

EFFECT OF FLUORIDE IN DRINKING WATER ON BIRTH HEIGHT AND WEIGHT: AN ECOLOGICAL STUDY IN KERMAN PROVINCE, ZARAND COUNTY, IRAN

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SUMMARY: The present study evaluated the association between maternal exposures to drinking water fluoride and birth height and weight in 35 villages and towns in Zarand county, in Iran. Birth height and weight data on 492 infants born during 2013 were obtained from Zarand Central Hospital records. Results from the Pearson's correlation test showed that there is a nearly strong positive correlation between the babies' height and the drinking water fluoride ($R^2=0.479$, $r=0.69$, $p<0.001$) and a mild positive correlation between the birth weight and the drinking water fluoride ($R^2=0.196$, $r=0.44$, $p<0.001$). We found that exposure to fluoride at concentrations higher than the WHO drinking water guideline of a "desirable" upper limit of 1.5 mg/L was not associated with lower birth height and weight and that lower birth height and weight were observed with lower drinking water fluoride concentrations. Because of the importance of this issue, it is reasonable to conduct more studies.

Key Words: Birth height and weight; Drinking water; Fluoride; Zarand, Iran.

INTRODUCTION

The fluoride ion (F) is a toxic natural element found at varying concentrations in drinking water.¹ Waugh reported that the pollutant F was identified as one of the twelve critical pollutants by the US EPA and the fluoride ion is listed on the priority list of hazardous substances by the US Agency for Toxic Substances and Disease Registry that pose a threat to human health and the environment.² F is not an essential trace element that is required for human health or the proper development of teeth and bones and can accumulate in both soft tissues and calcified tissues with the detrimental impacts depending on the levels of exposure.^{1,3,4} Humans are exposed to F through different sources such as potable water, food, tea and beverages, pesticide residue on food, pharmaceutical drugs, toothpastes, etc.⁵ Although water is not the only source of F, drinking water is, nevertheless, for most people, a significant source of exposure and a major source of dietary F intake.⁵ Although claims have been made that moderate levels of F ingestion can reduce the incidence of dental caries or decay,⁶ this view is controversial and various studies, in areas where added or naturally occurring F is high, have shown negative and inverse impacts on health of prolonged over-exposure to F in water, e.g., decreased red blood cells,⁷ osteoporosis,⁸ decreased thyroid function,⁹ oxidative stress,¹⁰⁻¹² nervous system impairment,¹ periodontal disease,¹³ renal disease¹⁴⁻¹⁶ decreased intelligence in children,¹⁷⁻¹⁹

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hypertension,²⁰ and decreased fertility in animals and humans.²¹⁻²³ F may pass the placental barrier and accumulate in the fetus,³ but this is also still controversial.²⁴ F in potable water, food, and other commodities may affect the occurrence in pregnant women of premature births and the prevalence of low birth weight (LBW) babies.^{7,25} Premature births were found to be more common in communities with fluoridated potable water than those with non-fluoridated water and F was shown to increase the rate of occurrence of LBW infants in pregnancy.^{7,25}

Some areas of Iran lie in the geographical F belt, with high levels of F in water and fluorosis existing in various regions including West Azerbaijan, Khuzestan and Kerman provinces. Zarand city (30°48'46"N, 56°33'50"E) located in Kerman province has F levels higher than the WHO drinking water guideline of a "desirable" upper limit of 1.5 mg/L. It is noted that the WHO also allows countries to set Country Standards, their own national standards or local guidelines.²⁶ While some studies have been done in Iran on the effect of F of drinking water on human health,²⁷⁻³⁵ few epidemiological studies have been carried out.^{17,36} Thus, the main objective of our research was to investigate the relationship between maternal exposure to drinking water F and the height and weight of their babies in 35 villages and towns in Zarand county, Kerman province, Iran.

MATERIAL AND METHODS

Selection of study sites: Thirty-five rural and urban areas in the Zarand district with differing concentrations of F in drinking water were selected. (Figure 1).

Fluoride determination: Data on F exposure in the 35 villages and towns in Zarand district were available from published data.²⁶ Groundwater is a major source of human exposure to F in the Zarand region.

Data gathering for birth weight and height: Using random sampling proportional to the size of the population, 492 babies born during 2013 were selected from the 35 regions. The height and birth weight data of the infants were obtained from the Zarand Central Hospital records. Women were excluded if they had a recorded history of illness such as abortion, hypertension, and diabetes. The mothers of the 492 babies selected did not have any of these complicating conditions. The mothers of all participating babies were long-life residents in the study areas, and lived there during their pregnancies. Many women were excluded from the study because of their history of previous illness.

Statistical analysis: The statistical analysis of results was performed by SPSS version 18 software (mean± SD) and Pearson's correlation coefficient.

RESULTS

This study was conducted in 35 areas of the Zarand district, both in urban and rural areas. According to the results of previous study,²⁶ the mean F concentration in the groundwater samples provided for all the participants (n=492) from all study sites was 1.8± 0.83 mg/L. The minimum and maximum F levels were 0.33 and 3.51 mg/L in Sang and Motahar Abad, respectively. In 63% of the groundwater

samples in the Zarand area the F level was above 1.5 mg/L, the “desirable” upper limit of the WHO drinking water guideline.³⁷ In the 35 study areas, the water supply source was from springs in 11 regions, from wells in 9 regions, and from qanats, a series of well-like vertical shafts connected by gently sloping tunnels, in 15 regions.

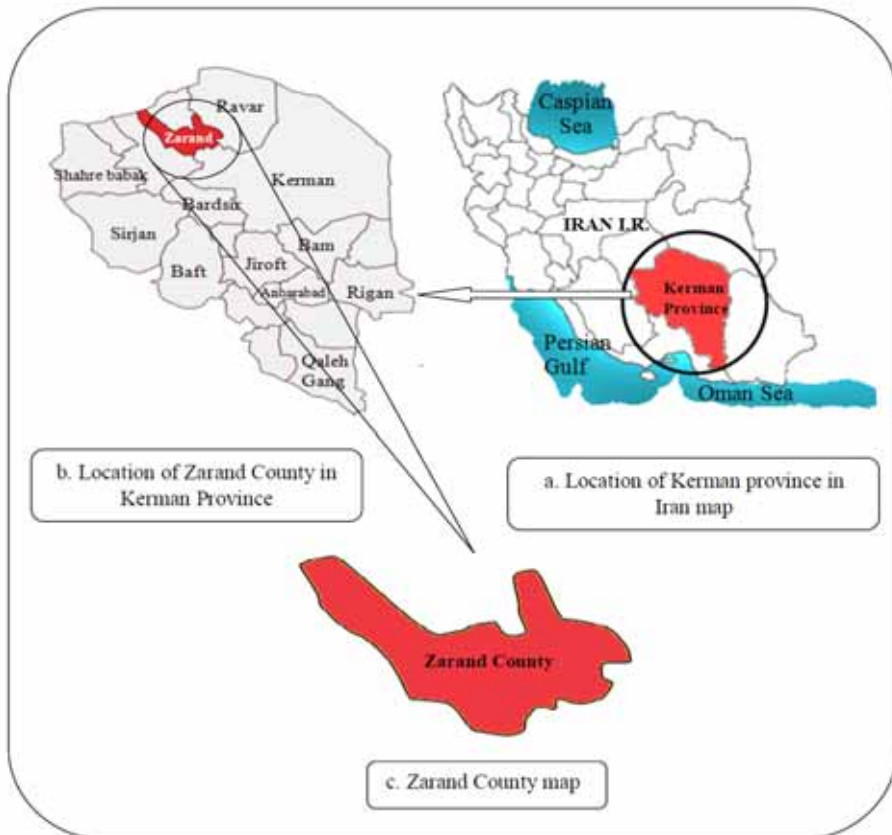


Figure 1. Location of study sites.

The mean birth heights and weights in the low, normal, and high F groups, and for the total sample of 492 babies, are shown in Table 1.

Table 1. Details of the birth height and weight means in the low, normal, and high fluoride groups

Characteristics	Low F group	Normal F group	High F group	Mean
Fluoride level (mg/L)	<0.7	0.7–1.5	>1.5	1.8 ± 0.83
Sample size (%) [Total N = 492 (100%)]	98 (20%)	96 (19.5%)	298 (60.5%)	
Height (mean ±SD) (cm)	47.7± 0.7	49.1± 0.3	51.2± 1.4	50.3± 2.9
Weight (mean ±SD) (g)	2728.8± 233.7	2808.3± 175.5	3201.4± 146	3063.7± 437

*Standard Deviation

Pearson's correlation was used to examine whether there was an association between the maternal exposure to water F and the heights and weights of their babies. Initially, the scatter plot of the data was drawn to see if any underlying trend in the relationship was present. A Pearson correlation coefficient of 0.69 ($p < 0.001$) was calculated for the 492 data pairs plotted in the scatter graph in Figure 2. The results from the Pearson's correlation test showed that there was a nearly strong positive correlation between the babies' height and the water F in the study regions ($R^2 = 0.479$, $r = 0.69$, $p < 0.001$) (Figure 2).

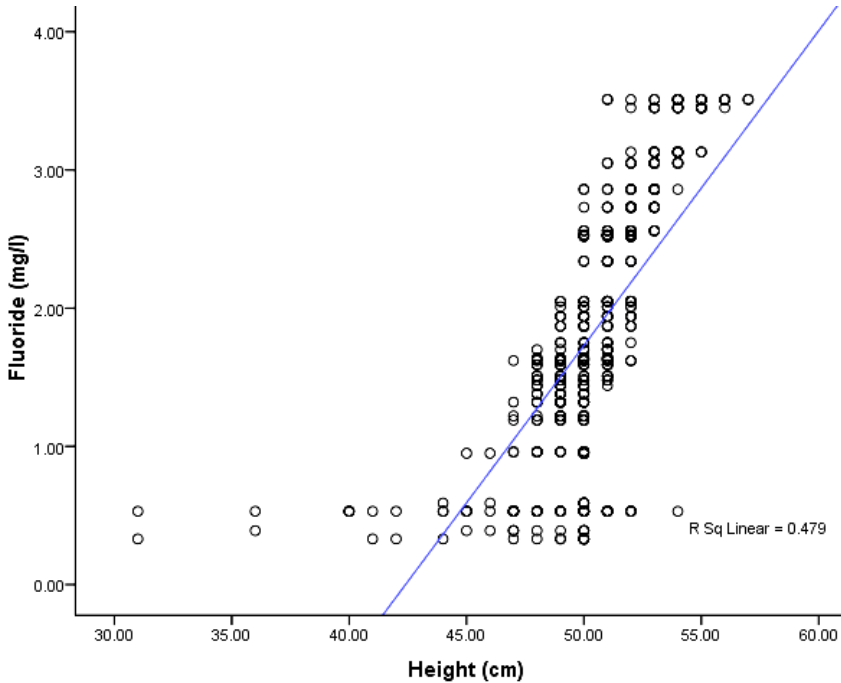


Figure 2. Scatter plot between the babies' height and the fluoride level in the drinking water in 35 villages and towns of the Zarand region, SE Iran.

As seen in Figure 3, the Pearson correlation test showed a mild positive correlation between birth weight and water F. This means that an increase of the F level in the drinking water was correlated with an increase in the birth weight. The Pearson's correlation coefficient (r) equals 0.44 ($R^2 = 0.196$, $p < 0.001$).

DISCUSSION

Iran is located in the geographical F belt, with high levels of F in water in some areas³⁸ and fluorosis existing in various regions including West Azerbaijan, Khuzestan and Kerman province. The Zarand region, located in Kerman province, has areas where the concentration of F in the drinking water is higher than the 1.5 mg/L "desirable" upper limit in the WHO drinking water guideline and it is notable for having more dental fluorosis.^{26, 39}

We found that exposure to F at concentrations higher than the 1.5 mg/L "desirable" upper limit in the WHO drinking water guideline was associated with an increase in the birth height and weight. Lower birth heights and weights were

observed with lower drinking water F concentrations. In the low F group (drinking water F <0.7 mg/L) the mean height and weight of the babies (47.7 cm and 2728 g, respectively) were less than those in the high F group (drinking water F >1.5 mg/L, 51.2 cm and 3201 g, respectively).

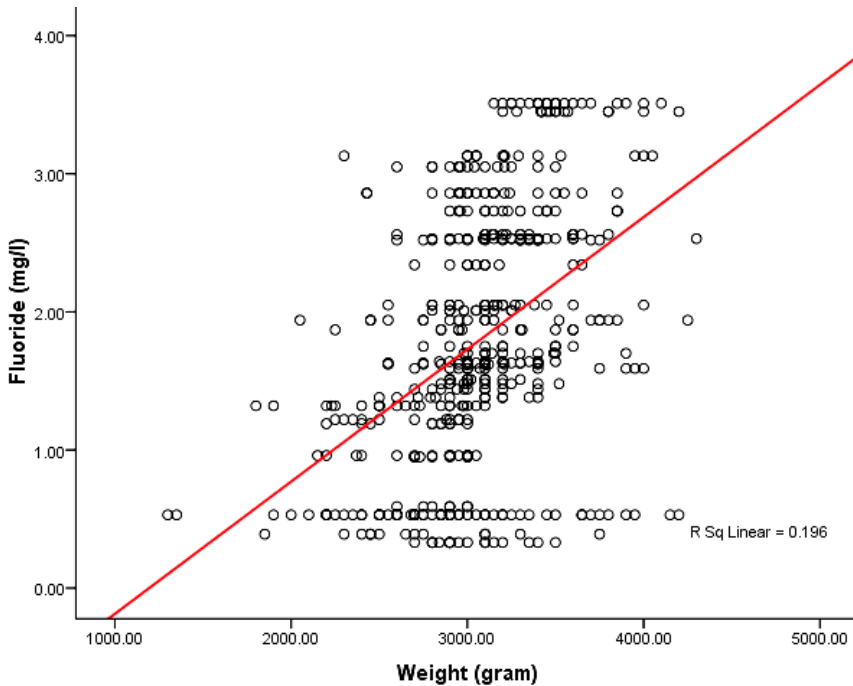


Figure 3. Scatter plot between the babies' weight and the fluoride level in the drinking water in 35 villages and towns of the Zarand region, SE Iran.

Conflicting reports have been made about the association between F exposure and birth weight. A cross sectional study on the association between low birth weight and dental fluorosis among African-American children did not find a statistically significant association between low birth weight and F exposure.⁴⁰ Similarly, other researchers failed to find any association exposure to F and fetal weight.⁴¹

In contrast, a clinical study by Susheela et al.²⁵ found that the number of low birth weight babies declined to 22% in a sample group of mothers who avoided the intake of F, compared to the control group where LBW was present in 52%. In addition, a study by Gurumurthy et al.,⁴² on the relationship between serum F levels in 17–36 year-old-pregnant women and adverse fetal outcomes, found a significant negative correlation between maternal serum F and birth weight and gestational age. The researcher concluded that there was a tendency toward premature birth and low birth weight with increasing serum F. In a study in Poland,⁴³ mean urine F levels for 31 pregnant women in their 28th and 33rd week of pregnancy were 0.653 and 0.838 mg/L, respectively whereas it was 1.3 mg/L in 30 healthy non-pregnant women in the control group. Decreasing urinary fluorine levels occurred during pregnancy and this was probably related to the mobilization

of F by the fetus. In a study conducted in Huaxi, China, ⁴⁴ on the effects of F on the human fetus, a higher F content was found in fetal brain and bone tissue in a F endemic area had than in these fetal tissues in a control group ($p < 0.05$). This might be due to the previous excess F intake by the mothers. Although the underlying mechanisms are somewhat unclear, the study also reported that when the F entered the mother's body, it crossed to the fetus via the placenta and entered into the different tissues and organs of the fetus.⁴⁴ A case control study conducted in an endemic region in Senegal ⁴⁵ found that low birth weight in newborns was statistically correlated with the mothers residing in endemic areas during pregnancy and having dental fluorosis.

Size at birth can be affected by maternal blood glucose levels in addition to other factors including parity, length of gestation, the mother's adult size, and the mother's own birth weight.⁴⁶ Fetal growth is also affected by maternal age, ethnicity, parity, prepregnancy body mass index (BMI), weight gain during pregnancy, smoking, hypertension, fetal gender, and gestational age at birth.⁴⁷ In the infants of diabetic mothers, there is increased glucose transfer to the fetus resulting in β -cell hyperplasia, increased insulin secretion, and greater fetal adiposity.⁴⁶ A continuous relationship has been observed between maternal glucose levels and the birth weight of the offspring.⁴⁶ Impaired glucose tolerance in humans has been reported in separate studies at F intakes of 0.07–0.4 mg/kg/day, corresponding to serum F concentrations above about 0.1 mg/L.⁴⁸ The primary mechanism appears to involve inhibition of insulin production.⁴⁸ Animal studies have found that acute treatment with F increases the blood glucose levels.⁴⁹⁻⁵⁰ Thus a possible mechanism for the increase in birth height and weight with increased drinking water F levels might be through increased F levels being associated with higher maternal blood glucose levels. However, the extent to which the blood glucose rose in association with impaired insulin production would depend on the maternal carbohydrate intake and, if this was low, hyperglycaemia might not occur leading to a smaller increase in the birth height and birth weight. High drinking water F levels may also result in damage to the small intestinal microvilli leading to impaired maternal nutrition and lower fetal growth.⁵¹⁻⁵³ Preventing gastrointestinal damage by lowering the F intake can lead to improved absorption of nutrients and increased fetal growth.⁵³ Thus mechanisms could be present by which a raised F intake could lead to fetal growth being both increased (via increased maternal hyperglycaemia) and decreased (via increased damage to the microvilli with reduced nutrient absorption). Similarly, decreasing the F intake could lead to fetal growth being both increased (via reduced damage to the microvilli with increased nutrient absorption) and decreased (via decreased maternal hyperglycaemia). The net effect would depend on the relative strengths of these two effects. In addition, the level of total water hardness and the levels of calcium and magnesium ions, particularly the latter, may affect the level of toxicity for a given level of drinking water F.⁵⁴⁻⁵⁶ Soft water containing F may be more toxic than hard water despite the F level being the same.

CONCLUSION

Unlike previous studies that reported a negative correlation between an excessive F level in water and birth weight, we found a positive correlation. We found that the heights and weights of infants were increased when the mothers were exposed to high levels of F in the drinking water. Similarly, when mothers consumed water with low levels of F in the drinking water, their babies had a decreased birth height and weight. In contrast, some researchers reported that very high concentrations of F are associated with decreased birth height and weight. The reasons for these different results are not clear with the possibilities including differences in the F levels, the presence of other ions in the water, and the maternal diet. Because of the importance of this issue, it is appropriate to conduct further studies.

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