language development whereas the Psycho-motor Development Index (PDI) scale assesses gross motor development… To standardize the raw scores for children who were born prematurely, the number of months of prematurity was subtracted from their chronological age. The scores below 85 points indicated a possible developmental delay."
Results:	In this study near to 60% of the children consumed contaminated water and the prevalence of children with IQ below 90 points was 25% in the control group (F urine 1.5 mg/g creatinine) in comparison with the 58% of children in the exposed group (F urine >5 mg/g creatinine) (OR = 4.1, CI 95% 1.3–13.2) (data unpublished).Only 66.2% of the babies were at term. "We found higher levels of F in urine across trimester in premature compared with full term 2.4 vs 1.6 mg/l (1st); 2.3 vs 1.8 mg/l (2nd); and 4.1 vs 2.8 mg/l (3rd) (data not shown)
Conclusions:	"After adjusting for potential confounding factors (gestational age, age of child, marginalization index and type of water for consumption), the MDI [Mental Development Index] showed an inverse association with F levels in maternal urine for the first (b = -19.05, $p = 0.04$) and second trimester (b = -19.34, $p = 0.01$). Our data suggests that cognitive alterations in children born from exposed mothers to F could start in early prenatal stages of life.
Funding for study:	The authors acknowledge the financial support of this research by CONACYT with number 181577, FONSEC 2012 and the University of Guanajuato through DAIP support with number FO-DAI-05, 2013. The present work was carried out during the first period of the first author postdoctoral training (fellowship number 239404).

IQ Study #51: (Das-2016)

Citation:	Das K, Mondal NK. 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.** *Environmental Monitoring & Assessment* 188(4):218.
Location of Study:	**INDIA.** West Bengal.
Size of Study:	149 schoolchildren
Age of Subjects:	6 to 18

Source of Fluoride:	Water
Water Fluoride Level:	Average = 2.1 mg/L (S.D. = 1.64 mg/L)
Type of IQ Test:	Combined Raven's Test for RuralChina (CRT-RC)
Results:	"IQ has anegative significant correlation with dental fluorosis (r=0.253,P<0.01). Dental fluorosis acts as an indicator of decreasing level of IQ. As fluorosis is a consequence of fluoride exposure, so IQ has a negative significant correlation with exposure dose (r =0.343, P<0.01) which was considered as a fluoride input source.""IQ values were plotted against the urinary fluoride concentration and it was found that they have a significant negative correlation (r=0.751, P<0.01)."
Conclusion	"[C]hildren residing in areas with higher than normal water fluoride level demonstrated more impaired development of intelligence and moderate [dental fluorosis]. Millions of children including adults around the world are affected by higher level of fluoride concentration through their drinking water and are therefore potentially at risk. It is concluded that for the benefit of the future generation, urgent attention should be paid on this substantial public health problem."

IQ Study #50: (Aravind-2016)

Citation:	Aravind A, Dhanya RS, Narayan A, Sam G, Adarsh VJ, Kiran M. 2016. **Effect of fluoridated water on intelligence in 10-12-year-old school children**. *Journal of International Society of Preventive & Community Dentistry* 6 (Suppl 3), S237-S242.
Location of Study:	Schools: Virajpet (low fluoride level < 1.2 ppm), Banavara (Medium fluoride level 1.2-2 ppm), and Mastihalli (High fluoride levels > 3 ppm).
Size of Study:	96 children from each of the three fluoride water levels above, for a total of 288.
Age of Subjects:	10–12 years
Source of Fluoride:	Drinking water
Type of IQ Test:	Raven's Standard Progressive Matrices was conducted on each child in the study sample.
Results:	A significant inverse relationship was found between the fluoride concentration in drinking water and IQ (r value = -0.204; $P <$ 0.000). It was observed that IQ level was negatively correlated with fluoride concentration in drinking water.
Conclusions:	It is concluded that IQ level was negatively correlated with fluoride level in drinking water. Factors that might affect children's IQ need to be considered, and it is necessary to devise solutions for preventing the harmful effects of excessive intake of fluoride ion to the body.
Funding:	No financial support or sponsorship.

IQ Study #49: Mondal (2016)

Citation:	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.** *Environmental Geochemistry & Health* 38(2):557-76.
Location of Study:	**INDIA.** Birbhum district.

Size of Study:	40 children (20 from endemic fluorosis area; 20 from control area)
Age of Subjects:	10 to 14 years old
Source of Fluoride:	Water
Water Fluoride Levels:	"Mean F concentration in the study area varies from 0.32 to 13.29 mg/L."
Type of IQ Test:	Raven Standard Theoretical Intelligence Test
Results:	"This study indicates that students exposed to high F (children of Junidpur and Nowapara) show an average IQ of 21.17 ± 6.77 in comparison with low-F exposed students (children of Bilaspur, Mohula, Bhalian) having an average IQ of 26.41 ± 10.46. . . . Statistical analysis (Z test) demonstrates that there is a significant (Z = 2.59) difference in IQ among the high- and low-F area student."
Conclusion	"[S]tudents of the study area have less IQ than students of non-contaminated area, demonstrating that consumption of F also has a major role with the intellectual development of children."

IQ Study #48: Khan (2015)

Citation:	Khan SA, Singh RK, Navit S, Chadha D, Johri N, Navit P, Sharma A, 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 & Diagnostic Research* 9(11):ZC10-15.
Location of Study:	**INDIA.** Lucknow district.
Size of Study:	429 schoolchildren
Age of Subjects:	6-12 years old
Source of Fluoride:	Water
Results:	"In this study, on comparison of children at two locations according to IQ grades [Table/Fig-4], majority of the children (74.8%) living in low fluoride area had an IQ grade 2 (definitely above the average in intellectual capacity). None of the children from the low fluoride area had an IQ grade 4 and 5 (definitely below average and intellectually impaired). On the other hand, majority of children (58.1%) from high fluoride area fall under IQ grade 3 (intellectually average). None of the children from high fluoride area had an IQ grade 1 (intellectually superior). This difference in IQ grades of children amongst the two areas was found to be statistically significant ($p<0.001$)."""[I]t is clearly evident that with increase in the grade of fluorosis, a trend of increase in the IQ grade (decrease in intellectual capacity) was observed indicating a strong correlation between fluorosis grade and IQ grade (Spearman's $p=0.766$)."
Conclusion:	"The data from this research may support the hypothesis that excess fluoride in drinking water has toxic effects on the nervous system."

IQ Study #47: Sebastian (2015)

Citation:	Sebastian ST, 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 the Indian*

	Preventive Dentistry 33(4):307-11.
Location of Study:	**INDIA.** Mysore district.
Size of Study:	405 schoolchildren (135 children from high fluoride area; 135 children from "normal" fluoride area; 135 chidren from "low" fluoride area)
Age of Subjects:	10-12 years old
Source of Fluoride:	Water
Water Fluoride Levels:	High-fluoride: 2.2 mg/L; "Normal" Fluoride: 1.2 mg/L; "Low" Fluoride: 0.4 mg/L
Type of IQ Test:	Raven's colored Progressive Matrices Test
Results:	"In bivariate analysis, significant relationships were found between water fluoride levels and Intelligence Quotient of school children ($P < 0.05$). In the high fluoride village, the proportion of children with IQ below 90, i.e. below average IQ was larger compared to normal and low fluoride village. Age, gender, parent education level and family income had no significant association with IQ."
Conclusion:	"School children residing in area with higher than normal water fluoride level demonstrated more impaired development of intelligence when compared to school children residing in areas with normal and low water fluoride levels."

IQ Study #46: Kundu (2015)

Citation:	Kundu H, Basavaraj P, Singla A, Gupta R, Singh K, Jain S. (2015). **Effect of fluoride in drinking water on children's intelligence in high and low fluoride areas of Delhi.** *Journal of the Indian Association of Public Health Dentistry* 13(2):116-121. April-June.
Location of Study:	**INDIA.** Delhi.
Size of Study:	200 school children: 100 from low F area and 100 from high F area.
Age of Subjects:	8-12 years of age. Equal numbers of male and female children were included in the study.
Source of Fluoride:	Water
Type of Cognitive Tests:	Ravens Standardized Progressive Matrices Test
Results:	"Comparison of mean IQ of children in both high (76.20 ± 19.10) and low F (85.80 ± 18.85) areas showed a significant difference ($P = 0.013$). Multiple regression analysis between child IQ and all other independent variables revealed that mother's diet during pregnancy ($P = 0.001$) along with F in drinking water ($P = 0.017$) were the independent variables with the greatest explanatory power for child IQ variance ($r^2 = 0.417$) without interaction with other variables."
Conclusion:	"Fluoride in the drinking water was significantly related with the IQ of children. Along with fluoride, mother's diet during pregnancy was also found to be significantly related with IQ of children."

IQ Study #45: Choi (2015)

Citation:	Choi AL, Zhang Y, Sun G, Bellinger D, Wang K, Yang XJ, Li JS, Zheng Q, Fu Y, Grandjean P. (2015). **Association of lifetime exposure to fluoride and cognitive functions in Chinese children: A pilot study.** *Neurotoxicology & Teratology* 47:96-101.
Location of Study:	**CHINA.** Southern Sichuan Province.
Size of Study:	51 children from elevated fluoride area
Age of Subjects:	Avg = 7.1 years old
Source of Fluoride:	Water
Urine Fluoride Levels:	Mean = 1.64 mg/L; Range = 0.22 to 5.84 mg/L
Water Fluoride Levels:	Mean = 2.2 mg/L; Range = 1.0 to 4.07 mg/L
Confounding Factors:	"In this rural community, social differences are limited. The parents or guardians completed a questionnaire on demographic and personal characteristics including the child's sex, age at testing, parity, illnesses before age 3, past medical history of the child and caretakers, parental or guardian age, education and occupational histories, and residential history, and household income. It is known that iron deficiency can impair motor and mental developments in children, iron concentration was therefore considered as a covariate. These potential confounders were used for adjustment in the statistical analysis.""Among possible confounders, both arsenic and lead are known to be low in drinking water in the area."
Type of Cognitive Tests:	WRAML, WISC-R, WRAVMA
Results:	"Results of our pilot study showed that moderate and severe dental fluorosis was significantly associated with deficits in WISC-R digit span. Children with moderate or severe dental fluorosis scored significantly lower in total and backward digit span tests than thosewith normal or questionable fluorosis. These results suggest a deficit in working memory. Scores on other tests did not show significant relationships with indices of fluoride exposure."
Conclusion:	"Results of our field study raise a concern about the safety of elevated systemic exposure to fluoride from high concentrations in the drinking water.While topical fluoride treatment confers benefits of reducing caries incidence, the systemic exposure should not be so high as to impair children's neurodevelopment especially during the highly vulnerable windows of brain development in utero and during infancy and childhood and may result in permanent brain injury. We are planning a larger scale study to better understand the dose–effect relationships for fluoride's developmental neurotoxicity in order to characterize the appropriate means of avoiding neurotoxic risks while securing oral health benefits."

IQ Study #44: Zhang (2015)

Citation:	Zhang S, Zhang X, Liu H, Qu W, Guan Z, Zeng Q, Jiang C, Gao H, Zhang C, Lei R, Xia T, Wang Z, Yang L, Chen Y, Wu X, Cui Y, Yu L, Wang A. (2015). **Modifying Effect of COMT Gene Polymorphism and a Predictive Role for Proteomics Analysis in Children's Intelligence in Endemic Fluorosis Area in Tianjin, China.** *Toxicological Sciences* 144(2):238-45. April.
Location of Study:	**CHINA.** Tianjin City.
Size of Study:	180 children (96 from control area; 84 from "high fluoride" area)

Age of Subjects:	Avg = 11 years old
Source of Fluoride:	Water
Water Fluoride Levels:	High = 1.4 mg/L Control = 0.63 mg/L
Urine Fluoride Levels:	High = 2.4 + 1.01 mg/L Control = 1.10 + 0.67 mg/L
Serum Fluoride Levels:	High = 0.18 + 0.11 mg/L Control = 0.06 + 0.03 mg/L
Type of IQ Test:	Combined Raven's Test for Rural China (CRT-RC)
Confounding Factors:	"Covariates included the indicator variables for age, gender, educational levels of parents (primary and below, junior high school, senior high school, and above), and continuous variables for drinking water fluoride (mg/l) and levels of thyroid hormones (T3, T4, and TSH)."
Results:	"[T]he present work demonstrated that the IQ scores of children exposed to high fluoride drinking water were significantly lower than those who lived in control area . . . . [O]ur findings further showed that, across the full range of serum and urinary fluoride, children's IQ decreased gradually with the increase of fluoride contents in serum and urine, in a dose-dependent manner."
Conclusion:	"In summary, our data suggest that the intelligence of children is affected by the COMT gene polymorphism and, in particular, this SNP plays a role in modifying the effect of fluoride exposure on cognition. Children with COMT reference allele had a higher risk for cognitive impairments after fluoride exposure. Additionally, proteomics analysis represents early specific markers of developmental fluoride neurotoxicity. Hence, our findings provide certain basis for clarifying the mechanisms and identifying molecular targets of pharmacological interventions for potential delayed therapy."

IQ Study #43: Bai (2014)

Citation:	Bai Z, Li Y, Fan Z, Li X, Li P. (2014) **Investigation and analysis of the development of intelligence levels and growth of children in areas suffering fluorine and arsenic toxicity from pollution from burning coal.** *Chinese Journal of Endemiology* 33(2):160-163.
Location of Study:	**CHINA.** Shaanxi Province.
Size of Study:	303 children (120 children from high-fluoride area; 95 from mid-fluoride area, 98 from low-fluoride area)
Age of Subjects:	8 to 12 years old
Source of Fluoride	Coal burning
Urine Fluoride Levels:	"The median urinary fluoride levels for children 8–12 years old in the areas of significant, minor and no morbidity were, respectively, 1.96, 0.81 and 0.54 mg/L."
Results:	"The children's urinary fluoride and urinary arsenic levels versus intelligence [quotients] were both negatively correlated (r=-0.560, -0.353, all P<0.05)."
Conclusion	"Exposures to fluorine and arsenic are deleterious to the development of intelligence and the development of growth in children"

IQ Study #42: Wei (2014)

Citation:	Wei N, Li Y, Deng J; Xu S, Guan Z. (2014). **The effects of comprehensive control measures on intelligence of school-age children in coal-burning-borne endemic fluorosis areas.** *Chinese Journal of Endemiology* 33(3):320-22.
Location of Study:	**CHINA.** Bijie City, Guizhou Province.
Size of Study:	741 children (104 children from low-fluoride area; 298 children from an endemic fluorosis area with long-term defluoridation measures; 339 children from endemic fluorosis area with short-term defluoridation measures).
Age of Subjects:	8-12 years old
Source of Fluoride:	Coal
Urinary Fluoride Levels:	Control: 1.34 ± 0.64 mg/L; Long-term defluoridation: 2.33 ± 0.18 mg/L; Short-term defluoridation: 3.03 ± 0.16) mgL.
Results:	"Above average IQ of children in the control group was 97.1% (101/104),which was significantly higher than that of long and short treatment groups; after a lengthy treatment, mental retardation detection rate was significantly lower in the low-age group,8-10 year-old children(x^2 =7.542,$P < 0.01$). Urinary fluoride content was negatively correlated with the level of IQ (r =-0.553,$P < 0.01$)."
Conclusion:	"The intelligence development of children in coal-burning-borne endemic fluorosis area is significantly delayed. After a certain period of comprehensive treatment,the decreased level of cognition is inhibited and the mental retardation in the low-age group is improved."

IQ Study #41: Nagarajappa (2013)

Citation:	Nagarajappa R, Pujara P, Sharda AJ, Asawa K, Tak M, Aapaliya P, Bhanushali N. (2013). **Comparative assessment of intelligence quotient among children living in high and low fluoride areas of Kutch, India: a pilot study.** *Iranian Journal of Public Health* 2(8): 813–818.
Location of Study:	**INDIA.** Kutch District, Gujarat.
Size of Study:	100 children (50 children from high-fluoride area; 50 children from control area)
Age of Subjects:	8-10 years old
Source of Fluoride:	Water
Water Fluoride Levels:	High Fluoride: 2.4 to 3.5 mg/L; Control: 0.5mg/L.
Type of IQ Test:	Seguin Form Board Test
Results:	"Mean scores for average, shortest and total timing category were found to be significantly higher ($P<0.05$) among children living in Mundra (30.45±4.97) than those living in Bhuj (23.20±6.21). Mean differences at 95% confidence interval for these timings were found to be 7.24, 7.28 and 21.78 respectively."

Conclusion:	"Chronic exposure to high levels of fluoride in water was observed to be associated with lower intelligence quotient."

IQ Study #40: Singh (2013)

Citation:	Singh VP, Chauhan DS, Tripathi S, Kumar S, Gaur V, Tiwari M, Tomar A. (2014). **A correlation between serum vitamin, acetylcholinesterase activity and IQ in children with excessive endemic fluoride exposure in Rajasthan, India.** *European Academic Journal* 2(4):5857-5869.
Location of Study:	**INDIA.** Jaipur, Rajasthan.
Size of Study:	42 children (70 from high-fluoride area; 72 from control area)
Age of Subjects:	9 to 14 year olds
Source of Fluoride:	Water
Levels of Fluoride in Water:	High Fluoride = 6.8 mg/L Control area = <1.03 mg/L
Confounding Factors:	"The subjects were similar in living conditions, parental literacy, socioeconomic status, and health history. Moreover, age and sex matched controls were selected from the [low-fluoride area]."
Type of IQ Test:	Raven's Test
Conclusion:	"We observed reduced AChE activity in [the high fluoride area] which may be directly correlate[d] with the reduced intelligence score of the subjects."

IQ Study #39: Karimzade (2014)

Citation:	Karimzade S, Aghaei M, Mahvi AH. (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.
Location of Study:	**IRAN.** Poldashi and Piranshahr, West Azerbaijan province.
Size of Study:	39 male children (19 from high-fluoride area; 20 from control area)
Age of Subjects:	9 to 12 year olds
Source of Fluoride:	Water
Water Fluoride Levels:	High Fluoride = 3.94 mg/L Control = 0.25 mg/L
Confounding Factors:	No significant differences were found in the potential confounding factors of educational, economic, social, cultural, and general demographic characteristics between the high- and low-F regions.

Type of IQ Test:	Iranian version of the Raymond B Cattell test
Results:	“The IQ of the 19 children in the high-F region was lower (mean±SD: 81.21±16.17), than that of the 20 children in the low-F region (mean±SD: 104.25±20.73, p=0.0004). In the high-F region, 57.8% had scores indicating mental retardation (IQ <70) or borderline intelligence (IQ 70–79), while this figure was only 10% in the low–F region.”
Conclusions:	“The study found that children residing in a region with a high drinking water F level had lower IQs compared to children living in a low drinking water F region (p<0.001). The differences could not be attributed to confounding educational, economic, social, cultural, and general demographic factors.”

IQ Study #38: Trivedi (2012)

Citation:	Trivedi MH, Sangai NP, Patel RS, Payak M, Vyas SJ. (2012). **Assessment of groundwater quality with special reference to fluoride and its impact on IQ of schoolchildren in six villages of the Mundra Region, Kachchh, Gujurat, India.** *Fluoride* 45(4):377-83.
Location of Study:	**INDIA.** Gujurat.
Size of Study:	84 children (34 from high-fluoride villages, 50 children from control village)
Age of Subjects:	6th and 7th grade students
Source of Fluoride:	Water
Water Fluoride Levels:	High Fluoride = 2.3 + 0.87 mg/L Control = 0.83 + 0.38 mg/L
Urine Fluoride Levels:	High Fluoride = 2.69 + 0.92 mg/L Control = 0.42 + 0.23
Confounding Factors:	Same socioeconomic status (E on an A-E scale); same attendance status at school (regular students attending more than 80% of classes)
Type of IQ Test:	Questionnaire prepared by Prof. JH Shah; standardized on the Gujarati population with 97% reliability rate in relation to the Stanford-Binet Intelligence Scale
Results:	“The average IQ score of the 34 students drinking the high F water was significantly lower (p?0.05) than among the 50 students drinking the low F water.”
Conclusions:	“the present investigation concludes that the three villages of Chhasara, Gundala, and Mundra, are F-contaminated villages. Because of high F concentrations in the [groundwater], children in these villages have greater exposure to F that may lead in to low IQ as compared to the nearby villages of Baroi, Zarpara, and Pragpar, which have low F in their [groundwater].”

IQ Study #37: Seraj (2012)

Citation:	Seraj B, Shahrabi M, Shadfar M, Ahmadi R, Fallahzadeh M, Eslamlu HF, Kharazifard MJ. (2012). **Effect of high water fluoride concentration on the intellectual development of children in Makoo/Iran.** *Journal of Dentistry, Tehran University of Medical Sciences* 9(3): 221-29.
Location of Study:	**IRAN.** Makoo.

Size of Study:	293 children (91 children in control village; 106 children in medium F village; 96 children in high F village)
Age of Subjects:	6 to 11 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	Control = 0.8+0.3 ppm Medium fluoride = 3.1+0.9 ppm High fluoride = 5.2+1.1 ppm
Confounding Factors:	Age, gender, child's educational level, mother's educational level, father's educational level, fluorosis intensity, iodine level in water, lead level in water.
IQ Test:	Raven's Color Progressive Matrices (RCPM)
Results:	"The mean IQ scores decreased from 97.77+18.91 for the normal fluoride group to 89.03+12.99 for the medium fluoride group and to 88.58+16.01 for the high fluoride group (P=0.001)."
Conclusion:	"Since all potentially confounding factors were adjusted, the difference in IQ scores may reveal the potential effect of high fluoride exposure on the intellectual development of children."

IQ Study #36: Saxena (2012)

Citation:	Saxena S, Sahay A, Goel P. (2012). **Effect of fluoride exposure on the intelligence of school children in Madhya Pradesh, India.** *Journal of Neurosciences in Rural Practice* 3(2):144-49.
Location of Study:	**INDIA.** Madhya Pradesh.
Size of Study:	173 children (120 children in three high-F areas and 53 children from a control group)
Age of Subjects:	School children in the 5th & 6th grades
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	Group 1 = >4.5 ppm Group 2 = 3.1-4.5 ppm Group 3 = 1.5-3.0 ppm Control = <1.5 ppm
Urine Fluoride Levels:	Group 1 = 7.01+1.02 Group 2 = 4.85+0.50 Group 3 = 3.28+0.48 Control = 2.25+0.28
Confounding Factors:	(1) No significant differences in urinary lead, arsenic, or iodine levels between the four groups. (2) No significant differences in gender ratio, socio-economic status, SES, parental education, height/age ratio, and weight/height ratio. (3) Children were excluded if they were not lifelong resident of area, if they had changed their water source since birth, or if they had history of congenital or acquired neurological disease and/or head injury.
IQ Test:	Raven's Standard Progressive Matrices

Results:	"Reduction in intelligence was observed with an increased water fluoride level (*P* 0.000). The urinary fluoride level was a significant predictor for intelligence (*P* 0.000)."
Conclusion:	"This study indicates that exposure to fluoride is associated with reduced intelligence in children. We have found a significant inverse relationship between intelligence and the water fluoride level, and intelligence and the urinary fluoride level. After adjusting for confounders, urinary fluoride was the significant predictor for intelligence."

IQ Study #35: Ding (2011)

Citation:	Ding Y, Yanhui G, Sun H, Han H, Wang W, Ji X, Liu 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):1942-46.
Location of study:	**CHINA**. Hulunbuir, Inner Mongolia.
Size of study:	331 children from four sites
Age of Subjects:	7-14 years old
Source of Fluoride:	Water
Water Fluoride Levels:	Mianduhe town=0.28+0.03 mg/L Nan district=0.79+0.33 mg/L Donghu district=1.78+0.60 mg/L Zhalainuoer county=1.82+1.00 mg/
Urine Fluoride Levels:	No dental fluorosis = 0.80+0.55 mg/L Questionable fluorosis = 1.13+0.73 mg/L Very mild fluorosis = 1.11+0.74 mg/L Mild fluorosis = 1.31+0.78 mg/L Moderate fluorosis =1.46+0.79 mg/L.
Confounding Factors:	(1) Sites selected to match social and natural factors like economic situation, educational standard, and geological environments. (2) Schools had similar teaching quality. (3) Sites are not exposed to known neurotoxins (e.g. arsenic) in drinking water, nor are they endemic areas for iodine deficiency disorders. (4) Five children who had not lived in these areas at least 1 year were excluded.
IQ Test:	CRT-RC3 (Combined Raven's Test for Rural China)
Results:	Children's IQ was inversely related to urinary fluoride content, ($p<0.0001$). Each increase in 1 mg/L of urine F was associated with 0.59 point decrease in IQ ($p=0.0226$).
Conclusion:	"In conclusion, our study suggested that low levels of fluoride exposure in drinking water had negative effects on children's intelligence and dental health and confirmed the dose-response relationships between urine fluoride and IQ scores as well as dental fluorosis."

IQ Study #34: Poureslami (2011)

Citation:	Poureslami HR, Horri A, Khoramian S, Garrusi B. (2011**). Intelligence quotient of 7 to 9 year-old children from an area with high fluoride in drinking water.** *Journal of Dentistry and Oral Hygiene* 3(4):61-64.
Location of study:	**IRAN.** Kerman Province; Koohbanan (high-F) and Baft (low-F).

Size of study:	120 children: 60 children per city
Age of Subjects:	7-9 years old
Source of Fluoride:	Water
Water Fluoride levels:	High-F = 2.38 mg/L Low-F = 0.41 mg/L
Confounding Factors:	(1) Exclusion criteria: genetic, congenital, or acquired diseases related to the nervous system, past or present. (2) Inclusion criteria (high-F village): signs of grade III TSIDF (total surface index of Dental Fluorosis) or more. (3) Inclusion criteria (low-F village): similar physical and mental health criteria adopted, but children lacked any sign of Dental Fluorosis. (4) Both towns at high altitude.
Type of IQ Test	Raven's Progressive Matrices Intelligence Test (Persian version)
Results:	Average IQ of High F group (91.37+16.63) is significantly lower than average IQ of Low-F group (97.80+15.95), $p < 0.05$.
Conclusion:	"Based on the findings, chronic exposure to high levels of fluoride can be one of the factors that influence intellectual development."

IQ Study #33: Eswar (2011)

Citation:	Eswar P, Nagesh L, Devaraj CG. (2011). **Intelligent quotients of 12-14 year old school children in a high and low fluoride village in India.** *Fluoride* 44:168-72.
Location of study:	**INDIA.** Ajjihalli (low F) and Holesirigere (high F) villages, Davangere district, Karnataka.
Size of study:	133 children total (low F village=65; high F village=68)
Age of Subjects:	12-14 years old
Source of Fluoride:	Water
Water Fluoride levels:	High F village=2.45 mg/L Low F village =0.29 mg/L
Confounding Factors:	(1) Children included were continuous residents of study villages since birth; drinking water from same public water supply (1 per village); (2) attended same high school (1 per village). (3) Children with history of trauma or injury to head; affected by congenital or acquired neurological disorders, psychological disorders were excluded.
Type of IQ Test	Raven's Standard Progressive Matrices Test
Results:	63.2% of children in high F area had IQ less than 90, versus 47.7% of children in low F village. (p=0.06).
Conclusion:	"Though there was a trend in our study towards lower IQ in a greater number of children from high F village than in the low F village, probably the small sample size of the present study failed to establish a statistically significant difference."

IQ Study #32: Shivaprakash (2011)

Citation:	Shivaprakash PK, Ohri K, Noorani H. (2011). **Relation between dental fluorosis and intelligence quotient in school children of Bagalkot district.** *J Indian Soc Pedod Prev Dent.* 29(2):117-20.
Location of study:	**INDIA.** Bagalkot district, Karnataka state.
Size of study:	160 children
Age of Subjects:	7-11 years old
Source of Fluoride:	Water
Water Fluoride Levels:	high F village = 2.5-3.5 mg/L low F village = < 0.5 mg/L
Confounding Factors:	(1) Children included in study had normal birth history, were permanent residents in the region of study, had no history of trauma to the head, no history of chronic illness, not on medication. (2) Villages have similar culture, standard of living, and lifestyle habits.
Type of IQ Test	Raven's Colored Progressive Matrices Test
Results:	(A) Children with dental fluorosis had lower IQ (66.63+18.09) than those without dental fluorosis (76.36+20.84), $p < 0.05$. (B) Children with mild dental fluorosis had lower IQ (66.73) than those without dental fluorosis (75.89), $p < 0.05$.
Conclusion:	"Previous studies had indicated toward decreased Intelligence in children exposed to high levels of fluoride and our study also confirmed such an effect."

IQ Study #31: Sudhir (2009)

Citation:	Sudhir KM, Chandu GN, Prashant GM, Subba Reddy VV. (2009). **Effect of fluoride exposure on intelligence quotient (IQ) among 13-15 year old school children of known endemic area of fluorosis, Nalgonda District, Andhra Pradesh.** *Journal of the Indian Association of Public Health Dentistry* 13:88-94.
Location of Study:	**INDIA.** Nalgonda District, Andhra Pradesh.
Size of Study:	1000 children
Age of Subjects:	13-15 years old
Source of Fluoride:	Water
Water Fluoride Levels:	Four areas were studied: <0.7 mg/L; 0.7-1.2 mg/L; 1.2-4.0 mg/L; >4 mg/L
Type of IQ Test:	Raven's standard progressive matrices

Results:	"Number of intellectually impaired children were gradually increased with the increase in fluoride concentration in the drinking water."
Conclusion:	"Findings of this study suggest that overall IQ levels in children's exposed to high fluoride level were significantly lower than the low fluoride areas."

IQ Study #30: Li (2009)

Citation:	Li F, Chen X, Huang R, Xie Y. (2009). **The impact of endemic fluorosis caused by the burning of coal on the development of intelligence in children.** *Journal of Environmental Health* 26(4):838-40.
Location of study:	CHINA. Xinhua County, Hunan Province.
Size of study:	80 children total: 20 children from "mild" fluorosis area, 20 from "medium" fluorosis area, 20 from "severe" fluorosis area, and 20 from non-fluorosis area.
Age of Subjects:	8-12 years old
Source of Fluoride:	Coal burning
Fluoride exposure levels:	Urine F (by region):severe = 2.34+1.13 mg/L medium = 1.67+0.66 mg/L mild = 1.24+0.43 mg/L control = 0.96+0.52 mg/LUrine F (by dental fluorosis type): severe = 2.66+1.09 mg/L medium = 2.01+0.80 mg/L mild = 1.64+0.68 mg/L very mild = 1.17+0.48 mg/L suspected = 1.09+0.36 mg/L no fluorosis = 0.87+0.23 mg/L.
Confounding Factors:	(1) All children were born and raised in the respective areas. (2) Children were excluded if they had been diagnosed with physical deformation, developmental disorders, delayed mental development, emotional/behavioral obstacles or challenges, or other forms of mental disorders.
Type of IQ Test	CRT-RC (Combined Raven's Test for Rural China)
Results:	– IQ decreased with increasing F level in urine ($p < 0.01$) – IQ was significantly reduced among children with severe fluorosis as compared to children without fluorosis ($p < 0.05$) – A trend (albeit not statistically significant) for IQ to decrease with increasing severity of dental fluorosis (NS) and with increasing severity of the region's fluoride poisoning
Conclusion:	"High exposure to fluoride most definitely has an adverse effect on the development of intelligence in children, in particular on the capability of abstract inference."

IQ Study #29: Rocha-Amador (2007)

Citation:	Rocha-Amador D, Navarro ME, Carrizales L, Morales R, Calderón J. (2007). **Decreased intelligence in children and exposure to fluoride and arsenic in drinking water.** *Cadernos de Saude Publica* 23(Suppl 4):S579-87.

Location of study:	**MEXICO.** Durango State, Mexico & San Luis Potosi State.
Size of study:	132 children
Age of Subjects:	6 to 10 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels	Lowest F village: 0.8+1.4 mg/L Middle F village: 5.2+0.9 mg/L Highest F village: 9.4+0.9 mg/L
Urine Fluoride Levels	Lowest F village: 1.8+1.5 mg/L Middle F village: 6.0+1.6 mg/L Highest F village: 5.5+3.3 mg/L
Confounding Factors:	(1) A multiple regression analysis was used that controlled for blood lead levels, socioeconomic status, mother's education, height-for-age (an index of malnutrition), and transferrin saturation. (2) Each child's water fluoride level, and urine fluoride level, levels were individually determined. (3) The test examiner was blinded as to the children's fluoride exposure.
IQ Test:	Wechsler Intelligence Scale for Children–Revised Mexican Version (WISC-RM)
Results:	(1) Both fluoride in urine, and fluoride in water, were significantly correlated with IQ, and this correlation remained significant after controlling for lead exposure, socioeconomic status, mother's education, malnutrition, and transferrin. (2) Fluoride's effect on IQ was larger than the effect from arsenic.
Conclusion:	"We found that exposure to F in urine was associated with reduced Performance, Verbal and Full IQ scores before and after adjusting for confounders. The same pattern was observed for models with F in water as the exposure variable. . . . The individual effect of F in urine indicated that for each mg increase of F in urine a decrease of 1.7 points in Full IQ might be expected."

IQ Study #28: Wang (2007)

Citation:	Wang SX, Wang ZH, Cheng XT, Li J, Sang ZP, Zhang XD, Han LL, Qiao XY, Wu ZM, Wang ZQ. (2007). **Arsenic and fluoride exposure in drinking water: children's IQ and growth in Shanyin county, Shanxi province, China.** *Environmental Health Perspectives* 115(4):643-7.
Location of study:	CHINA. Shanyin County, Shanxi Province.
Size of study:	720 children: 21-196 per village (3 villages for each of the arsenic groups)
Age of Subjects:	8-12 years old
Source of Fluoride:	Water
Water Fluoride Levels:	High-Arsenic group = 0.9+0.5 mg/L Medium-Arsenic group = 1.7+1.1 mg/L High-Fluoride group = 8.3+1.9 mg/L Control group = 0.5+0.2 mg/L
Urine Fluoride levels:	High-Arsenic group = 1.0+1.7 mg/L Medium-Arsenic group = 2.8+1.9 mg/L

	High-Fluoride group = 5.1+2.0 mg/L Control group = 1.5+1.6 mg/L
Confounding Factors:	(1) Arsenic used as variable. Similar manganese levels in water for all groups. (2) All groups lived in rural areas with similar geographic and cultural conditions and a comparable level of socioeconomic development (years of parental education, average income, years of exposure). (3) All children currently attending school.
Type of IQ Test	CRT-RC (Combined Raven's Test for Rural China)
Results:	– Average IQ in high-arsenic area (95.1+16.6) is significantly lower than IQ in control area (104.8+14.7). $p < 0.05$ – The average IQ in high-fluoride area (100.5+15.8) is also significantly lower than average IQ in control area (104.8+14.7). $p < 0.05$ – Significantly more children with IQ lower than 70 (mental retardation) in high-F area (4%), medium-arsenic area (3.3%), and high-arsenic area (8.3%) as compared to control (0%).
Conclusion:	"This study indicates that exposure to fluoride in drinking water is associated with neurotoxic effects in children."

IQ Study #27: Trivedi (2007)

Citation:	Trivedi TMH, Verma RJ, Chinoy NJ, Patel RS, Sathawara NG. (2007). **Effect of high fluoride water on intelligence of school children in India.** *Fluoride* 40(3):178-183.
Location of study:	**INDIA.** High F area: Sachana, Sanand district, Gujarat; Medium F area: Chandlodia, Ahmedabad.
Size of study:	190 children (89 in high F area; 101 in medium F area)
Age of Subjects:	12-13 years old
Source of Fluoride:	Water
Water Fluoride Levels:	High F area=5.55+0.41 mg/L Medium F area=2.01+0.009 mg/L
Urine Fluoride Levels:	High F area = 6.13+0.67 mg/L Medium F area = 2.30+0.28 mg/L
Confounding Factors:	(1) The study included only those children who were life-long residents of the areas. respective location. (2) The areas have similar nutritional status and both have middle class socioeconomic status (although Sachana is slightly poorer). (3) Iodized salt is used in both areas.
Type of IQ Test	Questionnaire prepared by Prof. JH Shah; standardized on the Gujarati population with 97% reliability rate in relation to the Stanford-Binet Intelligence Scale
Results:	(A) Average IQ is lower in High-F area (91.72+1.13) than in Low-F area (104.44+1.23), $p<0.001$. (B) High F area has 28.09% of children with IQ below normal (over twice the percentage found in lower F area).
Conclusion:	"In agreement with other studies elsewhere, these findings indicate that children drinking high F water are at risk for impaired development of intelligence."

IQ Study #26: Fan (2007)

Citation:	Fan Z, Dai H, Bai A, Li P, Ro L, Li G, Zhang C, Li X. (2007). **The effect of high fluoride exposure on the level of intelligence in children.** *Journal of Environmental Health* 24(10):802-03.
Location of study:	**CHINA.** Pucheng County, Shaanxi Province.
Size of study:	79 children (42 children in High F area; 37 children in low F area)
Age of Subjects:	7-14 years old
Source of Fluoride:	Water
Water Fluoride Levels:	– High F area=3.15 mg/L – Low F area=1.03 mg/L (water-improvement schemes implemented 14-18 years before study)
Urine Fluoride Levels:	– High F area group=2.89+1.97 mg/L (range: 1.14-6.09 mg/L); – Low F area group=1.78+0.46 mg/L (range: 1.33-2.35 mg/L) *(non-significant difference, likely because F is consumed from various sources other than water)*
Confounding Factors:	(1) The two areas have common habits and lifestyles in terms of cuisine, economy, culture, education, agricultural goods, etc.. (2) No chemical factories in area. (3) The area does not have an iodine deficiency problem.
Type of IQ Test	CRT-C2 intelligence module
Results:	(A) Average IQ in High-F area (96.11 + 12.00) is lower than Low-F area (98.41 + 14.75), although difference is not statistically significant. (B) No child in High-F area has outstanding or excellent intelligence. The respective rates in the Low-F area are 2.7% and 5.4%, respectively.
Conclusion:	"Exposure to high levels of fluoride is likely to cause a certain level of harm to a child's level of intelligence."

IQ Study #25: Seraj (2006)

Citation:	Seraj B, Shahrabi M, Falahzadeh M, Falahzadeh F, Akhondi N. (2006). **[Effect of highfluoride concentration in drinking water on children's intelligence]. [Study in Persian]** *Journal of Dental Medicine* 19(2):80-86.
Location of study:	**IRAN**
Size of study:	126 children (85 children from low-F village, 41 children from high-F village)
Age of Subjects:	Not provided in English abstract (full study is in Persian)
Source of Fluoride:	Water
Water Fluoride Levels:	High F village = 2.5 mg/L Low F village = 0.4 mg/L
Confounding Factors:	The history of illnesses affecting the nervous system, head trauma, birth weight (>2.5kg or < 2.5kg), residental history, age and sex of children were investigated by questionnaires completed by the children's parents.
Type of IQ Test	Raven's

Results:	"In the high fluoride area the mean IQ of children (87.9±11) was significantly lower than in the low fluoride area (98.9±12.9) (P=0.025)."
Statistical significance	""Based on the findings of this study, exposure of children to high levels of fluoride may carry the risk of impaired development of intelligence."

IQ Study #24: Wang (2005)

Citation:	Wang S, Zhang H, Fan W, Fang S, Kang P, Chen X, Yu M. (2005). **The effects of endemic fluoride poisoning caused by coal burning on the physical development and intelligence of children.** *Journal of Applied Clinical Pediatrics* 20(9):897-898 (republished in *Fluoride* 2008; 41:344-348).
Location of study:	**CHINA.** Zhijin County, Ghizhou Province.
Size of study:	226 children (176 children in High F area, including 119 children with skeletal fluorosis and 57 children with only dental fluorosis; 50 children in low-F area without skeletal or dental fluorosis)
Age of Subjects:	7-12 years old
Type of Exposure:	Coal burning
Urine Fluoride Levels:	High F group=1.352+0.457 mg/L (n=144) Lower F group=1.611+0.467 mg/L (n=35)
Confounding Factors:	(1) Both areas are free from iodine deficiency. (2) Both areas have similar standard of living, sanitation, culture, and availability of medical treatment.
Type of IQ Test	Raven's Standard Theoretical Intelligence Test, Chinese version
Results:	Children from high F (endemic) areas had lower IQ than those from lower F (control) area ($p<0.01$). Negative correlation between urine F and IQ ($p<0.01$).
Conclusion:	"High fluoride burden has a definite effect on the intellectual and physical development of children."

IQ Study #23: Xiang (2003a), Xiang, (2003b)

Citation:	– Xiang Q, et al. **(2003a).** Effect of fluoride in drinking water on children's intelligence. *Fluoride* 36: 84-94. – Xiang Q, et al. **(2003b)**. Blood lead of children in Wamiao-Xinhuai intelligence study. *Fluoride* 36: 198-199.
Location of study:	**CHINA.** Sihong County, Jiangsu Province.
Size of study:	512 children (222 children in high-F village, 290 children in low-F village)
Age of Subjects:	8-13 years old

Type of Exposure:	Water
Water Fluoride Levels:	High F village=2.47+0.79 mg/L (range=0.57-4.50 mg/L) Low F village=0.36+0.15 mg/L (range=0.18-0.76 mg/L)In the high-F village, children were subdivided into the following five fluoride water levels:Group A<1.0 mg/L; Group B=1.0-1.9 mg/L; Group C=2.0-2.9 mg/L; Group D=3.0-3.9 mg/L; Group E>3.9 mg/L.
Urine Fluoride Levels:	High F village=3.47+1.95 mg/L Low F village=1.11+0.39 mg/L
Confounding Factors:	(1) The two villages have similar urine iodine levels (p>0.3), and blood lead levels (p>0.48). (2) Neither village has fluoride pollution from burning coal or other industrial sources. (3) None of the residents reported drinking brick tea. (4) Children who had been absent from either village for 2 years or longer, or who had a history of brain disease or head injury were excluded from study.
Type of IQ Test	CRT-RC (Combined Raven's Test for Rural China)
Results:	(A) Mean IQ of high F village (92.02+13.00) is lower than low F village (100.41+13.21), p<0.01. (B) Higher drinking water F is significantly associated with higher rates of mental retardation (IQ<70) and borderline intelligence (IQ=70-79), p<0.05. (C) Children's IQs are not related to urinary iodine, family income, or parent's education level.
Conclusion:	"In endemic fluorosis areas, drinking water fluoride levels greater than 1.0 mg/L may adversely affect the development of children's intelligence."

IQ Study #22: Li (2003)

Citation:	Li Y, Jing X, Chen D, Lin L, Z Wang Z. (2003). **Effects of endemic fluoride poisoning on the intellectual development of children in Baotou.** *Chinese Journal of Public Health Management* 19(4):337-338 (republished in *Fluoride* 2008; 41:161-64).
Location of study:	**CHINA.** Baotou, Inner Mongolia.
Size of study:	936 children (720 children from high-F endemic area; 236 children from low-F control area)
Age of Subjects:	6-13 years old
Source of F exposure:	Water
Fluoride exposure levels:	"The region classified as endemic was designated using the 1981 standards for designation of endemic regions laid out in 1981's Standards for Endemic Fluorosis Prevention and Treatment Work"
Type of IQ Test	Illustrated version of the Chinese Standardized Raven Test for children in rural areas
Results:	(A) Average IQ of children in endemic area (92.07) somewhat lower than that of control area (93.78), NS. (B) Rate of children with low IQ (<69) greater in endemic area (10.38%) than in control area (4.24%) ("high statistical significance", but no p value given).
Conclusion:	"In our study, we found that the average IQ of children in a fluoride endemic area was somewhat lower than the control, but the result was not statistically significant (p > 0.05). The percentage of children with fluorosis, however, was higher as compared to the control, and this was very significant statistically."

IQ Study #21: Shao (2003)

Citation:	Shao Q, Wang Y, Li L, Li J. (2003). **Study of cognitive function impairment caused by chronic fluorosis.** *Chinese Journal of Endemiology* 22(4):336-38.
Location of study:	**CHINA.** Bijie City (high F area) and Tongren area (control area), Guizhou Province.
Size of study:	88 adults (49 adults in High-F area; 39 adults in Low-F area)
Age of Subjects:	Aged 30-50 (High-F area = 42+6 years; Low-F area = 43+6 years)
Source of Fluoride Exposure:	Water
Fluoride exposure levels:	Adults in high-F area diagnosed as suffering from fluoride poisoning (as evident by dental and skeletal changes). Water F levels not provided.
Confounding Factors:	Non-iodine deficient areas. Exclusions of mental disorders caused by mental retardation, brain organic and somatic diseases. All farmers. Similar distribution of age, sex, education level.
Type of IQ Test	Wechsler Adult Intelligence Scale test for Rural China (WATS-RC); Associated learning (AL) test; Digit Span (DS) test; Similarity test; Speech fluency test (SFT); Comprehension test.
Results:	(A) Significantly lower operation score on IQ test in high F area (48-54) versus low F area (52-59), $p < 0.01$. (B) Lower total IQ score in high F area (78-100, average) than in low F area (109-118, average-high), although not statistically significant (C) High F subjects have significantly lower scores on several of the performance tests (speech fluency, recognition, similarity, $p < 0.01$, and digit span, $p < 0.05$), and this correlates with elevated levels of oxidative stress.
Conclusion:	"The results suggest that some cognitive function limitations exist in those suffering from chronic fluoride poisoning, and its biologic basis may be related to the levels of SOD and NO [indices of oxidative stress]."

IQ Study #20: Wang (2001)

Citation:	Wang X, Wang L, Hu P, Guo X, Luo X. (2001). **Effects of high iodine and high fluorine on children's intelligence and thyroid function.** *Chinese Journal of Endemiology* 20(4):288-90.
Location of study:	**CHINA.** Binzhou and Dezhou, Qingyun County, Shandong Province.
Size of study:	513 children (322 children from school in high iodine/high fluoride area; 193 children from school in lower iodine/lower fluoride area).
Age of Subjects:	8-12 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	– High iodine/high fluoride area=2.97 mg/L – Lower iodine/lower fluoride area=0.5 mg/L

Urine Fluoride Levels:	– High iodine/high fluoride = 3.08+1.03 mg/L – Low iodine/low fluoride = 0.82+0.56 mg/L
Type of IQ Test	CRT-RC (Combined Raven's Test for Rural China)
Results:	(A) Average IQ is lower in High-F area than in Low-F area (76.67+7.75 vs. 81.67+11.97), although the difference does not reach statistical significance. (B) The rate of extremely low and borderline IQ is higher in the High F areas than in the Low F areas (16.67% vs. 10% and 36.67% vs. 16.67, respectively), although these differencese do not reach statistical significance.
Conclusion:	"High iodine and high fluorine have certain influence on children's intelligence and thyroid function."

IQ Study #19: Hong (2001)

Citation:	Hong F, Cao Y, Yang D, Wang H. (2001). **Research on the effects of fluoride on child intellectual development under different environmental conditions.** *Chinese Primary Health Care* 15(3):56-57 (republished in *Fluoride* 2008; 41(2):156–60).
Location of study:	**CHINA.** Wukang, Boxing, and Zouping counties, Shangdong Province.
Size of study:	205 children (32 controls; 85 High F; 32 High-F/High Iodine; 28 High F/Low Iodine; 28 Low F/Low Iodine)
Age of Subjects:	8-14 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	– Control area = 0.75 mg/L – High F only = 2.90 mg/L – High F/High I = 2.85 mg/L – High F/Low I = 2.94 mg/L – Low F/Low I = 0.48 mg/L
Confounding Factors:	– Areas have same geographical features and standard of living.
Type of IQ Test	Chinese Standardized Raven's Test for Rural areas (CRT-R)
Results:	(A) Average IQ of High F/Low I group (68.38+19.12) and Low F/Low I group (75.53+6.92) is lower than control group (82.79+8.98), $p<0.01$. (B) IQ of High F/Low I group is lower than Low F/Low I group, $p<0.01$. (C) Significant interaction exists between High Fluoride and Low Iodine, $p<0.01$. (D) IQ ranking of high F groups show significant deficits compared to control, $p<0.01$.
Conclusion:	"The IQ results of this study show no significant difference between the average IQs of those children from the high fluoride only areas and the high fluoride/high iodine areas, however the result from the high fluoride/low iodine group show statistically significant differences as compared to that of the low fluoride/low iodine group. In short, it appears that the presence or lack of iodine is a more significant factor in both the prevalence of goiter and average IQ."

IQ Study #18: Lu (2000)

Citation:	Lu Y, Sun L, Wu LN, Wang X, Lu W, Lis SS. (2000). **Effect of high-fluoride water on intelligence of children.** *Fluoride* 33:74-78.
Location of study:	**CHINA.** Tianjin Xiqing District.

Size of study:	118 children (60 children in High-F village; 58 children in Low-F village)
Age of Subjects:	10-12 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	– High F village = 3.15+0.61 mg/L – Low F village = 0.37+0.04 mg/L
Urine Fluoride Levels:	– High F village = 4.99+2.57 mg/L – Low F village = 1.43+0.64 mg/L
Confounding Factors:	(1) Children included in the study are lifelong residents of study area. (2) Villages have similar population size, social, economic and educational backgrounds. (3) Children with congenital or acquired neurological disorders were excluded.
Type of IQ Test	Chinese Combined Raven's Test, Copyright 2 (CRT-C2)
Results:	(A) Average IQ of children from High F village (92.27+20.45) is lower than children from Low F village (103.05+13.86), p<0.005. (B) More "retarded" (IQ=<70) and "borderline" intelligence (IQ=70-79) children in high F group (21.6%) than in low F group (3.4%), p<0.005. (C) Significant inverse relationship exists between urinary F and IQ.
Conclusion:	"The findings of this study thus replicate those of earlier studies and suggest that a real relationship exists between fluoride exposure and intelligence."

IQ Study #17: Zhang (1998)

Citation:	Zhang J, Yao H, Chen Y. (1998). **The effect of high levels of arsenic and fluoride on the development of children's intelligence.** *Chinese Journal of Public Health* 17(2):119.
Location of Study:	**CHINA.** Kuitun region, Urumqi.
Size of Study:	164 children
Age of Subjects:	4-10 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	For the 4 to 8 year olds, the fluoride level their entire life (including during fetal development) was between 0.49 and 0.81 ppm. The 9 year olds were exposed to high fluoride (level not provided) during fetal development. The 10 year olds were exposed to high fluoride during fetal development and their first year of life.
Type of IQ Test:	50-point evaluation tests created by Japanese researcher, Shigeo Kobayashi
Results:	No difference in IQ among the 4 to 8 year olds, a slight (non-significant) reduction in IQ among the 9 year olds (who were exposed to fluoride during fetal development), and a significant reduction among the 10 year olds (who were exposed during fetal development and their first year of life).
Conclusion:	"Even though there were differences in the results from the 10 year-old subjects from the normal comparative group, in contrast to subjects from the high fluoride high arsenic group and the high fluoride group, these results might n as

	less number of subjects from the high fluoride group has been tested."

IQ Study #16: Yao (1997)

Citation:	Yao L, Deng Y, Yang S, Zhao J, Wang X, Cui Z. (1997). **Comparative assessment of the physical and mental development of children in endemic fluorosis area with water improvement and without water improvement.** *Literature and Information on Preventive Medicine* 3(1):42-43.
Location of study:	**CHINA.** Chaoyang City, Liaoning Province.
Size of study:	823 children (326 children from fluorosis area with water improvement; 183 children from fluorosis area without water improvement; 314 children from non-fluorosis area)
Age of Subjects:	7-14 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	– Fluorosis area without water improvements = 2.0 mg/L- Fluorosis with water improvements = 0.33 mg/L (prior to improvement 8 years before study, the F level was 2.0 mg/L)- Non-fluorosis area = 0.4 mg/L
Confounding Factors:	– All children born locally.- Areas in study have adequate iodine exposure and similar levels of economic development, living conditions, school size, and number of teachers.
Type of IQ Test	CRT-RC (Combined Raven's Test for Rural China)
Results:	(A) Children in fluorosis area (without water improvement) have lower average IQ than children in fluorosis area (with water improvement) for all age groups, $p<0.01$. (B) Children in fluorosis area without water improvement have lower average IQ than children in non-fluorosis area for all age groups, $p<0.01$. (C) Children born prior to water improvement program in fluorosis area with water improvement have lower average IQ than children in non-fluorosis area, $p<0.05$. (D) No significant difference in intelligence exists between children born after water improvement and children in non-fluorosis area.
Conclusion:	"These results show that water improvement and defluoridation can improve the mental and physical development of children in a fluorosis area."

IQ Study #15: Yao (1996)

Citation:	Yao L, Zhao J, Wang X, Cui Q, Lin F. (1996). **Analysis on TSH and intelligence level of children with dental Fluorosis in a high fluoride area.** *Literature and Information on Preventive Medicine* 2(1):26-27.
Location of study:	**CHINA.** Chaoyang City, Liaoning Province.
Size of study:	536 children (78 children from high-fluorosis area; 188 children from light-fluorosis area; 270 children from non-fluorosis area)
Age of Subjects:	8-12 years old
Source of Fluoride Exposure:	Water

Water Fluoride Levels:	High-F area: <11 mg/L Low-F area: 2.0 mg/L Control area: 1.0 mg/L
Confounding Factors:	(1) Children in each of the three areas have adequate iodine exposure as determined through urine analysis. (2) The three areas have similar economic development, schools, and teachers.
Type of IQ Test	Raven test—Associative Atlas (Version of Chinese village)
Results:	(A) Average IQ of children with dental fluorosis in high-fluorosis area and light-fluorosis areas is lower than children in non-fluorosis area, $p<0.01$. (B) Average IQ of children with dental fluorosis from high-fluorosis area is lower than those from light-fluorosis area, $p<0.05$. (C) Rate of high IQ (>120) is lower in high-fluorosis area (3.85%) and light-fluorosis area group (6.91%) than non-fluorosis area (10.74%) (no p value given).
Conclusion:	"The results of the intelligence tests show that a high level of fluoride influences children's IQ, which is consistent with some previous data. It is worth mentioning that the higher the degree of dental fluorosis, the more negative the impact on the children's intelligence level. This is an issue which merits utmost attention."

IQ Study #14: Zhao (1996)

Citation:	Zhao L, Liang G, Zhang D, Wu X. (1996). **Effect of high-fluoride water supply on children's intelligence.** *Fluoride* 29: 190-192.
Location of study:	**CHINA.** Shanxi Province.
Size of study:	320 children (160 children from high-F village; 160 children from lower-F village)
Age of Subjects:	7-14 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	High-F village = 4.12 mg/L Lower-F village = 0.91 mg/L
Confounding Factors:	(1) Similar occupations, living standards, and social customs in the two villages. (2) Only children whose mothers lived in the village during pregnancy were included in study. (3) Parents' educational level was determined (and found to have a significant influence on IQ, $p < 0.01$).
Type of IQ Test	"Official intelligence quotient (IQ) tests lasting 40 minutes"
Results:	Children in High-F village have significantly lower average IQ (97.69+13.00) than children in lower-F village (105.21+14.99), $p<0.01$.
Conclusion:	"The results of this study indicate that intake of high-fluoride drinking water from before birth has a significant deleterious influence on children's IQ in one of two similar villages."

IQ Study #13: Wang (1996)

Citation:	Wang G, et al. (1996). **A study of the IQ levels of four- to seven-year-old children in high fluoride areas.** *Endemic Diseases Bulletin* 11(1):60-6 (republished in *Fluoride* 2008; 41:340–43).

Location of study:	**CHINA.** Shehezi, Xinjiang Province.
Size of study:	230 children (147 children from High-F village; 83 children from Low-F village)
Age of Subjects:	4-7 years old
Source of Fluoride Exposure:	Water & Coal-Burning
Water Fluoride Levels:	– All wells = 0.58-8.60 mg/L – High F area = > 1.0 mg/L – Low F area = < 1.0 mg/L
Confounding Factors:	(1) Children were excluded from study if they had a low intellectual ability due to genetic inheritance, past illness, malnutrition, uses of medication, or other reasons. (2) "Significantly greater" percentage of children with below average head circumference in High F area (18.37%) than in Control area (9.64%) (no p value given).
Type of IQ Test	Wechler Preschool and Primary Scale of Intelligence (WPPSI)
Results:	(A) Average Total IQ in High F group (95.64+14.34) is lower than in control group (101.23+15.84), $p<0.05$. (B) Average Performance IQ in High F group (94.33+14.76) is lower than in Control group (101.77+18.12), $p<0.01$. (C) Average Verbal IQ is not significantly different. (D) In High F area, children with below-normal head circumference have lower average IQ (89.07+15.69) than those with normal head circumference (97.13+8.06), $p<0.01$.
Conclusion	"The results show that a high fluoride intake has a clear influence on the IQ of preschool children, manifesting itself primarily as damage to performance intelligence."

IQ Study #12: Duan (1995)

Citation:	Duan J, Zhao M, Wang L, Fang D, Wang Y, Wang W. (1995). **A comparative analysis of the results of multiple tests in patients with chronic industrial fluorosis.** *Guizhou Medical Journal* 18(3):179-180.
Location of study:	**CHINA.** Guiyang, Guizhou Province.
Size of study:	157 adults (72 adults with diagnoses with industrial fluorosis; 43 adults exposed to occupational fluoride but without industrial fluorosis; 42 non-exposed workers)
Age of Subjects:	35 to 62 yrs
Source of Fluoride Exposure:	Occupational exposures
Air Fluoride Levels	Avg = 2.21 mg/m3
Confounding Factors:	Non-exposed workers had similar work conditions, economic status, and lifestyle habits.
Type of IQ Test	Wechsler Adult Intelligence Scale revised by Prof Gong Yaoxian of Human Medical Sciences University (WAIS-RC)

Results:	Average IQ of workers with industrial fluorosis was significantly lower (68 to 72) than fluoride-exposed workers without industrial fluorosis (84.5), and IQ of fluoride-exposed workers without fluorosis (84.5) was significantly lower than IQ of non-exposed workers (99.4).
Conclusion:	"it may be determined that industrial fluorine poisoning has gradually progressive effects on the normal function and metabolism of the adult brain and other aspects of the nervous system. With the progression of the course of fluorosis, neurological damage gradually worsens, with the degree of damage closely related to the length of exposure to fluorine, nail fluorine content, and other factors. Damage from high concentrations of fluorine not only affects bones and ligaments, tendons, and other soft tissue, but is also quite widespread throughout the entire nervous system. This is of major significance for worker protection and other areas."

IQ Study #11: Li (1995)

Citation:	Li X, Zhi J, Gao R. (1995). **Effect of fluoride exposure on intelligence in children.** *Fluoride* 28:189-192.
Location of study:	**CHINA.** Anshu and Zhijin counties, Guizhou Province.
Size of study:	907 children (230 children from severe fluorosis area; 224 children from medium fluorosis area; 227 children from slight fluorosis area; 226 children from non-fluorosis area)
Age of Subjects:	8-13 years old
Source of Fluoride Exposure:	Coal burning
Urine Fluoride Levels	– Severe dental fluorosis = 2.69 mg/L – Medium dental fluorosis = 2.01 mg/L – Slight dental fluorosis = 1.81 mg/L – No dental fluorosis = 1.02 mg/L
Confounding Factors:	(1) All children of Han nationality.(2) Children were excluded from study if they had congenital or acquired diseases "not related to fluoride." (3) Groups separated by intervals of 6 months in age.
Type of IQ Test	China Rui Wen's Scaler for Rural Areas
Results:	Average IQ of children in severe (80.3+12.9) and medium (79.7+12.7) fluorosis areas is lower than the slight (89.7+12.7) and non-fluorosis (89.9+10.4) areas, $p<0.01$.
Conclusion:	"A high fluoride intake was associated with a lower intelligence."

IQ Study #10: Xu (1994)

Citation:	Xu Y, Lu C, Zhang X. (1994). **The effect of fluorine on the level of intelligence in children.** *Endemic Diseases Bulletin* 9(2):83-84.
Location of study:	**CHINA.** Shandong Province.
Size of study:	330 children (8 groups of 21-97 children categorized based on fluoride and iodine content of water)
Age of Subjects:	8-14 years old
Source of Fluoride	Water

Exposure:	
Water Fluoride Levels:	– High Fluoride/High Iodine = 3.9 mg/L – High Fluoride/Low Iodine = 2.0 mg/L – High Fluoride = 1.8 mg/L – Low Fluoride = 0.38-0.5 mg/L – Control Area = 0.8 mg/L
Confounding Factors:	(1) Water iodine level used as variable. (2) Child's pre-school education history was determined. (3) Parent's literacy was determined.
Type of IQ Test	Bient-Siman
Results:	(A) Children in areas with high-fluoride and low-iodine have significantly lower IQs than children in areas with high-fluoride and high-iodine, $p < 0.01$. (B) More children have low IQ (< 69) in areas with High F/High I (10.53%), High F only (7.32%), and High F/Low I (12.82%) than in control group (1.61%)
Conclusion:	"The number of children whose level of intelligence is lower is significantly increased in regions of high fluoride/iodine, regions of high fluoride only, regions of high fluoride/low iodine, against their respective comparative groups. . . . This could be demonstrative of the fact that fluoride acts to increase the toxicity and worsen the occurrence of thyroid swelling."

IQ Study #9: Li (1994)

Citation:	Li Y, Li X, Wei S. (1994). **Effects of high fluoride intake on child mental work capacity: Preliminary investigation into the mechanisms involved.** *Journal of West China University of Medical Sciences* 25(2):188-91 (republished in *Fluoride* 2008; 41:331-35).
Location of study:	**CHINA.** Sichuan Province.
Size of study:	158 children from two neighboring townships (107 children with various degrees of dental fluorosis; 51 children with no dental fluorosis)
Age of Subjects:	12-13 years old
Source of Fluoride Exposure:	Food contaminated by coal smoke
Fluoride Content of Grain:	– Children with no dental fluorosis = 0.5 mg/kg- Children with dental fluorosis (HiF1) = 4.7 mg/kg- Children with dental fluorosis (HiF2) = 5.2 mg/kg- Children with dental fluorosis (HiF3) = 31.6 mg/kg
Confounding Factors:	(1) The areas have similar levels of fluoride in water (0.3 mg/L) and air (0.02-0.51 mg/m3) and similar levels of zinc in soil. (2) The areas townships have similar economic and cultural status, lifestyle, dietary habits, basic constituents of food. (3) Age, gender, and grade level of the children are kept "as constant as possible." (4) Children with acute or chronic diseases not related to fluoride were excluded from study.
Type of IQ Test	Mental Work Capacity determined by number of letters found (NLF), rate of error (RE), index of mental capacity (IMC), short-term memory capacity (SMC), visual reaction time (RT).
Results:	(A) Children with dental fluorosis in mid-exposure group (HiF2) have reduced short-term mental capacity ($p<0.05$), reduced mental capacity index ($p < 0.01$), and reduced NLF scores ($p<0.01$) as compared to children with no fluorosis and children with lower exposure.(B) Children with dental fluorosis in high-exposure group (HiF3) have reduced short-term mental capacity ($p<0.01$), reduced mental capacity index ($p < 0.01$), and reduced NLF scores ($p<0.01$) as compared children with no fluorosis and children with low exposure.
Conclusion:	"As shown in this study, the mental work capacity (MWC) of the two groups of children with grade 3 dental fluorosis was lower than the two groups with no dental fluorosis. . . . This indicates that early, long-term exposure to excess fluoride causes deficits in memory, attention, and reaction time, but 12–13 year-old children with only recent exposure show no major effects. Studies [on human fetuses] have already shown that the developing brain is one of the ripest targets for disruption by fluoride poisoning. Given

	that before six years of age the human brain is in its fastest stage of development, and that around seven and eight basic structural development is completed, therefore the brain is most vulnerable to damage from excess fluoride intake before this age."

IQ Study #8: Yang (1994)

Citation:	Yang Y, Wang X, Guo X, Hu P. (1994). **The effects of high levels of fluoride and iodine on intellectual ability and the metabolism of fluoride and iodine.** *Chinese Journal of Epidemiology* 15(4):296-98 (republished in *Fluoride* 2008; 41:336-339).
Location of study:	**CHINA.** Shandong Province.
Size of study:	60 children (30 from high-F village, 30 from Low-F village)
Age of Subjects:	8-14 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	High F/High Iodine area = 2.97 mg/L Control area = 0.5 mg/L
Urine Fluoride Levels:	High F/High Iodine area = 2.08+1.03 mg/L Control area = 0.82+0.56 mg/L
Type of IQ Test	Chinese Comparative Scale of Intelligence Test
Results:	(A) Children in high F/high iodine area have lower IQ (76.67+7.75) than those in low F area (81.67+11.97), although the difference is not statistically significant.(B) Greater percentage of children have moderately low IQ (<79) in High F/High Iodine area (76.67%) than in control area (36.67%), p<0.01.
Conclusion:	"An excess of fluoride and a lack of iodine in the same environment has been shown to have a marked effect on child intellectual development, causing a more significant intellectual deficit than lack of iodine alone."

IQ Study #7: An (1992)

Citation:	An J, Mei S, Liu A, Fu Y, Wang Q, Hu L, Ma L. (1992). **The effects of high fluoride on the level of intelligence of primary and secondary students.** *Chinese Journal of Control of Endemic Diseases* 7(2):93-94.
Location of study:	**CHINA.** Xingshunxi Town, Guyang County, Inner Mongolia (4 neighboring villages with high fluoride centered around Wubu Ziyao village and 6 neighboring villages with lower fluoride centered around Hada Heshao Village).
Size of study:	242 children (121 children from high-F villages and 121 children from the low-F villages)
Age of Subjects:	7-16 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	High-F villages = 2.1+7.6 mg/L Control villages = 0.6+1.0 mg/L

Confounding Factors:	(1) Dental fluorosis rates were determined in both areas (90.9% in High-F area vs. 21.5% in Low-F area). (B) Both areas are in the countryside, are 15 km from each other, and share the same Han ethnicity. (C) The geography, culture, education, living standard, and social economic conditions are "very similar."
IQ Test:	Wechsler Intelligence Scale for Children
Results:	(A) Children in the High-F villages have significantly lower IQs at each age group studied: 7-10 ($p < 0.02$); 11-13 ($p < 0.01$); 14-16 ($p < 0.03$); 7-16 ($p < 0.01$). (B) Significantly more children in High-F villages have "critical state" IQ, $p < 0.01$. (C) When children within the High-F villages are stratified into highest-F (5.2-7.6 mg/L), and lowest-F levels (2.1-3.2 mg/L), the children in the higher-F areas had significantly lower IQ than the lower-F areas ($p < 0.05$).
Conclusion	"The results show that the level of intelligence of primary and secondary students from the high fluoride area and that of primary and secondary students from the non-high fluoride area had very significant differences, proving that high fluoride has adverse effects on the mental development of students. The higher the water fluoride is, the lower the level of IQ."

IQ Study #6: Lin (1991)

Citation:	Lin FF, Aihaiti, Zhao HX, Lin J, Jiang JY, Malmaiti, and Aiken. (1991). **The relationship of a low-iodine and high-fluoride environment to subclinical cretinism in Xinjiang.** *Endemic Disease Bulletin* 6(2):62-67 (republished in *Iodine Deficiency Disorder Newsletter* Vol. 7(3):24-25).
Location of study:	**CHINA.** Hetian prefecture, Xinjiang.
Size of study:	749 children (250 children in High-F/Low Iodine area; 256 children in Low-F/Low-Iodine area; and 243 children in Low F/Low Iodine area)
Age of Subjects:	7-14 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	High F/Low Iodine = 0.88 mg/L Low F/Low Iodine = 0.34 mg/L Control area = n/a
Urine Fluoride Levels:	High F/Low Iodine = 2.56 mg/L Low F/Low Iodine = 1.34-1.61 mg/L Control area = 1.6 mg/L
Confounding Factors:	(1) Lower socioeconomic status in all areas. (2) Areas have similar nationalities, habits, customs, and income.
IQ Test:	CRT-RC (Combined Raven's Test for Rural China)
Results:	Children from the High F/Low Iodine area have significantly lower IQs (IQ=71) than children from the Low F/Low Iodine area (IQ=77-79; $p<0.05$), and control area (IQ=96); $p<0.01$).
Conclusion:	"The significant differences in IQ among these regions suggests that fluoride can exacerbate central nervous lesions and somatic developmental disturbance caused by iodine deficiency."

IQ Study #5: Guo (1991)

Citation:	Guo X, Wang R, Cheng C, Wei W, Tang L, Wang Q, Tang D, Liu G, He G, Li S. (1991). **A preliminary investigation of the IQs of 7-13 year old children from an area with coal burning-related fluoride poisoning.** *Chinese Journal of Endemiology* 10(2):98-100 (republished in *Fluoride* 2008; 41(2):125–28).
Location of study:	**CHINA.** Xinshao County, Hunan Province.
Size of study:	121 children (60 children with mild to severe fluorosis from an endemic area where coal is used as a fuel source; 61 children from a non-endemic area where wood is used as a fuel source)
Age of Subjects:	7 to 13 years old
Source of Fluoride Exposure:	Coal burning (Fluoride levels in water < 0.5 mg/l in both areas)
Blood Fluoride Levels:	Endemic area=0.1483+0.0473 mg/L Non-endemic area=0.1044+0.0652 mg/L ($p<0.01$)
Confounding Factors:	The two areas are neighboring townships with "very similar" economies, cultures, living standards, lifestyles, public health, and education.
IQ Test:	Chinese Binet IQ Test
Results:	(A) Children from endemic fluorosis area have lower average IQ (76.7) than children in non-endemic area (81.4), $p<0.05$. (B) A greater percentage (30%) of children in endemic area have low IQ (<69) than in non-endemic area (11.5%), $p<0.05$.
Conclusion:	"In summary, although diminished intellectual ability can result from a multitude of factors (both innate and acquired) that influence neural development and cell division in the cerebrum, the comparison conducted in this study of two areas where the other environment factors are basically the same shows clear differences in IQ, and it [is] probable that this difference is due to a high fluoride environment."

IQ Study #4: Chen (1991)

Citation:	Chen Y, Han F, Zhou Z, Zhang H, Jiao X, Zhang S, Huang M, Chang T, Dong Y. (1991). **Research on the intellectual development of children in high fluoride areas.** *Chinese Journal of Control of Endemic Diseases* 6(Suppl):99-100 (republished in *Fluoride* 2008; 41:120–24).
Location of study:	Linyi County, Shanxi Province, China
Size of study:	**CHINA.** 640 children (320 children from High-F village; 320 children from Lower-F village)
Age of Subjects:	7 to 14 years old
Source of Fluoride Exposure:	Water
Water Fluoride Levels:	High-F village = 4.55 mg/L Lower-F village = 0.89 mg/L
Confounding Factors:	The occupations, culture, standard of living, lifestyle habits, access to health and transportation facilities are "essentially the same" between the two areas.

IQ Test:	Rural version of Chinese Standardized Raven Test
Results:	Average IQ of children in High-F village (100.24+14.52) significantly lower than children in lower-F village (104.03+14.96), p<0.01.
Conclusion:	"The results of this study indicate that there is significant difference between the intellectual ability of the 7–14 year old children from the [fluorosis] endemic area and those of the control, and moreover that the average IQ of the children from the endemic area is clearly lower."

IQ Study #3: Sun (1991)

Citation:	Sun M, et al. (1991). **Using drawing tests to measure intelligence in children from areas impacted by combined Al-F endemic toxicosis (Shuicheng, Guizhou).** ***J****ournal of Guiyang Medical College* 16(3):204-06.
Location of study:	**CHINA.** Guizhou Province: Liupanshui City (endemic fluorosis area) and Guiyang City (non-endemic area)
Size of study:	420 children (196 children from endemic fluorosis area; 224 children from non-endemic area)
Age of Subjects:	6.5-12 years old
Source of Fluoride Exposure:	N/A
Fluoride exposure levels:	N/A
Confounding factors:	(1) Majority of children of farmers. (2) Children with bone and joint deformities or nervous system symptoms were excluded from study.
IQ Test:	Drawing test for children (Japanese researcher's Shigeo Kobayashi's 50-point scoring method).
Results:	Children from endemic fluorosis area had lower IQ than those from non-endemic area at all ages except <7 ($p < 0.05$)
Excerpt:	"From these results, it can be concluded that excessive consumption of fluorine and aluminum in the early stage of development directly impacts the development of the human brain, which causes the delayed intellectual development seen in children living in the endemic areas."

IQ Study #2: Qin (1990)

Citation:	Qin LS, Cui SY. (1990). **Using the Raven's standard progressive matrices to determine the effects of the level of fluoride in drinking water on the intellectual ability of school-age children.** *Chinese Journal of the Control of Endemic Diseases* 5(4):203-04 (republished in *Fluoride* 2008; 41:115–19).
Location of study:	**CHINA.** Jing County, Hubei Province.
Size of study:	447 children (141 children from High-F area; 159 children from "normal" F area; 147 children from low-F area)
Age of Subjects:	9 to 10.5 years old

Source of Fluoride Exposure:	Water
Water Fluoride Levels:	High F = 2.1-4.0 mg/L“Normal” F = 0.5-1.0 mg/LLow F = 0.1-0.2 mg/L
Confounding factors:	All children had grown up drinking well water in their home village.
IQ Test:	Raven’s Standard Progressive Matrices
Results:	Children in High F (21.17%) and Low F (23.03%) areas had lower average IQ scores than children in normal F area (28.14%), p<0.01.
Conclusion:	“All of these finding serve to indicate that both high and low fluoride can affect the normal development and function of the cerebrum as well as the entire nervous system causing a decrease in intellectual ability.”

IQ Study #1: Ren (1989)

Citation:	Ren D, Li K, Liu D. (1989). **A study of the intellectual ability of 8-14 year-old children in high fluoride, low iodine areas**. *Chinese Journal of Control of Endemic Diseases* 4(4):251 (republished in *Fluoride* 2008; 41:319-20).
Location of study:	**CHINA.** Shandong Province.
Size of study:	329 children (160 children in High F/low Iodine area: 169 children in Low-F/Low Iodine area)
Age of Subjects:	8 to 14 years old
Source of Fluoride Exposure:	Water
Fluoride exposure levels:	N/A
Confounding factors:	Both study groups had low iodine intake.
IQ Test:	Wechsler Intelligence Test
Results:	– Average IQ of children in the High Fluoride/Low Iodine group (IQ=64.8) significantly lower than the children in the Low Fluoride/Low Iodine group (IQ = 85.0), p<0.01.- The percentage of children with low IQ (<69) significantly greater in High F/Low Iodine group (40.6%) than in Low Fluoride/Low Iodine group (13.6%), p<0.01.
Conclusion:	“From the results it is evident that disrupted child intellectual development is among the effects on the human body from a harmful environment containing both high fluoride and low iodine, and this disruption is clearly much more serious than the effects of iodine deficiency alone.”