Chemosphere 91 (2013) 882–887

Contents lists available at SciVerse ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Impact of pregnancy and other factors on the levels of urinary perchlorate, thiocyanate, and nitrate among females aged 15–44 years: Data from National Health and Nutrition Examination Survey: 2003–2008 ☆

Ram B. Jain *

1061 Albemarle Way, Lawrenceville, GA 30044, United States

HIGHLIGHTS

- Pregnant females had lower thiocyanate levels than non-pregnant females.
- Iodine deficiency was associated with lower levels of perchlorate, nitrate, and thiocyanate.
- Smokers had significantly higher levels of thiocyanate than among non-smokers.
- Non-Hispanic Blacks had the lowest and Mexican Americans had the highest levels of perchlorate and nitrate.
- Non-Hispanic Blacks had the highest and Mexican Americans had the lowest levels of thiocyanate.

ARTICLE INFO

Article history:
Received 14 December 2012
Received in revised form 5 February 2013
Accepted 19 February 2013
Available online 19 March 2013

Keywords:
Iodine deficiency
Thiocyanate
Perchlorate
Pregnancy

ABSTRACT

Impact of pregnancy on levels of urinary perchlorate, thiocyanate, and nitrate has not been studied using large scale data. Data from National Health and Nutrition Examination Survey for the years 2003–2008 were used to evaluate risk factors that impact levels of these contaminants among females of child bearing age. In addition to pregnancy, other risk factors evaluated were: age, race/ethnicity, smoking status, serum triglyceride levels, and iodine deficiency status. Pregnancy did not affect the levels of perchlorate and nitrate but, new to this study, it was found that thiocyanate levels were statistically significantly lower among pregnant females as compared to non-pregnant females ($p < 0.01$). Iodine deficient females had statistically significantly lower levels of these contaminates than iodine replete females ($p < 0.01$). Levels of thiocyanate among smokers were about five times higher than among non-smokers. Non-Hispanic Blacks had the lowest and Mexican Americans had the highest levels of perchlorate and nitrate. The reverse was true for thiocyanate levels. There was an inverse association between nitrate and education levels. There was a positive association between serum triglyceride levels and the levels of these contaminants. Also, new to this study, of concern, was the fact that levels of these contaminants increased among females over the period 2005–2008. Levels of perchlorate, thiocyanate, and nitrate did not vary across pregnancy trimesters.

1. Introduction

Perchlorate, thiocyanate, and nitrate have been identified as competitive inhibitors of sodium/iodine symporter in pharmacologic doses (Pearce and Braverman, 2009). Thus, these contaminants have the potential to cause goiter and hypothyroidism, particularly in iodine deficient individuals. However, in quite a few studies, perchlorate and thiocyanate have not been found to affect thyroid function (Gibbs and Van Landingham, 2008; Pearce et al., 2010, 2012) among pregnant females. A comprehensive review of environmental exposure and thyroid function also resulted in the same conclusion (Tarone et al., 2010). No effect of perchlorate on thyroid function was discovered even among occupational workers for whom perchlorate exposure is higher than general population. Braverman et al. (2005) concluded that long term, intermittent, high exposure to perchlorate does not induce hypothyroidism or goiter among adults. Blount et al. (2009) found no association between cord blood levels of perchlorate, thiocyanate,

☆ No funds were made available to the author for conducting this research. The data used in this research are available without charge from http://www.cdc.gov/nchs/nhanes.htm.

* Tel.: +1 678 431 9728.
E-mail address: jain.ram.b@gmail.com

0045-6535/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.chemosphere.2013.02.040

and nitrate and newborn weight, length, and head circumference. Steinmaus et al. (2010) did report a positive association between perchlorate and neonatal thyroid stimulating hormone (TSH) levels. Thiocyanate exposure was not found to affect thyroid function among mildly iodine-deficient Greek women (Pearce et al., 2012). Pearce et al. (2010), however, did find "...a small but significant inverse correlation between urine thiocyanate and serum FT_4...". Thiocyanate levels have found to be higher among smokers than non-smokers (Blount et al., 2009). Perchlorate was not found to be a significant predictor of T_4 or TSH in men (Blount et al., 2006) but was found to be a predictor of T_4 and/or TSH among females aged 12 years and over depending up on their urine iodine levels (<100 μg L^{-1} vs. ⩾100 μg L^{-1}). In a longitudinal study (Manassaram et al., 2010), pregnant females exposed to nitrate levels below the maximum contaminant level for drinking water were unlikely to have methemoglobin levels above the physiologic normal. The risk of thyroid disorders among pregnant females exposed to high nitrate levels in drinking water was more than five times that of the risk for those exposed to low nitrate levels (Gatseva and Argirova, 2008).

Using data from 2003–2004 cycle of National Health and Examination Survey (NHANES), Woodruff et al. (2011) found unadjusted geometric means of perchlorate to be higher among pregnant female as compared to non-pregnant females (4.17 ng mL^{-1} vs. 2.68 ng mL^{-1}) of child bearing age. The same was true for median and 95th percentiles. It has been suggested (Leung et al., 2010) that impact of perchlorate be interpreted in combination with other thyroidal endocrine disrupters.

The objective of this study was to delineate the risk factors, particularly pregnancy, that affect the levels of urinary perchlorate, thiocyanate, and nitrate among females of child bearing age or aged 15–44 years. The risk factors considered were: pregnancy status (pregnant, non-pregnant), race/ethnicity (non-Hispanic White or NHW, non-Hispanic Black or NHB, Mexican American or MA, other race/ethnicities or ORE), marital status (married, never married, others including separated, divorced, and widowed), education (less than high school, high school, greater than nigh school), family income (<$20 000 $year^{-1}$, $20 000–$55 000 $year^{-1}$, above $55 000 $year^{-1}$), serum cotinine levels, smoking status (non-smoker, smoker), fish/shell fish eating status during the last 30 d (Eaten, Not Eaten), serum cholesterol, serum triglyceride levels, serum total lipid levels, quantity of alcohol, plain water, bottled water, caffeine, and total fat in grams consumed during the last 24 h, number of live births, total number of pregnancies, number of children breast fed for at least 1 month, body weight, body height, body mass index, urinary creatinine levels, and urinary iodine levels.

2. Materials and methods

Publicly available NHANES data for the years 2003–2008 from demographic, reproductive health, biochemistry, individual and total dietary files were downloaded and match merged with data on urinary perchlorate, thiocyanate, and nitrate. It should be noted that urinary perchlorate was measured in one third of the sample for 2003–2004 and iodine was measured in one third of the samples for both 2003–2004 and 2005–2006 and no data were available for thiocyanate and nitrate for 2003–2004 NHANES years. NHANES uses a complex, stratified, multistage, probability sampling designed as representative of the civilian, non-institutionalized U.S. population based on age, sex, and race/ethnicity (http://www.cdc.gov/nchs/nhanes.htm). A detailed description of sample design specifications for NHANES 2003–2004 can be found elsewhere (http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/general_data_release_doc_03-04.pdf) and for other years in the similar files. Sampling weights are created in NHANES to account for the complex survey design, including oversampling, survey non-response, and post-stratification. Specifically, data were downloaded for all female participants aged 15–44 years old females. After these files were merged, database was created for use in this study. In a preliminary study, it was found that data on urine iodine were too important to be excluded from any analysis for perchlorate, thiocyanate, or nitrate. As such, only one third of the available data for 2005–2006 could be used.

The database generated for this study with non-missing values of perchlorate contained a total of 3553 participants. The database for non-missing values of thiocyanate and nitrate had 2972 participants. First, bivariate bivariate analyses each using logs of perchlorate, thiocyanate, and nitrate were conducted to find out which dependent variables should be included in the final models for perchlorate, thiocyanate, and nitrate respectively. Any dependent variable with a p-value of >0.10 was excluded from the final analysis. The variables selected for final analysis for perchlorate were: pregnancy status, race/ethnicity, fish/shell fish eating status, marital status, iodine deficiency status, age, urine creatinine, serum triglyceride, number of children breast fed for at least 1 month, total alcohol consumed during the last 24 h, total fat consumed during the last 24 h, plain water consumed during the last 24 h, body height, and NHANES survey year. The variables selected for final analysis for thiocyanate were: pregnancy status, race/ethnicity, smoking status, iodine deficiency status, age, urine creatinine, serum triglyceride, number of live births, total alcohol and caffeine consumed during the last 24 h, total fat consumed during the last 24 h, plain water consumed during the last 24 h, body weight, and NHANES survey year. The variables selected for final analysis for nitrate were: pregnancy status, race/ethnicity, smoking status, iodine deficiency status, marital status, education, age, urine creatinine, serum triglyceride, number of live births, total alcohol consumed during the last 24 h, total fat consumed during the last 24 h, plain water consumed during the last 24 h and NHANES survey year. Those who had urine iodine levels below 100 ng mL^{-1} were defined as iodine deficient and those with iodine levels of ⩾100 ng mL^{-1} as iodine replete.

After excluding missing values for all dependent variables, the database for analysis for urinary perchlorate contained a total of 2027 participants (235 pregnant females, 1792 non-pregnant females; 805 NHW, 468 NHB, 494 MA, 260 ORE; 1525 who ate fish and/or shell fish during the last 30 d, 502 who did not fish and shell fish during the last 30 d; 810 who were married, 801 who were never married, and 460 others including those who were separated, divorced, and widowed, 704 who were iodine deficient, 1323 who were iodine replete). After excluding missing values for all dependent variables, the database for analysis for urinary thiocyanate and nitrate contained a total of 1548 participants (159 pregnant females, 1389 non-pregnant females; 605 NHW, 346 NHB, 376 MA, 221 ORE; 810 who were married, 540 who were iodine deficient, 1008 who were iodine replete, 1197 non-smokers defined as those having serum cotinine concentrations of <10 ng mL^{-1}, and 351 smokers defined as those who had serum cotinine concentrations of ⩾10 ng mL^{-1}). The laboratory methodology to measure serum cotinine has been described elsewhere (http://www.cdc.gov/nchs/nhanes/nhanes2007-2008/COTNAL_E.htm#Component_Description).

3. Results

3.1. Perchlorate data

R^2 for the model for perchlorate with actual N of 2027 was 39.7%. Unadjusted means (UGMs) with 95% confidence intervals are given in Table 1. Pregnant females had higher UGM than non-pregnant females but the differences were not statistically