Iron consumed through groundwater is associated with iron status of women of reproductive age in rural Bangladesh

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Introduction

Rates of iron deficiency (ID, plasma ferritin < 12 μg/l) and resultant anemia (IDA, ID plus low Hb) were very low among women of reproductive age (n=1198) participating in a field trial in rural Bangladesh from 2002 – 2006, both being < 7% at 1st and 3rd trimester and 3 months postpartum assessments. Intakes of iron sources (heme foods and supplements) were infrequent suggesting consumption of unconventional iron sources was enabling the maintenance of sufficient iron stores through pregnancy and lactation.

In Bangladesh, groundwater, naturally rich in minerals such as arsenic and iron (1), provides more than 90% of the population with drinking and cooking water (2). Previous studies have suggested that iron in water is bioavailable and positively associated with iron status and growth (3-6). This study was conducted to investigate the association between consumption of iron through drinking groundwater and iron status of women.

Methods

PANI* study participants were selected from a biochemical substudy (n=1198, 2% of all subjects) nested within the first "JiVitA" community-based trial (n=~60,000) conducted from 2002 to 2007 in rural northwestern Bangladesh designed to assess the impact of weekly vitamin A or beta carotene supplementation on maternal and infant mortality. The PANI sampling frame (n=464, 39% of 1198) was composed of JiViTA subjects who: 1) maintained the same residence throughout participation, 2) contributed a live birth, and 3) completed the full panel of 1st trimester and 3 months post partum assessments.

PANI Data Collection (2008)

Rounds 1 and 2
- 24-hr rice and drinking water intake
- 7-day drinking and cooking water collection and use
- 7-day dietary intake
- 30-day supplement use
- 7-day morbidity
- Field-based drinking tubewell water analysis

Round 2
- Iron status (Hb, ferritin, TfR, and CRP)

After assessing current eligibility (residence in the study area and non-pregnancy) for 400 subjects randomly selected from the sampling frame, 307 enrolled subjects were visited in 2008 during 2 seasonal data collection rounds (1: May – July; 2: October – November) for interviews (7-day dietary and morbidity recall, water collection and use patterns, and 24-hr drinking water and rice intake) and field-based drinking tubewell water analysis. Iron status was assessed in round 2. Complete PANI data was collected from 222 (72% of the 307 enrolled) subjects.

* Project of Arsenic N' Iron; *pani* means "water" in Bengali

Results

Table 1. Iron status of PANI women (2008)

	n	Mean (SD)	Median (IQR)	Range	< cutoff[a]
Hb (g/L)	264	117 (16)	118 (106, 129)	80, 162	145 (55)
Ferritin (μg/L)	222	78 (49)	67 (42, 100)	13, 287	0 (0)
TfR (mg/L)	222	2.5 (0.9)	2.3 (2.0, 2.8)	1.2, 8.0	0 (0)
CRP (mg/L)	222	1.6 (4.2)	0.3 (0.1, 1.2)	0.1, 30.0	15 (7)

[a] n (%), Cutoffs: Anemia, Hb <110 g/L or 120 for pregnant and non-pregnant women, respectively; Iron deficiency, ferritin < 12μg/L or TfR >8.5 mg/L; Infection, CRP>5.0 mg/L.
[b] Appropriate Hb cutoffs applied for 8 (4%) participants in 1st trimester of pregnancy.

Groundwater was the main source of drinking water for 100% of participants. Iron concentration in groundwater sources was elevated (100% above the WHO defined 0.3 mg/L cutoff (7)) and variable (**Table 2**). Subjects reported consuming 2.5 L of water a day (excluding filtered water), on average, from the identified tubewells leading to a wide range of daily iron intake through drinking water (1.5 – 144.1 mg/day).

Table 2. Iron intake through drinking groundwater (n=208)

	May – July	Oct - Nov	Usual
Groundwater iron content (mg/L)	14.6 (7.0, 27.0)[a] 0.9, 50.5	15.9 (5.7, 29.1) 0.6, 50.5	16.8 (6.9, 28.0) 0.8, 43.5
Water intake[1] (L/day)	2.6 (2.0, 3.4) 0.6, 6.0	2.3 (1.9, 2.8) 0.6, 9.0	2.5 (2.0, 3.1) 0.8, 5.8
Daily iron intake[2] (mg/day)	39.5 (15.8, 72.1) 1.1, 212.1	36.6 (13.6, 63.3) 0.9, 209.0	41.4 (16.6, 67.8) 1.5, 144.1

[1] Excludes filtered water (≤2% of intake at both visits) because filtering eliminates iron.
[2] Water intake (L/day) X groundwater iron concentration (mg/L)
[a] Data presented as median (IQR), range

Maps were developed to illustrate the distribution of usual (mean of rounds 1 & 2) daily iron intake through water (mg/day) and plasma ferritin (ug/L) in round 2 **(Figure 1)**.

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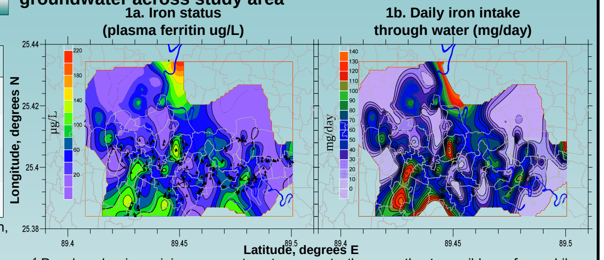
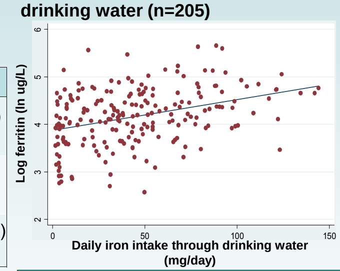
Figure 1. Distribution of iron status and iron intake through groundwater across study area[1]



[1] Developed using minimum curvature to generate the smoothest possible surface while attempting to honor the raw data as closely as possible.

Daily iron intake through water was positively associated with iron status (R^2=0.21, p<0.001, **Figure 2**).

Figure 2. Ferritin as a function of daily iron intake through drinking water (n=205)



Coefficient = 0.006
SE = 0.001
p value = 0.000

Multiple linear regression adjusted for BMI (kg/m^2), Hb (g/L), log-transformed TfR (ln mg/L), and infection status (CRP >5 mg/L). Age, parity, diet, and SES were not significant covariates.

Conclusions

- Daily iron intake through drinking groundwater was positively associated with iron status of women (p=<0.001, R^2 = 0.21).
- Iron status was not associated with age, parity, and dietary intake of animal food sources (heme iron).
- Iron rich drinking water should be considered when evaluating maternal iron intake and status in populations consuming groundwater.

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