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Nitrate-Contaminated Drinking Water Followback Study

Research Report

by

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BACKGROUND

Nitrate is one of the most common contaminants found in Wisconsin's groundwater. Groundwater naturally contains traces of nitrate that are produced by decaying vegetation and transported through soil by rainwater and snow melt. Under current landuse conditions, however, the major contributors of nitrate to aquifers are related to human activities. Seepage from septic tanks, discharges from municipal sewage facilities, waste from farm animals, and agricultural and lawncare fertilizers contribute millions of pounds of nitrate to Wisconsin's groundwater each year.

The federal drinking water standard for nitrate-nitrogen (nitrate-N) which applies only to public water supplies was set at 10 mg/L in 1991.[1] Private water supplies fall under a health advisory issued by the Wisconsin Department of Health and Family Services. This advisory recommends that water that exceeds the federal standard not be fed to infants that are less than six months of age. The advisory was expanded in 1993 to include pregnant women. A recent water supply survey conducted by the Wisconsin Division of Health and the National Center for Disease Control and Prevention found that nearly seven percent of Wisconsin's 750,000 private wells had nitrate levels that exceeded the health advisory level. The problem varies regionally with the highest nitrate levels being found in the southern and central regions of the state where agriculture is most intense.[2]

Nitrate was first recognized as a health hazard in 1945 when a young Iowa City pediatrician named Hunter Comly treated two rural infants for recurrent symptoms of cyanosis, diarrhea, and drowsiness.[3] Clinical tests confirmed that these infants were suffering from a condition called "methemoglobinemia" in which red blood cell hemoglobin is oxidized to a form that cannot transport oxygen. Dr. Comly's investigation of these cases determined that both infants developed symptoms after being fed formula that had been prepared with boiled water from farm wells. Water samples from these wells were later found to be contaminated with coliform bacteria and to contain nitrate-N levels of 90 and 140 mg/L.

Infants suffering from methemoglobinemia have a bluish-gray or lavender skin color, rapid, shallow breathing, and a rapid heart beat. Those under six months of age are more susceptible to methemoglobinemia than other age groups because they have a higher gastric pH that allows the growth of nitrate-reducing bacteria and because methemoglobin reductase, a red blood cell enzyme that converts methemoglobin back to hemoglobin, is poorly developed in newborns.[4] The illness can develop rapidly in infants who are fed formula that has been prepared with nitrate-contaminated water.

The current drinking water standard for nitrate was based on a survey of state health departments that was conducted by the American Public Health Association in 1950.[5] This survey identified 278 cases of methemoglobinemia that occurred between 1945-1950. Graham Walton's analysis of the survey responses found that most of these cases involved nitrate-N levels above 30 mg/L and none involved levels below 10 mg/L. Very few cases of nitrate-induced methemoglobinemia have been publicized during the last decade. A review of the medical literature found only three cases that were documented during this period. These included a case that occurred in Trempealeau County, Wisconsin during the summer of 1992,[6] and two cases that occurred in South

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Dakota during 1986.[7] One of the S. Dakota infants died after being fed formula that was prepared with well water that contained 150 mg nitrate-N per liter. Whether other cases occurred during this period of time is unknown since physician reporting of the condition is voluntary.

Several investigators have studied the chronic health and reproductive impacts of nitrate-contaminated drinking water. Recent studies have implicated nitrate exposure in the etiology of lymphoma,[8] gastric cancer,[9] hypertension,[10] thyroid disorder,[11] and birth defects.[12] In addition, a recent investigation conducted by local public health officials in La Grange Co. Indiana implicated nitrate-contaminated drinking water as a possible cause of spontaneous abortions.[13] Most experts believe that nitrate is not the direct cause of these diseases, but acts as a substrate that is subject to conversion to other more toxic nitrogen-containing substances. Nitrate is readily reduced to nitrite by bacteria that are present in the mouth and colon. Once formed, nitrite can combine with dietary amines to produce nitrosamines which are known to cause genetic mutations that can produce birth defects and cancer.[14,15] The formation of nitrite and nitrosamines is inhibited by anti-oxidants like Vitamins C and E. The complexity of these processes and the difficulty of assessing human exposure to nitrate have made the study of nitrate toxicity in humans exceedingly difficult and have contributed to the current state of confusion regarding the importance of nitrate-contaminated water as a public health threat.

While these issues continue to be debated by the scientific community, thousands of rural and suburban families in Wisconsin continue to obtain their drinking water from nitrate-contaminated wells. The well-being of these individuals and the effectiveness of the existing advisory for pregnant women and infants are not known. This report summarizes the results of a followback survey that was conducted jointly by the Wisconsin Division of Health and the UW Department of Preventive Medicine. This survey, which was mailed to more than 1500 rural families across Wisconsin, asked them several questions about their drinking water supplies, their general health status, and reproductive outcomes. Almost half of the families that were contacted volunteered to participate in the survey. The information they have provided gives us valuable insights into the impact of nitrate-contaminated groundwater on their daily lives, finances, and health.

RESEARCH METHODS

A retrospective cohort study was done using 1994-1996 data from groundwater analyses that were conducted by the State Laboratory of Hygiene (SLH), the Department of Agriculture, Trade, and Consumer Protection (DATCP), and the Central Wisconsin Groundwater Center at the UW-Stevens Point (UWSP). Information provided by these laboratories included the nitrate level, the sampling date, and the name and address of the well owner. Initially, all well water nitrate test results from the SLH that were above 15 mg/L were selected to be in the high-exposure group. A low-exposure household with a nitrate-N test result of 0 to 2.0 mg/L was matched by county of residence to each high-exposure household. Matching by county was done to control for possible geographic differences in other environmental exposures and for socioeconomic factors. Because the SLH database contained an insufficient number of elevated nitrate test results, additional data was obtained from DATCP and UWSP. To

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further increase the number of families in this survey the high exposure cohort was expanded to include nitrate-N levels of 13 mg/L or higher. The corresponding "low" exposure group was again matched by county and included wells with nitrate-N levels ranging from below detection to 2 mg/L.

A letter of invitation and a 10-page survey booklet (see Appendix A) was sent to wellowners who were selected using the criteria described above. Letters of invitation identified the researchers, explained the purpose of the study, and encouraged the reader to participate in this research effort. The survey booklet was divided into two parts. Part I, was a general household questionnaire. This section contained several demographic questions about the family, such as ages, household income, and residential history. In addition, this section included questions about their household water supply and nitrate test result and asked about chronic illnesses and cancer diagnoses.

The second half of the survey was completed by the female head of each household. This section was subdivided into two parts. The first of these included questions about her water supply and daily water intake, diet, smoking history, and exposure to pesticides and commercial-strength cleaners. In addition, this section asked about her general health and reproductive history. Women who reported a pregnancy within the last 10 years, also completed the final section of the survey which requested information about each of her pregnancies including the outcome of the pregnancy and her water use habits during the pregnancy.

The survey and letter of invitation were sent with a postage-paid, self-addressed return envelope. One week after the survey was mailed, a reminder post card was mailed to everyone who had not yet returned their survey. Between November 1996 and January 1997, 1558 surveys were mailed out. The Post Office returned 280 surveys as undeliverable. The overall response rate was 44%, with 562 surveys completed and returned for analysis. Response rates were 45% and 43% for families in the high- and low-exposure groups, respectively. These rates were not significantly different (p = 0.64). Twenty-five surveys were omitted from the analysis either because they were incomplete or because the nitrate test result could not be linked to the family's current drinking water supply.

Survey data was entered into a database that using EPI INFO software provided by the National Centers for Disease Control and Prevention. Tests of differences in means, odds ratios, and confidence intervals were conducted using EPI INFO and SAS software. Ten year observed-to-expected ratios were used to compare cancer rates among each exposure group. Baseline rates were calculated using data from *Cancer in Wisconsin*[16] and *Vital Statistics.*[17] To assess the impact of nitrate exposure on reproductive success, the outcomes of pregnancies that occurred in the family's current home between 1991 and 1996 were compared using well-water nitrate levels and maternal drinking water intake estimates.

RESULTS

Respondent demographics

Demographic information for survey respondents is summarized in Table 1. As shown, the average age of respondents in the high-exposure group was 50.6 years, which was approximately 4 years older than the average age of respondents in the low-exposure group. This age difference is due to a much higher number of adults aged 50 years or older, and a smaller number of children in the high-exposure cohort. In addition to being slightly older, families with nitrate-contaminated water supplies had resided in their homes longer, were more likely to live on a working or non-working farm, were slightly smaller, and had lower household incomes than families in the low-exposure group. However, no significant differences were noted in smoking rates, racial makeup, or home-ownership status of these groups.

Table 1: Demographic Variables by Exposure Level

	Exposure Group	
Variable	High	Low
No. of households	280	257
Race†		
White	263 (99.6%)	248 (99.2)
Other	1 (< 1%)	1 (<1%)
Home		
Owned	255 (92.7%)	242 (96.4%)
Rented	20 (7.3%)	9 (3.6%)
No. years in current home	1-80 (mean 18.8)*	1-70 (mean 12.8)*
Age of respondents in years		
0-4	99	120
5-9	74	87
10-14	60	61
15-19	48	49
20-29	47	52
30-49	243	295
50-69	165	134
>70	86	41
Mean age of adults in years	50.6*	46.4*
Annual income		
< $15,000	11 %	5 %
$15,000-24,999	23 %	15 %
$25,000-39,999	31 %	26 %
$40,000-59,999	23 %	29 %
> $60,000	12 %	25 %
Type of home		
Working farm	44 %	26 %
Non-working farm	14 %	11 %
Country home	34 %	47 %
City/Village	4 %	9 %
Other	4 %	7 %
Number of current smokers	65 (14.6%)	54 (12.4%)
No. residents/household	1-8 (mean 2.9)*	1-8 (mean 3.3)*

† Race was based on female head of household response
*Statistically significant difference between exposure groups at $p \leq 0.05$.

Well characteristics

Most survey respondents obtained their water from a private well, however eight families lived in homes that were supplied by municipal water utilities (see Table 2). Tap water samples from two of these homes were high in nitrate. The majority of participants -- 85% in the high-exposure and 93% in the low-exposure cohort -- used their household water supply as their primary source of drinking water. Although many of the high-nitrate wells were less than 10 years old and more than 200 feet deep, the general tendency was for these wells to be older and shallower than the low-nitrate wells. Nitrate-contaminated wells were more likely to have been tested for nitrate at least once before the most recent test was done, and owners of these wells reported higher testing frequencies than owners of uncontaminated wells. Nitrate-contaminated wells were also more likely to have been tested for other contaminants. Of the wells that had been tested for these parameters, 10% of the high- and 9% of the low-nitrate wells contained unsafe levels of bacteria or pesticides.

Table 2. Well Characteristics and Testing Frequencies

	Exposure Group	
	High	Low
Nitrate-N level in mg/L	13-66 (mean 20.5)	0-2.0 (mean 0.5)
Average age of well in years	21.0*	15.7*
Source of household water		
Private well	98.6%	97.7%
Municipal water supply	1.4%	2.3%
Well depth in feet	18-340 (mean 114)*	9-452 (mean 144)*
No. (%) who had tested previously	178 (65%)*	128 (51%)*
Reported testing frequencies		
Once	35%	49 %
Less than once a year	40%	37 %
About once a year	20%	10 %
More than once a year	5%	4 %
Comparison to previous test result		
Most recent result higher	25 %	10 %
Most recent result lower	24 %	5 %
Results about the same	33 %	58 %
Not sure	18 %	27 %
No. who tested for other contaminants	131 (48%)	89 (36%)
No. with unsafe levels of -		
Pesticides	13*	2*
Bacteria	1*	5*

* Significantly different at $p \leq 0.05$.

Reasons for testing

Families were selected for this survey based on water analyses conducted by the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), the State Laboratory of Hygiene (SLH), or the Central Wisconsin Groundwater Center at the University of Wisconsin-Stevens Point (UWSP). The reasons that wellowners gave for testing their drinking water for nitrate are shown in Figure 1. The most commonly cited
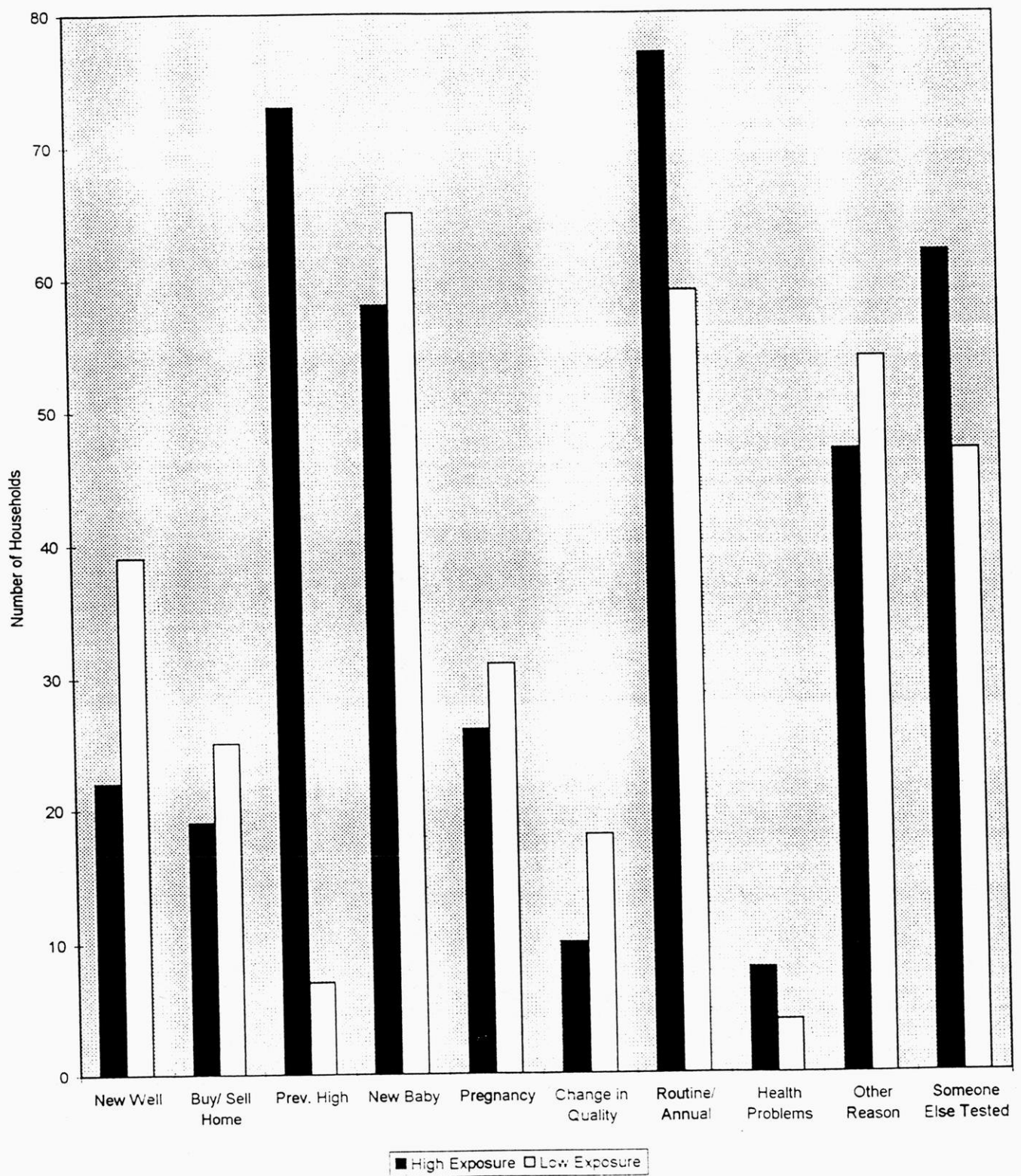
Figure 1. Reason for Testing

reasons were: 1) routine or annual test, 2) new baby/pregnancy, 3) testing conducted by someone else, and 4) previous high test result. Twelve respondents tested their wells because of human or animal health problems. In two of these cases, the specific health problem was not identified. Three cases involved health problems in cattle or horses. The remaining families in this group listed a variety of symptoms including sinus infections, skin rashes, gastrointestinal illnesses, and muscular aches and pains. Other reasons for testing included: a change in water quality, "wanted to know," pesticide contamination, elevated nitrate in neighboring well, test was offered free of charge, property sale/refinancing, newly installed well, or test needed for a daycare or organic farm license application.

Interpretation of test result and awareness of health advisories
Although most survey participants interpreted their laboratory result accurately, respondents in the high exposure group seemed less certain of their test result. Almost one-third of these families stated that their nitrate level was below the health advisory level or indicated that they were unsure about this (Table 3). In comparison, 88 % of the low-exposure families knew that their nitrate level was below the drinking water standard.

Table 3: Response to Health Advisories and Educational Information

	Exposure Group	
	High	Low
Did your nitrate result exceed the health advisory level?**		
Yes	169 (65%)	5 (2%)
No	38 (15%)	220(88%)
Not sure	51 (20%)	26(10 %)
% of Women aware of prenatal advisory	90%*	79%*
No. (%) who were familiar with the Nitrate in Drinking Water brochure	129 (46%)	70 (27 %)
No. (%) who contacted someone to discuss their nitrate result	88(31%)	41 (16%)
No. who contacted -		
Dept. of Natural Resources	33	4
Local/State Health Dept.	37	15
Health care provider	18	7
Other	27	22
% Who thought information was helpful	78 %	83 %

*Significantly different at $p \leq 0.05$.
**Respondents who had a new well or more recent test result were excluded.

Most respondents were not familiar with the *Nitrate in Drinking Water* brochure that is distributed by the Department of Natural Resources and by local health departments. Fewer than thirty percent of the low, and fifty percent of the high exposure respondents had seen the brochure. Awareness of the prenatal exposure advisory was high, however, with 90% of the women in the high exposure group knowing of the advisory that was issued in 1993.

Owners of nitrate-contaminated wells were almost twice as likely to have requested assistance or information about their test result as those with safe nitrate levels.

Department of Natural Resources' staff and local or state health officials were the most frequently identified contacts. Private health care providers, plumbers and county extension agents were also consulted by some families. Regardless of who they contacted, most respondents felt that the information they received was helpful.

Remedial actions

As shown in Table 4, less than one-third of the families in the high exposure group took action to reduce their nitrate exposure in response to their most recent test. The most common actions taken were purchasing bottled water, installing a nitrate-removal system, or hauling water from an alternate source. Seven percent of the families whose water contained low nitrate levels reported regular use of bottled or filtered water. This action may have been taken because of other water quality problems, such as bacterial contamination or poor taste.

Table 4: Actions Taken by Families in High Exposure Group

Action	Number	%	Average Cost
No action taken	189	70	0
Installed new well	6	2	$7,799
Repaired existing well	3	1	$745
Installed treatment system	16	6	$857
Purchased bottled water	43	15	$174 per year
Hauling water	10	4	0
Other	4	2	$83

Actions taken by families in the high exposure group appear to have been chosen based on their cost and effectiveness. Purchasing bottled water was the least expensive option costing less than $200 annually. Commercially bottled water is usually very low in nitrate and is considered safe for use by infants. Installation of a reverse osmosis unit is considerably more expensive costing an average of $857 with additional maintenance costs. Although reverse osmosis units have been approved by the Department of Commerce for use when nitrate-N levels are below 30 mg/L, they are not effective for removing higher levels of nitrate. In addition, they require regular maintenance and testing to ensure continued effectiveness. Very few families opted to install a new well or repair their existing well. This was probably due to the expense of these actions and the fact that neither guarantees a better water supply. An additional explanation for the popularity of bottled water might be that since the health advisory applies only to pregnant women and infants under six months of age, the easiest and least expensive compliance strategy is to purchase bottled water from the time a pregnancy is confirmed until the infant is six months old. If an infant is exclusively breastfed, the purchase of bottled water would only be necessary during pregnancy. The total cost of bottled water would be less than $300 per pregnancy.

Household income and nitrate levels were not predictive of actions taken by individual families. Households reporting the highest incomes and nitrate levels were no more likely to take action than others in the high exposure group (see Table 5). Instead the strongest predictor of whether a family took action was the presence of a pregnant woman or infant in the home. Fifty-five percent of families that reported a pregnancy or recent birth took some type of remedial action. This percentage may be an underestimate because the question specifically asked whether any action was taken as a result of the family's *latest nitrate test result*. Thus, families that were already using an

alternate source of water for an infant or pregnant woman when their latest test was done may have been counted as not having taken action.

Table 5: Predictors of Remedial Actions Taken By Families with Nitrate-Contaminated Wells

	Installed New Well	Installed Treatment System	Repaired Well	Bottled Water	Other	No. who took action/ No. in subgroup
Household income						
<$15,000	0	3	1	5	1	10/27 (37%)
$15-24,999	1	2	0	9	2	14/56 (25%)
$25-39,999	2	7	1	10	6	26/79 (33%)
$40-60,000	1	2	0	15	3	21/57 (37%)
>$60,000	1	1	0	2	2	6/28 (21%)
Not reported	1	1	1	2	0	5/33 (15%)
Nitrate-N level						
13-18 mg/L	2	5	1	20	8	36/131 (28%)
18.1-25 mg/L	2	7	1	12	4	26/93 (28%)
> 25 mg/L	2	4	1	11	2	20/56 (36%)
Other contaminants detected at unsafe levels	2	2	0	3	1	8/14 (57%)
Infants/pregnancies in home?						
Yes	0	2	0	18	5	26/48 (54%)*
No	6	14	3	25	9	56/232 (24%)
Ave. Nitrate-N level (mg/L)	20.5	21.3	25.6	21.4	19.4	

Analysis of chronic disease and cancer incidence

Chronic disease

In an effort to assess the health impacts of chronic ingestion of nitrate-contaminated drinking water, respondents were asked whether anyone in their household had been diagnosed with cancer or a chronic disease while living in their current home. Specific information was requested for hypertension, arthritis, fibromyalgia, and thyroid disorders. Thyroid disorder and blood pressure changes have been associated with exposure to nitrate-contaminated drinking water in previous studies.[11,18] Fibromyalgia and arthritis have not, to our knowledge been associated with nitrate-contaminated water before, however, bureau staff are frequently asked whether drinking water contamination could be a risk factor for these conditions. Families in the high exposure group reported thyroid disorders, arthritis, and fibromyalgia more frequently than families in the low-exposure group, however the differences in the prevalence of these illnesses were not statistically significant after adjusting for the residents' current ages (Table 6).

Table 6: Chronic Disease Incidence in High and Low Exposure Households

	No Cases		Crude		Age-Adjusted	
Disease	High	Low	Risk Ratio	95% CI	Risk Ratio	95 % CI
Hypertension	56	47	1.15	0.80-1.66, NS	0.82	0.56-1.21, NS
Arthritis	42	23	1.76	1.08-2.89, S	1.39	0.88-2.21, NS
Fibromyalgia	7	3	2.25	0.59-8.66, NS	2.08	0.52-8.37, NS
Thyroid Disorder	21	9	2.25	1.04-4.87, S	1.87	0.83-4.21, NS

S = Significant, NS = Not significant at p = 0.05

Other illnesses that were listed by survey participants included heart disease, diabetes, asthma, and emphysema. Unspecified heart disease was reported by eight families in the high-exposure group and by two families in the low-exposure group. Based on age-adjusted rates, heart disease was more prevalent in the high-exposure households, however this difference was not statistically significant (OR = 1.77, 95% CI 0.32-9.79; not significant). Rates for diabetes, asthma, and emphysema were similar in both exposure groups.

Cancer
Because ingestion of nitrate-contaminated water has been associated in other studies with a higher incidence of lymphoma and gastric cancer, respondents were asked whether anyone in their family had been diagnosed with cancer while living in their current home. Families that reported cancers were asked to provide information about the type of cancer, resident's age at the time of diagnosis, and the year of diagnosis. Cancer rates for families in the high and low exposure groups were evaluated by comparing the number of cases observed to the number expected based on the age distribution of that cohort. Expected rates for cancers of the breast, colon, lungs, prostate, and gastric, and lymphoma were calculated using 1985-1994 cancer-incidence data from the Wisconsin Cancer Reporting System. As shown in Table 7, none of the observed rates were significantly different than expected.

Table 7: Cancer Incidence in High and Low Exposure Families*

Tumor site	No. Observed	No. Expected	Obs./Exp. Ratio	95% CI
High Exposure				
Breast	3	5.8	0.5	0.10-1.30, NS
Colon	2	4.0	0.5	0.05-1.44, NS
Lymphoma	1	1.1	0.9	0.00-3.56, NS
Prostate	6	6.8	0.9	0.36-1.98, NS
Lung	1	5.97	0.2	0.00-0.66, S
Gastric	1	0.7	1.4	0.00-5.50, NS
Low Exposure				
Breast	4	4.3	0.9	0.24-2.06, NS
Colon	5	2.5	2.0	0.79-5.17, NS
Lymphoma	0	0.8	—	—
Prostate	3	4.7	0.64	0.14-1.79, NS
Lung	1	4.4	0.23	0.00-0.90, S
Gastric	0	0.4	—	—

*For cases diagnosed while in the current home from 1986-1995.
NS = Not significant, S = Significant at p = 0.05

Evaluation of Reproductive Outcomes
Due to concerns that have been raised regarding potential associations between maternal exposure to nitrate-contaminated water during pregnancy and adverse reproductive outcomes such as birth defects and spontaneous abortions, the female head of each household was asked to complete a general health and reproductive history questionnaire. Each woman answered questions about her general health, work history, diet, use of alcohol and tobacco products, and exposure to commercial-strength cleansers and pesticides. In addition, each woman who had a pregnancy within the last ten years completed a reproductive history questionnaire in which she provided information about her drinking water source, the amount of water she consumed during each pregnancy, and whether the pregnancy resulted in a full-term live birth, pre-term

live birth, birth defect, spontaneous abortion, or stillbirth.

As shown in Table 8, women in the high exposure group were slightly older and reported fewer pregnancies than women in the low-exposure group. There was no difference, however, in the ages of women in the two groups who had pregnancies during the last six years. Without adjusting for maternal water use, overall pregnancy success rates were similar for women in both cohorts. However, spontaneous abortions tended to occur two to three weeks earlier among women who lived in high-exposure households.

Table 8. Reproductive data for high and low-exposure groups

	Exposure Group	
	High	Low
No. of women aged 20-39 years	91	105
Ave. age of all women	49.6	45.3
No. women who reported a pregnancy	63	85
No. pregnancies reported	98	144
Ave. age of women who reported a pregnancy	33.3	33.7
% Receiving prenatal care in first trimester	92.5	95.2
No. women (aged 20-39) who reported fertility problems	17	22
Ave. birthweight for live births (pounds)	7.7	7.7
No. of low weight births (< 5 lb.)	0	3
No. of births involving a birth defect	1	3
No. of women who reported pregnancy losses	15	20
Ave. age of women who reported a loss	34.9	34.4
No. of stillbirths	1	1
No. of spontaneous abortions (SABs)	16	22
Ave. gestational age at time of SAB (in weeks)	7.1*	9.6*
Spontaneous abortion rate per 100 pregnancies	16.3	15.3

*Difference significant at p = 0.06.
Note: Pregnancies included in this analysis were limited to those that occurred in the current home since 1991 and did not include pregnancies that were ongoing at the time the survey was conducted.

Table 9 shows the effect of vegetables, cured meats, alcohol, caffeine, smoking, pesticides and commercial-strength cleaners on the incidence of spontaneous abortions. As shown, women who consumed alcohol or had daily caffiene intakes of 300 mg or more were significantly more likely to report a pregnancy loss than others. However, ingestion rates for vegetables and cured meats did not affect the risk of spontaneous abortion or stillbirth. The effect of pesticides and commercial-strength cleaners is difficult to assess since reporting was incomplete for these substances and few women reported using these chemicals more than three times per year . Non-significant increases in the incidence of spontaneous abortions were observed among women who used indoor insecticides and flea-control products, and among women who lived on working farms. However, women who used farm or lawn-care pesticides, or commercial-strength cleansers reported slightly fewer SABs than others. In addition, women who worked on farms and orchards did not report higher miscarriage rates.

Table 9. Effect of dietary, lifestyle, and occupational hazards on pregnancy loss

Exposure	No. Losses	No. Pregnancies	Relative Risk	95% CI
Vegetable intake				
< 3 servings/day	29	158	1.00	
≥ 3 servings/day	8	34	1.23	0.61-2.49, NS
Cured meat intake				
< 3 servings/week	28	130	1.00	
≥ 3 servings/week	9	62	0.72	0.36-1.44, NS
Alcohol intake				
None	15	113	1.00	
Any	22	79	1.86	1.02-3.39, S
Caffeine intake				
< 300 mg/day	28	170	1.00	
≥ 300 mg/day	9	22	2.05	1.07-3.93, S
Smoking history				
Never/Former	34	180	1.00	
Current	3	12	1.23	0.43-3.53, NS
Farm pesticide use				
Never	27	131	1.00	
Ever	10	61	0.82	0.42-1.61, NS
Lawn chemical use				
Never	22	96	1.00	
Ever	15	96	0.72	0.40-1.32, NS
Commercial cleansers				
Never	22	95	1.00	
Ever	11	82	0.63	0.32-1.23, NS
Indoor insecticides				
Never	19	116	1.00	
Ever	17	68	1.42	0.78-2.58, NS
Flea-control products				
Never	23	134	1.00	
Ever	10	47	1.20	0.61-2.36, NS
Live on a working or non-working farm				
No	20	114	1.00	
Yes	17	78	1.20	0.66-2.16, NS
Worked on a farm or orchard				
No	34	171	1.00	
Yes	3	21	0.75	0.25-2.27, NS

NS = Not significant, S = Significant at p = 0.05
Criteria for inclusion: Pregnancies must have occurred in the current home between 1991 and 1996; the home was not equipped with a nitrate-removal system; pregnancy ended before the survey was conducted.

Analysis of pregnancies that occurred among women in the high exposure group during 1991 through 1996 found that the incidence of spontaneous abortions and stillbirths decreased over this time period. As shown in table 10, almost 30% of the pregnancies that occurred during the 1991 to 1993 time period ended in a spontaneous abortion. By comparison, almost 90% of the pregnancies that occurred between 1994 and 1996 resulted in a live birth. The increase in successful pregnancies corresponded with a decrease in the amount of tap water women in high exposure households reported consuming during their pregnancies. Between 1991 and 1996, tap water consumption decreased from an average of 4.1 to 2.1 glasses per day. Nitrate intake estimates also decreased from 26.1 mg/day to 12.7 mg/day. These trends could be interpreted as a positive effect of the advisory for pregnant women that was issued in 1993. However, higher success rates during the 1994-1996 time period could also be an artifact of the study design. As explained in the Research Methods and Reasons for Testing sections of this report, study participants were selected from a pool of families whose water supplies were tested for nitrate between January 1994 and December 1996, and many

of these families reported "new baby" as a reason for having their water tested. None of the families indicated that they had tested because of a recent spontaneous abortion or stillbirth. This pattern of testing introduces a potential selection bias into the study that favors a higher prevalence of successful pregnancies during the time period when the water supplies were tested.

Table 10. Water and Nitrate Intake versus Pregnancy Outcomes for High Exposure Group

	1991	1992	1993	'91-'93	1994	1995	1996	'94-'96
Ave. no. of glasses of tap water consumed per day during pregnancy	4.1	3.0	3.2	3.4	3.1	2.6	1.9	2.6
Ave. nitrate-N intake (mg/day)	26.2	18.9	18.7	20.2	15.7	13.1	8.8	12.7
Number of live births	5	4	10	19	23	15	15	53
Number of spontaneous abortions	2	1	5	8	0	3	4	7
Abortion rate per 100 pregnancies	28.6	20.0	33.3	29.6	0	16.7	21.0	11.7

Criteria for inclusion: Pregnancies must have occurred in the current home between 1991 and 1996; the home was not equipped with a nitrate-removal system; pregnancy ended before the survey was conducted.

In Table 11, the incidence of spontaneous abortion is compared to drinking water nitrate levels and daily nitrate intake estimates. These analyses found a non-significant increase in pregnancy loss rates reported by women whose nitrate-N intake estimates were more than 10 mg per day. When analyzed by drinking water nitrate level, pregnancy losses were more prevalent among women whose water supplies contained more than 13.0 mg/L nitrate-N. Of 130 pregnancies in the low exposure group, 19 (14.6%) ended in a spontaneous abortion. By comparison, 17.5 % of pregnancies reported by women who consumed water that contained 13-20 mg nitrate-N per liter ended in a spontaneous abortion, and women whose water supplies contained nitrate-N levels greater than 20 mg/L reported a pregnancy loss rate of 18.8%. These rates are based on a small number of pregnancies and are not statistically significant at $p \leq 0.05$.

Table 11. Risk of Spontaneous Abortion versus Water Intake Variables

	No. Losses	No. Pregnancies	Risk Ratio	95% CI
Estimated Nitrate-N Intake				
0 -4.0 mg/day	19	131	1.00	
4.1-10.0 mg/day	3	20	1.03	0.34-3.18, NS
> 10.0 mg/day	9	52	1.19	0.58-2.46, NS
Water Supply Nitrate-N Level				
0 - 2.0 mg/L	19	130	1.00	
13.0 - 20.0 mg/L	7	40	1.20	0.54-2.64, NS
> 20.0 mg/L	6	32	1.28	0.56-2.95, NS

Criteria for inclusion: Pregnancies must have occurred in the current home between 1991 and 1996; the home was not equipped with a nitrate-removal system; pregnancy ended before the survey was conducted, and maternal tap water intake was at least 8 oz. per day.

Fourteen women consumed more than 20 mg of nitrate-N per day during pregnancies that occurred after the advisory for pregnant women was issued. Half of them were not aware of the advisory at the time of their pregnancies. Two women consumed contaminated water despite being aware that their nitrate levels exceeded the advisory.

The others knew of the advisory, but didn't know that their nitrate levels exceeded the drinking water standard. Four of these women appear to have misinterpreted their test result. The fifth woman in this group learned after giving birth that the public water supply serving her home had a nitrate-N level of 16.9 mg/L. She provided the following comment,

> "When I was pregnant with my first child I was completely unaware of the dangerously high nitrates in our city drinking water. . . I was very disappointed and outraged when I discovered the way in which this situation was made aware to the public (by posting in the newspaper and on the post office wall). We do not get the local paper and with a new baby, you don't make many trips to the post office. I felt that if the village . . . has the time to bill me for this water, they have the time to mail me a notice describing this high nitrate situation."

All but one of these women's pregnancies resulted in a full-term, live birth. One woman had a spontaneous abortion at 12 weeks gestation in 1996. She also reported a stillbirth that occurred in 1992 while she lived in the same residence. She indicated that she was unaware of the advisory and had consumed four to eight 8-oz glasses of tap water per day during these pregnancies. The nitrate-N level in her well was 21.7 mg/L when it was tested during the spring of 1994.

Birth Defects and Infant Health
Only four women in this study gave birth to infants with a birth defect. Three women in the low-exposure group reported giving birth to infants with spina bifida, pulmonary stenosis, and an undescended testicle. One woman in the high-exposure group delivered in infant with a malformation of the trachea. None of the women in our survey reported having a therapeutic abortion because of a malformation or genetic defect.

All of the infants that were born to survey respondents since 1990, were living at the time the survey was conducted. There were no reports of methemoglobinemia or "blue-baby syndrome" in this cohort, however one respondent whose well water contained a nitrate-N level of 39.6 mg/L reported that her child was made "sick" by their water. This child's illness may have been caused by microbial contamination of the water supply, or by elevated copper levels.

Ten women in the high exposure group reported using their household tap water to prepare infant formula, however two of them lived in homes that were equipped with a nitrate removal system. Four others were unsure whether their nitrate level exceeded the health advisory or stated that their nitrate level did not exceed the health advisory level. Since the nitrate advisory applies only to pregnant women and infants less than six months old, some families may have been using their water to prepare formula for older infants.

DISCUSSION
The purpose of this research was to improve our understanding of the social, economic, and human health impacts of nitrate-contaminated groundwater. The findings presented in this report suggest that this common environmental problem has a significant impact on the daily lives of many rural families. The inconvenience associated with having a nitrate-contaminated water supply is reflected by the observation that nearly one in five

families whose wells contained unsafe nitrate levels was purchasing bottled water or hauling water from another source. Many of the families that took these actions did so because of a pregnancy or new baby. Thus, the inconvenience and expense of these actions fell on families that may have been the least able to cope with them. The financial costs reported by families in the high-exposure cohort ranged from less than $100 to haul water from another source to $10,000 to install a new well. A total costs reported by survey respondents was $66,459. More than half of these costs were reported by families whose annual incomes were less than $40,000 and all of these expenses were apparently paid by well owners since nitrate-contaminated wells do not qualify for well compensation or environmental repair funds.

The vast majority of families whose wells were high in nitrate did nothing to reduce their exposure even though many of their water supplies had nitrate-N levels above 20 mg/L -- twice the level of the federal drinking water standard. This lack of action is consistent with the state health advisory which applies only to pregnant women and infants. Currently no secondary advisory exists for other individuals regardless of the nitrate level.

Families in the high-exposure group reported higher rates of heart disease, fibromyalgia, thyroid disorders, and arthritis than families in the low-exposure group. After age-adjustment, however, these differences were not statistically significant. An association between exposure to nitrate-contaminated water and thyroid dysfunction was first reported in 1994 when van Maanen et al. found a dose-dependent difference in thyroid size with hypertrophy of the gland being more common among consumers of water that contained more than 11 mg/L nitrate-nitrogen.[13] These researchers suggested that nitrate may interfere with the uptake of iodine by the thyroid. To our knowledge fibromyalgia, arthritis, and heart disease have not been associated with nitrate exposure previously. Our finding of higher rates of these conditions in the nitrate-exposed cohort could be the result of an association between nitrate-contaminated water and a secondary risk factor that was not controlled for in our study design, or as a result of *recall* or *selection bias*. Recall and selection bias occur when citizens who are very concerned about an illness or exposure are more responsive to a survey than citizens who are less concerned.

Most women who responded to this survey were aware of the advisory for pregnant women. In addition, compliance with the advisories for pregnant women and infants was very high. The fact that most of the women who responded to this survey had not consumed significant quantities of nitrate-contaminated water weakened our ability to evaluate the reproductive effects of nitrate exposure. Our analysis of reproductive outcomes found no increase in the risk of birth defects or low birth weights among infants born to women who drank nitrate-contaminated water during their pregnancies. Although, these women reported a slightly higher incidence of spontaneous abortions and an earlier gestational age at the time of loss, neither of these differences was statistically significant. Comparison of spontaneous abortion rates is difficult using a residential survey because these events are often unrecognized or not medically confirmed.

CONCLUSIONS

This research opportunity has provided several important insights into the ways that nitrate-contaminated groundwater affects the lives of Wisconsin families. It has also provided insights into the way that families cope with this common environmental problem. Major conclusions from this study are summarized below:

1) Most private wells were tested less than once a year for nitrate.
2) Other than families with pregnant women and infants, very few households took any action to reduce their nitrate exposure.
3) Many families who tested because of a pregnancy or new baby, tested late in the pregnancy or shortly after the birth.
4) Many families whose nitrate test result exceeded 12.9 mg/L, didn't know that their nitrate level was above the health advisory level.
5) Less than half of the respondents were familiar with the Nitrate in Drinking Water brochure.
6) Most women were aware of the advisory for pregnant women.
7) Compliance with the advisories for pregnant women and infants was high.
8) Non-significant increases were observed in the incidence of unspecified heart disease, thyroid disorders, arthritis, fibromyalgia, and spontaneous abortions among families that consumed nitrate-contaminated water.
9) Due a small number of pregnancies in our study population, we were unable to evaluate the effects of maternal nitrate exposure on the incidence of low birthweight or birth defects.
10) The expense and inconvenience caused by nitrate-contaminated groundwater appears to impact young, low-income families more than others.

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Appendix A

Letter of invitation

Survey

November __, 1996

Subject's Name
Address
Address

I would like to invite you to participate in a drinking water and health survey that is being conducted by the University of Wisconsin Department of Preventive Medicine. The purpose of this study is to improve our understanding of the health and financial impacts of nitrate-contaminated drinking water supplies. Your name was selected from a pool of people who had their water tested for nitrate by a state-funded laboratory in 1994-96. Although this research is unlikely to benefit you directly, it may be used to set future guidelines for drinking water in Wisconsin. We hope that you will assist us in this effort by completing the enclosed survey.

Please note that the survey is divided into two parts:

Part I - is a Household Survey which should be completed by an adult living in your home who is familiar with your well and your family's general health.

Part II - is a Women's Health Survey which should be completed by an adult female. This survey requests information about her health, lifestyle, and reproductive history.

If there are no adult females living in your home, please complete Part I and return the survey in the enclosed postage-paid envelope. I would like to assure you that your participation in this project is voluntary and that any information you provide will be handled in a confidential manner. Returned surveys will be destroyed following our analysis and reports will not include the names or addresses of study participants. The survey contains an identification number which will be used to check your name off when the survey is returned so that you do not receive a second mailing.

Thank you for taking the time to complete this survey. I appreciate your time and effort, and hope that you will feel free to call me at 608-266-7480 if you have any questions about this research or the survey.

Sincerely,

Carla Schubert
Project Coordinator

Department of Preventive Medicine

504 North Walnut Street   Madison. WI 53705-2368   608/263-2880   FAX 608/263-2820

HOUSEHOLD SURVEY

Thank you for taking the time to fill out this survey. For each question please circle one number or fill in blank unless otherwise indicated.

TODAY'S DATE_____

COUNTY OF RESIDENCE _____

1. How is your household's water supplied? (circle one number)

    1. PRIVATE WELL - Please list → Depth of Well _____(Feet)
                                    → Year Installed _____
    2. SHARED WELL
    3. CITY/MUNICIPAL WATER SUPPLY
    4. OTHER, PLEASE SPECIFY _____

2. What is your family's main source of <u>DRINKING</u> water? (circle one number)

    1. TAP WATER
    2. BOTTLED WATER
    3. WATER HAULED FROM ANOTHER SOURCE
    4. OTHER, PLEASE SPECIFY _____

3. When was the <u>last</u> time your household's water supply was tested for nitrate? (fill in **ALL** the blanks)

    A) DATE (month/year)   _____
    B) NITRATE RESULT   _____
    C) SOURCE TESTED   _____
    (For example: current well, old well, city water, etc.)

4. What was the reason(s) you had your water was tested for nitrate?
                          (circle ALL numbers that apply)
    1. INSTALLED NEW WELL
    2. BUYING HOME/ SELLING HOME
    3. PREVIOUS HIGH NITRATE TEST
    4. NEW BABY
    5. PREGNANCY
    6. CHANGE IN WATER QUALITY (ex: bad taste, odor, cloudy)
    7. ROUTINE OR ANNUAL TEST
    8. HEALTH PROBLEMS, PLEASE SPECIFY _____
    9. OTHER REASON, PLEASE SPECIFY _____
    10. WATER TEST SENT IN BY SOMEONE ELSE, PLEASE SPECIFY
                         _____

5. Have you had your <u>current</u> water supply tested for nitrate before this most recent test? (Circle one number)

      1. YES ➔ ➔ If **YES**, please answer questions **A, B & C**
                   A) YEAR FIRST TESTED_____(Approximately)
      2. NO

                   B) ABOUT HOW OFTEN DO YOU TEST FOR NITRATE?
                      (Circle one number)
                      1. LESS THAN ONCE PER YEAR
                      2. ABOUT ONCE A YEAR
                      3. MORE THAN ONCE A YEAR

                   C) HOW DID THE LAST NITRATE LEVEL COMPARE TO THE PREVIOUS LEVEL(S)? (Circle one number)

                      1. LAST NITRATE RESULT HIGHER
                      2. LAST NITRATE RESULT LOWER
                      3. LEVELS WERE ABOUT THE SAME
                      4. NOT SURE

6. Did your most recent nitrate test result exceed the state health advisory level?

      1. YES
      2. NO
      3. DON'T KNOW

7. Please indicate what action, if any, was taken as a result of your most recent nitrate test result.   (circle one number and fill in corresponding blanks if indicated)

      1. NO ACTION TAKEN
      2. INSTALLED NEW WELL
      3. REPAIRED EXISTING WELL
      4. INSTALLED NITRATE REMOVAL SYSTEM
      5. PURCHASED TO BOTTLED WATER
      6. CONNECTED TO MUNICIPAL OR SHARED WATER SUPPLY
      7. HAULING WATER FROM ANOTHER KNOWN SAFE SOURCE
      8. OTHER, PLEASE SPECIFY _____

8. Please indicate the **cost** and **date** of any action taken(in question # 7). If no costs were incurred, please write 0.

      A) COST OF ACTION   _____(Estimate cost/year if
                                                     buying water)

      B) DATE ACTION TAKEN _____
                           (Month and Year)

9. Are you familiar with the *NITRATE IN DRINKING WATER* brochure?

      1. YES, I AM FAMILIAR WITH THE BROCHURE
      2. NO, I AM NOT FAMILIAR WITH THE BROCHURE
      3. NOT SURE

10. Did you contact anyone to discuss your nitrate test results? (circle one number)

      1. YES ➔ ➔ If you answered **YES**, please answer questions **A & B**.
      2. NO

              A) Who did you contact? (circle **all** that apply)

                  1. DEPARTMENT OF NATURAL RESOURCES
                  2. COUNTY AGENT
                  3. COUNTY OR STATE HEALTH DEPARTMENT
                  4. HEALTH CARE PROVIDER
                  5. OTHER, PLEASE SPECIFY _____

              B) Was the information helpful?

                  1. YES
                  2. NO
                  3. NOT SURE

11. In the last five years has your well been tested for any other contaminants, such as atrazine, triazines or other pesticides? (circle one number)

      1. YES ➔ If you answered **YES** please indicate **what you tested for** and the
          results-list as either **above** or **below** health advisory level

          <u>CONTAMINANT</u>   <u>RESULT</u>

          _____   _____
          _____   _____
          _____   _____

      2. NO
      3. NOT SURE

THE LAST FEW QUESTIONS ON THE HOUSEHOLD SURVEY ARE ABOUT YOUR HOUSEHOLD'S HEALTH AND LIVING ENVIRONMENT.

13. Do you own or rent the home in which you live?

      1. OWN
      2. RENT

14. Which of the following categories best describes your total 1995 household income for 1995? (Before taxes)   (circle one number)

    1. LESS THAN $15,000
    2. $15,000-24,999
    3. $25,000-39,999
    4. $40,000-60,000
    5. MORE THAN $60,000

15. Which of the following best describes the location of your home?
(circle one number)
    1. WORKING FARM OR ORCHARD
    2. NON-WORKING FARM
    3. COUNTRY HOME- NOT ON A FARM
    4. CITY OR VILLAGE
    5. OTHER, PLEASE SPECIFY _____

16. Please fill out the table for **all people** living in your household

	AGE	CHECK GENDER (√) M	F	NUMBER OF YEARS LIVED AT THIS RESIDENCE	CURRENT SMOKER (√) YES	NO	OCCUPATION (If older than 18)
1							
2							
3							
4							
5							
6							
7							
8							

17. While living in your current home, has anyone in your household been diagnosed with a cancer, lymphoma, or leukemia? (circle one number)

    1. YES � If you answered **YES**, please list type of cancer, year diagnosed and age when diagnosed.

TYPE OF CANCER	YEAR DIAGNOSED	AGE WHEN DIAGNOSED
_____	_____	_____
_____	_____	_____
_____	_____	_____

    2. NO

18. **While living in your current home**, has anyone in your household been told by a doctor that they have any of the following chronic diseases? (Please list **year** diagnosed and **age** when diagnosed for all persons with disease, if more than one person in your household has the same disease please list all years, and ages on the same line. Ex: year-1992, 1994, age 52, 45)

DISEASE	YEAR(S) DIAGNOSED	AGE(S) WHEN DIAGNOSED
1. HIGH BLOOD PRESSURE	_____	_____
2. ARTHRITIS	_____	_____
3. FIBROMYALGIA	_____	_____
4. THYROID DISORDER	_____	_____
5. OTHER, PLEASE LIST		
_____	_____	_____
_____	_____	_____

_____ CHECK(√) HERE IF NO ONE IN YOUR HOUSEHOLD HAS A CHRONIC DISEASE

END OF HOUSEHOLD SURVEY

Please have the female head of household continue with the woman's survey. If there is no female over the age of 18 in your household available to fill out this part of the survey please return the survey booklet with the completed household survey in the envelope provided.

WOMAN'S SURVEY

This part of the survey is to be filled out by the female head of household- 18 years of age or older.
First we have some general health and lifestyle questions.

Your present age _____

1. What is the highest grade or year of school that you completed?
   (Circle one number)
   1. TWELFTH GRADE OR LESS
   2. HIGH SCHOOL GRADUATE, G.E.D., OR EQUIVALENT
   3. TECHNICAL SCHOOL GRADUATE
   4. COLLEGE GRADUATE
   5. POST COLLEGE DEGREE- MASTERS, PhD., etc.

2. Which statement(s) best describes your current employment?
   (Circle **ALL** that apply)
   1. HOMEMAKER
   2. HOME BASED BUSINESS-NOT A FARM
   3. WORK AWAY FROM HOME
   4. WORK ON A FARM OR ORCHARD
   5. RETIRED
   6. UNEMPLOYED/LOOKING FOR WORK

3. Which statement best describes your racial or ethnic identification?
   (Circle one number)
   1. AFRICAN-AMERICAN (BLACK)
   2. WHITE
   3. HISPANIC
   4. AMERICAN INDIAN (NATIVE AMERICAN)
   5. OTHER

4. How many servings of <u>vegetables</u> do you usually eat a day? (Circle one number)
   (1 serving= approximately ½ cup)
   1. NONE
   2. 1-2 SERVINGS PER DAY
   3. 3-4 SERVING PER DAY
   4. 5 OR MORE SERVINGS A DAY

5. How often do you eat preserved, smoked or cured meats such as ham, sausages, bacon, hot dogs, smoked fish, or luncheon meats?   (Circle one number)

   1. NEVER
   2. 1-2 TIMES PER WEEK
   3. 3-5 TIMES PER WEEK
   4. 6-7 TIMES PER WEEK
   5. 8 OR MORE TIMES PER WEEK

6. On average, how many 8 ounce glasses of water a day do you drink from your home tap, including beverages or foods made from water such as juice, coffee, or soups?   (Circle one number)

   1. NONE
   2. 1-3 GLASSES A DAY
   3. 4-6 GLASSES A DAY
   4. 7-9 GLASSES A DAY
   5. 10 OR MORE GLASSES A DAY

7. On average, about how many alcoholic beverages do you drink per week? (One drink is equal to one glass of wine(4 oz.), one beer(12 oz.) or 1½ oz. of hard liquor)
                    (Circle one number)
   1. NONE
   2. 3 DRINKS OR LESS PER WEEK
   3. 4-6 DRINKS PER WEEK
   4. 7-14 DRINKS PER WEEK
   5. MORE THAN 15 DRINKS PER WEEK

8. How much of the following <u>caffeinated</u> beverages do you drink, on average, per day?   (Please fill in all blanks, if none write 0)

COFFEE _____ Cups/day
TEA   _____ Cups/Glasses/day
SODAS _____ 12 oz. Cans/day
    (COLAS, MOUNTAIN DEW, DR. PEPPER)

9. What is your smoking history? (Circle one number and fill in blanks if indicated)

    1. CURRENT SMOKER → Please answer **A & B**
        A) How many packs per day you smoke? _____
        B) How many years you have smoked?_____
    2. FORMER SMOKER → Please answer **A, B &C**
        A) How many packs per day did you smoke? _____
        B) How many years did you smoke?_____
        C) How many years since you quit? _____
    3. I HAVE NEVER SMOKED REGULARLY

10. In the last five years how often were these chemicals used in or around your home?
    (**Please check one box on <u>every line</u>**)

CHEMICAL	Never	1-3 times/yr	4-8 times/yr	> 8 times/yr
LAWN CARE PRODUCTS	☐	☐	☐	☐
FLEA CONTROL PRODUCTS	☐	☐	☐	☐
INDOOR INSECTICIDES	☐	☐	☐	☐
COMMERCIAL STRENGTH CLEANERS	☐	☐	☐	☐
AGRICULTURAL PESTICIDES	☐	☐	☐	☐
OTHER CHEMICALS PLEASE SPECIFY TYPE_____	☐	☐	☐	☐

11. Do you currently take any prescription medications?

    1. YES → Please list the medications you take_____
        _____

    2. NO

12. Have you been hospitalized for a reason other than childbirth in the last five years?

    1. YES- Please list reason(s) _____
    2. NO

NEXT WE HAVE SOME QUESTIONS ABOUT YOUR REPRODUCTIVE HISTORY. PLEASE REMEMBER THAT ALL ANSWERS ARE CONFIDENTIAL.

13. Are you aware of the State Health Advisory that recommends that pregnant women avoid drinking water that is high in nitrate?

    1. YES
    2. NO

14. Has a Doctor or Nurse ever told you that you have had one of the following conditions or diseases? (Please circle **all** numbers that apply)

1	ENDOMETRIOSIS	8	SYPHILIS
2	POLYCYSTIC OVARIES	9	GONORRHEA
3	OVARIAN CANCER	10	CHLAMYDIA
4	UTERINE CANCER	11	GENITAL HERPES
5	CERVICAL CANCER	12	INFERTILITY PROBLEMS
6	ENDOMETRIAL CANCER	13	UTERINE FIBROIDS
7	PELVIC INFLAMMATORY DISEASE	14	GESTATIONAL DIABETES

_____ **CHECK HERE IF YOU HAVE HAD NONE OF THE LISTED CONDITIONS OR DISEASES**

15. Have you ever tried for 12 months or more to become pregnant without success?

    1. YES
    2. NO

16. How many times have you been pregnant? _____(If none, write 0)

17. Have you had a pregnancy, including miscarriage or stillbirth, **in the last 10 years**(since 1986)? (Circle one number)

    1. YES ➜ **Please continue with question #18 on the next page.**
    2. NO ➜ If you answered **NO** you are done with this survey. Please return whole survey in postage paid envelope provided. Thank You.

18. Please fill out this table for all your **LIVE BIRTHS**, starting with the most recent pregnancy and working back. Please fill in **all** blanks for each birth as directed.

_____ CHECK (√) HERE IF CURRENTLY PREGNANT

_____ CHECK (√) IF YOU HAVE HAD NO LIVE BIRTHS AND PLEASE **SKIP** TO QUESTION **# 19**

(If you have had more than 8 pregnancies, please list information for the 8 most recent ones.)

Pregnancy number	#1	#2	#3	#4	#5	#6	#7	#8
Birth Date-**Month** and **Year** (of child)								
Birth Weight in **Pounds**								
Week in pregnancy that prenatal care began-(write **1, 2, etc.**, if none write **0**)								
Write **FULL** if pregnancy went to term, or write **PRE** if it was a premature delivery.								
Did this child have any birth defects? Write **YES** or **NO**- if YES, please list type of defect below.*								
Did you live in current home at time of this pregnancy? (write **YES** or **NO**)								
Did a doctor ever tell you this child had "blue baby" syndrome or nitrate poisoning? (Write **YES** or **NO**)								
Did you use your current home's tap water to make formula for this child? (Write **YES** or **NO**)								
Is this child still living? (write **YES** or **NO**)								
About how many **8 oz. glasses of water per day** did you drink from your home tap during this pregnancy?								
Was there a nitrate removal system on your home's drinking water at this time? (Write **YES** or **NO**)								

*Please list type of birth defects here, use the pregnancy number from table above to indicate which child had the birth defect._____

19. <u>While living in your current home</u>, have you ever had a therapeutic abortion for a severe or life-threatening birth defect?   (Circle one number)

   1. YES → IF YES, PLEASE LIST YEAR_____
   2. NO

20. Have you ever had a miscarriage (spontaneous abortion) or stillbirth ?
   1. YES → **Please continue with question # 21 on the next page.**
   2. NO → You are done with this survey. Thank you.
   3. NOT SURE → You are done with this survey. Thank you.

21. For each of your **4 most recent** miscarriages or **stillbirths** please fill out the following table with regard to the time you **were pregnant and the 3 months preceding that pregnancy. Please fill in ALL the blanks for EACH of your lost pregnancies.**

	#1	#2	#3	#4
Month and Year Pregnancy lost (ex: 1/11)				
Week of Pregnancy that loss occurred (ex: write week 1, 2 etc.)				
Was pregnancy confirmed by a doctor or nurse? (**YES or NO**)				
Was the loss of the pregnancy confirmed by a doctor or nurse? (**YES or NO**)				
Were you receiving pre-natal care at this time? (**YES or No**)				
Was this a multiple(twins, triplets) pregnancy? (Write **YES or NO**)				
Please indicate the **number of 8 ounce glasses of water a day** you drank from your home tap during this time? (Include beverages made from tap water like coffee or juice) (**if none, write 0**)				
Was there a **nitrate removal system** on your **tap water** at home at this time? (Write **YES or NO**)				
How many **cups of coffee** were you drinking a day, at this time? (**If none, write 0**)				
Were you smoking cigarettes at this time? (Write **YES or NO**)				
Please list any **medications** or **drugs** you were taking at this time. (**If none, write 0**)				
Were you taking any vitamin supplements at this time? (Write **YES or NO**)				
Were you using and electric blanket or heated waterbed at the time? (Write **YES or NO**)				
Did you use a hot tub or sauna during this time? (Write **YES or NO**)				
What was your **main occupation** at this time? (Please list)				
How many **hours per week** were you **working away** from the home or farm at this time? (If none, write 0)				

Thank you for completing this survey. Your cooperation is greatly appreciated.