THE JiVitA JOURNAL

Mountains of iron under rural Bangladesh: aquifers may prevent iron deficiency

Tubewell water may provide bioavailable dietary iron that helps maintain normal iron status among rural Bangladeshi women.

Anemia is widely prevalent throughout the developing world, affecting nearly half of all women, adolescent girls, and children.[1,2] It is widely held that half of all anemia is caused by iron deficiency, while acknowledging other important causes. These include hook worm and malaria infections, chronic inflammatory diseases, deficiencies of other micronutrients involved in red blood cell metabolism, such as folate, vitamin A and vitamin B_{12}, and inherited blood disorders, such as thalassemia.[3] The assumption is largely based on cross sectional surveys that have assessed both iron status indicators and hemoglobin concentration, often with other concurrent disease exposures, that enable causes to be inferred when combined with knowledge of poorly absorbed iron in traditional, staple-based diets lacking animal sourced food. However, the assumption that half of anemia is due to iron deficiency may be an oversimplification for a multifactorial condition such as anemia, the cause of which is critical to know in order to provide effective prevention and treatment. One environment in which half of anemia is attributed to iron deficiency is in rural Bangladesh, where anemia rates are often 25-60%[4-6] and where a traditional diet of rice and lentils, combined with little meat, fish or poultry, provide iron of low bioavailability.[7] Yet, on closer examination, not all anemic areas in Bangladesh are iron deficient. The large, 450 sq km JiVitA Project area in northern Bangladesh is one such region, where 35% of women in mid-pregnancy were anemic, where bioavailable dietary iron was low, but only 6% of women were iron deficient (3% had iron deficiency anemia). While common, thalassemias were one possible explanation for the anemia,[8] but they could not explain the lack of iron deficiency. Suspect was drinking and cooking water from tubewells which has long been known to be high in iron in many areas of the country but also widely considered poorly bioavailable for making hemoglobin.[9]

In many rural settings, such as in Gaibandha District, surface and groundwater, often untreated, provides most water for domestic use.[10] Groundwater, especially, contains naturally dissolved minerals, such as iron, the intake of which could potentially decrease risk of anemia and associated health risks.[11] Across rural Bangladesh, a country where 90% of households drink and cook with groundwater, the underground aquifer environment is known to have highly variable iron concentrations which may be providing heretofore an underappreciated supply of bioavailable dietary iron.[12]

Within the JiVitA Project study area, we used a geographic information system to map measured levels of naturally occurring iron in groundwater as sampled from tube wells (*Figure 1*). We subsequently investigated the relationship between reported chronic intake of water, from each local source, and the iron status of village women. Our study area wide survey of 948 equally spaced domestic tubewells revealed that groundwater iron concentration was elevated, with a median (25th, 75th percentile) concentration of 7.6 (1.6, 17.6) mg/L that in places reached 46.5 mg/L[13], values that represent 25 and ~150 times the aesthetic upper limit of 0.3 mg/L set by the World Health Organization (WHO). In a less extensive area, in 2008, we re-visited 276 women who had participated in a biochemical substudy, nested within the original JiVitA trial, for whom we had previously obtained iron status information. We collected data on their daily water intake and groundwater collection habits and did field-based analysis of groundwater iron concentration for all tube wells reportedly used by participant households. This study found that half of women were consuming 41.1 mg or more of iron per day from their drinking water alone and some were consuming more than 100 mg/day.[14] In further analyses of the association between consuming groundwater iron from drinking and iron status (measured by plasma concentrations of ferritin, reflecting iron stores), we revealed a strong, consistent, positive relationship between the two such that iron status was expected to increase by 6% for every 10 mg per day increase in groundwater iron intake, an association that was unaffected by adjusting for diet and other factors that could be expected to affect iron status (*Figure 2*).[15]

JOHNS HOPKINS UNIVERSITY BANGLADESH

The findings from this research reveal the potential importance of groundwater, from local tube wells, in providing an effective dietary source of iron that, when chronically consumed, may increase iron stores and reduce or even virtually eliminate risk of iron deficiency anemia. The findings are likely to be relevant to areas throughout rural Bangladesh where groundwater, a naturally mineral rich source of drinking and cooking water, is used for domestic purposes. In these environments, anemia may not be due to iron deficiency but rather perhaps from deficiencies of other micronutrients required for hemoglobin synthesis and homeostasis, genetic conditions (eg, thalassemias or other hemoglobinopathies), or infectious diseases. Such iron rich groundwater conditions do not exist everywhere in Bangladesh, but where they do, routine iron supplementation may be unnecessary and ineffective in preventing anemia due to other causes. We have shown that testing of local water supplies is a relatively simple, accurate and inexpensive way to reveal this environmental source of iron[16] which could be incorporated in public health programs.

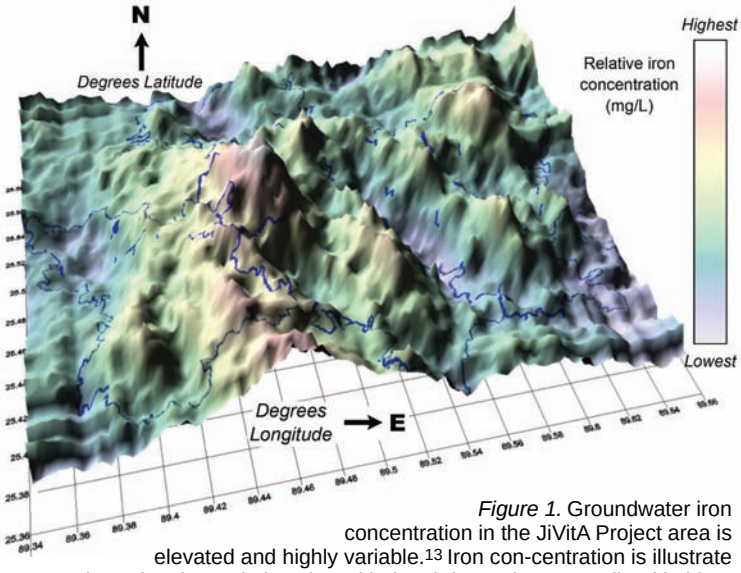

Figure 1. Groundwater iron concentration in the JiVitA Project area is elevated and highly variable.[13] Iron con-centration is illustrate through color and elevation with the JiVitAstudy area outlined in blue.

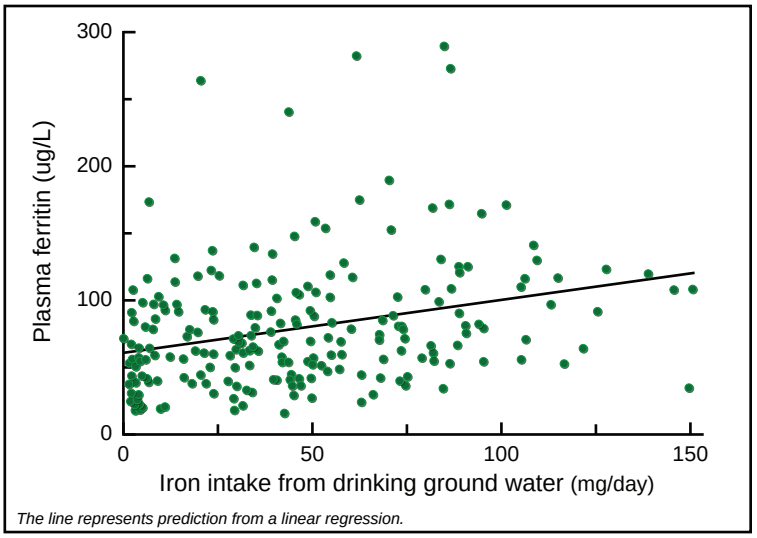

Figure 2. Women's (n=214) iron status (plasma ferritin, µg/L) is positively associated with daily iron intake from tubewell water (mg/day in rural Bangladesh.[9]

Acknowledgement

Partial support for this research was provided by a Proctor & Gamble Fellowship.

JiVitA is a project of the Center for Human Nutrition of Johns Hopkins University, spanning 19 unions of Gaibandha and Rangpur Districts in rural Northwestern Bangladesh. JiVitA has been conducting community trials, supported by epidemiologic, ethnographic, and laboratory research since 2000, to reveal the impact of public health interventions in order to guide nutrition and health programs and policies in Bangladesh and elsewhere in South Asia.

References

1) McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993-2005. Public Health Nutr 2009;12(04):444-54.
2) Balarajan Y, Ramakrishnan U, Ozaltin E, Shankar AH, Subramanian SV. Anaemia in low-income and middle-income countries. Lancet 378:2123-35.
3) World Health Organization. Focusing on anaemia: towards an integrated approach for effective anaemia control. Joint statement by the World Health Organization and the United Nations Children's Fund. WHO 2004 Geneva, Switzerland
4) Iron deficiency anemia throughout the lifecycle in rural Bangladesh. National Vitamin A Survey, 1997-98. Dhaka, Bangladesh: Hellen Keller International/Institute of Public Health Nutrition; 1999. Report No.: 16.
5) Hyder SM, Persson LA, Chowdhury M, Lonnerdal BO, Ekstrom EC. Anaemia and iron deficiency during pregnancy in rural Bangladesh. Public Health Nutr 2004;7:1065-70.
6) Lindstrom E, Hossain M, Lonnerdal B, Raqib R, Arifeen S, Ekstrom C. Prevalence of anemia and micronutrient deficiencies in early pregnancy in rural Bangladesh, the MINIMat trial. Acta Obstet Gynecol Scand 2011;90:47-56.
7) Bouis H. Relating the Bangladeshi diet to iron deficiency. In: Roos N, Bouis H, Hassan N, Kabir K, editors. Alleviating malnutrition through agriculture in Bangladesh: biofortification and diversification as sustainable solutions. IFPRI; 2004. p. 50-60.
8) Merrill R, Shamim A, Ali H, Labrique A, Schulze K, Christian P et al. High prevalence of anemia with lack of iron deficiency among women in rural Bangladesh: a role for thalassemia and iron in groundwater. Asia Pac J Clin Nutr 2012. Accepted.
9) World Health Organization. Guidelines for drinking-water quality. 1st ed. WHO. 1984 Geneva, Switzerland.
10) Milton A, Rahman H, Smith W, Shrestha R, Dear K. Water consumption patterns in rural Bangladesh: are we underestimating total arsenic load? J Water Health 2006;4:431-6.
11) World Health Organization. Nutrients in drinking water. WHO. 2006 Geneva, Switzerland.
12) Arsenic contamination of groundwater in Bangladesh. Kinniburgh D, Smedley P, editors. Volume 1: Summary. 2001. Keyworth, British Geologic Survey. British Geologic Survey Report WC/00/19.
13) Merrill R, Labrique A, Shamim A, Schulze KJ, Christian P, Merrill R et al. Elevated and variable groundwater iron in rural northwestern Bangladesh. J Water Health 2010;8:818-25.
14) Merrill R, Shamim A, Ali H, Jahan N, Labrique A, Christian P et al. Groundwater iron assessment and consumption by women in rural northwestern Bangladesh. Int J Vitam Nutr Res 2012. Accepted.
15) Merrill R, Shamim A, Ali H, Jahan N, Labrique A, Schulze K et al. Iron status of women is associated with the iron concentration of potable groundwater in rural Bangladesh. J Nutr 2011;141:944-9.
16) Merrill R, Shamim A, Labrique A, Ali H, Schulze KJ, Rashid M et al. Validation of two portable instruments to measure iron concentration in groundwater in rural Bangladesh. J Health Popul Nutr 2009;27:414-8.

For Further Information Contact

Center for Human Nutrition
Department of International Health
Johns Hopkins Bloomberg School of Public Health
Baltimore, MD 21205
Telephone: 1-410-955-2061
http://www.jhsph.edu/chn

The JiVitA Project
Johns Hopkins University
Road 25, Block A, House 48, Flat C-1
Banani, Dhaka, Bangladesh
NEW Telephone: (+88-02) 9840091
https://www.jivita.org

Funding Agencies

- The Bill & Melinda Gates Foundation
- The United States Agency for International Development
- The United States Department of Agriculture
- The Canadian International Development Agency
- The Sight and Life Research Institute
- The Ministry of Health and Family Welfare, The Government of the People's Republic of Bangladesh

MOUNTAINS OF IRON UNDER RURAL BANGLADESH: AQUIFERS MAY PREVENT IRON DEFICIENCY