# White Paper

**BARIUM EXPOSURE INVESTIGATION**

**TENNESSEE**

SEPTEMBER 12, 2014

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This document has not been formally reviewed and cleared by ATSDR.

# Foreword

This document summarizes an environmental public health investigation performed by the Environmental Epidemiology Program of the State of Tennessee Department of Health. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

*Evaluate Exposure:* Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

*Evaluate Health Effects:* If people have the potential to be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, clean-up actions, and the scientific literature.

*Make Recommendations:* Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of the Environmental Epidemiology Program in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory warning people of the danger, and will work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

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# Introduction

In 2014, the Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) assisted with a barium exposure investigation. A medical doctor reported a patient with an elevated amount of barium in blood with no known exposure source. The doctor asked for EEP's assistance to determine if there was something in the patient's home environment or social behavior that could result in elevated barium.

EEP enlisted the help of several agencies to assist with the investigation, including: the Tennessee Poison Center (TPC), Agency for Toxic Substances and Disease Registry (ATSDR), Tennessee Department of Environment and Conservation (TDEC), the U.S. Environmental Protection Agency (EPA).

Based on toxicology and with the contributions from each agency, EEP created an 82-question survey and methodology for a home inspection. Together these were used to understand the individual's medical history, gain knowledge about the home environment, gather more information about the routine habits of the individual, and learn about what took place in the days leading up to the detection of barium in the individual's blood.

EPA's On-Scene Coordinator (OSC) provided an emergency response coordinator, contractor personnel, and testing equipment to assess any potential barium sources in and around the home.

The purpose of this report is to document the efforts made trying to find possible sources of barium exposure. Our barium questionnaire is attached in the appendix to share with other risk assessors or public health professionals who may need to perform a barium exposure investigation. An explanation of the toxicology of barium and our home inspection follows.

## Discussion

When asked to determine whether persons have been or are likely to be exposed to chemicals, health risk assessors evaluate mechanisms that could lead to human exposure. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to a contaminant if they come into contact with it. An exposure pathway contains five parts:

- a source of contamination,
- contaminant transport through an environmental medium,
- a point of exposure,
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence all five of these elements have been, are, or will be present. An exposure pathway is considered incomplete if one of the five elements is missing.

For this investigation, the home, surrounding area, diet, work, hobbies, and behaviors were all considered as a potential exposure source. Environmental media such as soil, water, or air, can transport contaminants. For barium, the most important transport mechanism would be food, drink, dust, or residue. The point of exposure is the place where a person came into contact with the chemical. Working under the assumption that something in the house was causing the individual's elevated blood barium level, the point of exposure would be something the individual would eat, eat from, drink, or drink from. The route of exposure is the way the contaminant enters the body. Eating or drinking something containing barium could cause an elevated blood barium level.

A chemical's ability to affect health is controlled by a number of other factors, including:

- the amount of the chemical that a person is exposed to (dose),
- the length of time that a person is exposed to the chemical (duration),
- the number of times a person is exposed to the chemical (frequency),
- the person's age and health status, and
- the person's diet and nutritional habits.

It was unknown if the patient's elevated barium level was the result of acute or chronic exposure. Though, the patient's experience of sudden onset of severe symptoms, leading them to seek emergency medical care, suggested the possibility of ingesting a large amount of barium over a short period of time.

This investigation was focused on one individual with an elevated blood barium level. If there was an environmental source of barium in or around the home, other family members could also have been exposed. Together, the medical provider and EEP encouraged all family members to have their blood barium levels checked.

## Toxicology

Our starting point for understanding barium toxicology was ATSDR's *Toxicological Profile for Barium* (2007). To be inclusive, we considered all possible references including texts, journal articles, and online searches of media articles. Each of the contributing agencies gathered toxicological information to help assist the doctor and to create the exposure questionnaire.

Barium (CAS No. 7440-39-3) is a naturally occurring element. It is a soft metallic alkaline earth metal. Because of its high reactivity, barium is not found as a free element in nature. Barium is most often found in underground ore deposits. Barium is often found as the compounds barium sulfate and barium carbonate. These barium salts commonly appear as white crystals or powder. Small amounts of barium can be found naturally in water, soil, and food.

Background levels of barium in the environment are very low. Most surface water and public water supplies contain on average 30 micrograms of barium per liter of water (µg/L) or less, but can average as high as 300 µg/L in some regions of the United States. Water from underground wells has a wider range of barium levels, sometimes exceeding 2,000 µg/L. The amount of barium found in soil ranges from about 15 to 3,500 mg/kg. Some foods, such as nuts, seaweed, fish, and certain plants, may contain greater amounts of barium. The amount of barium in food and water is usually not enough to be a health concern (ATSDR 2007).

Because certain barium compounds, such as barium sulfate and barium carbonate, do not mix well with water, the amount of barium in drinking water is usually small. Other barium compounds, such as barium chloride, barium nitrate, and barium hydroxide, are manufactured from barium sulfate. Barium compounds, such as barium acetate, barium chloride, barium hydroxide, barium nitrate, and barium sulfide, dissolve more easily in water than barium sulfate and barium carbonate. Because these compounds are not commonly found in nature, they are not typically found in drinking water. Barium sulfate does not dissolve in the stomach. Barium carbonate can be harmful if eaten because it will dissolve in the acids within the stomach.

Eating or drinking very large amounts of barium compounds that dissolve in water or in the stomach can cause changes in heart rhythm or paralysis in humans. Barium blocks cellular efflux of potassium resulting in profound hypokalemia. Symptoms following an acute high dose include perioral paresthesias, vomiting, diarrhea, weakness, paralysis, hypertension, and cardiac dysrhythmias (CDC 2014). Some people who eat or drink somewhat smaller amounts of barium for a short period may experience vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness (ATSDR 2007).

Clinical evaluation of barium would suggest it should not be present in blood in significant amounts. Standard laboratory test results may flag any amount of barium in blood above the detection level. When our investigation was on-going, the National Health and Examination Survey (NHANES) had limited information about urine barium levels and did not seem to track blood barium levels in the general population. Only a few references to a normal or background level of barium in the blood of people were located. ATSDR assisted with a possible barium exposure investigation near a hazardous waste site called the Cox Road Dump Site in Texas

(ATSDR 2006). Their research found a few references in the scientific literature about normal ranges for barium in blood. Consolidating their referenced studies, a normal range for blood barium levels would be between 30 and 400 micrograms of barium per liter of blood (µg/L). ATSDR suggested blood barium levels more than four times higher than this range would be needed to witness significant clinical signs or symptoms of barium poisoning.

Even after a literature search, it was unknown whether children would be more or less sensitive to barium exposure compared to adults. Limited data seemed to exist on which to make an assessment of possible childhood susceptibility (EPA 2014a). Gastrointestinal absorption data suggest that barium absorption may be higher in children than in adults. One study in rats that swallowed barium showed a decrease in newborn rat body weight; it is unknown if a similar effect would be seen in humans.

Health guidance values, also called comparison values, have been developed by toxicologists and risk assessors to estimate levels of human exposure without appreciable risk of adverse health effects. ATSDR and EPA have published health guidance values for barium. Guidance values for soil and water were important in this investigation which focused on ingestion. Since the soil values were derived for ingestion of solids, soil values were also used as a proxy for food.

ATSDR publishes Minimal Risk Levels (MRLs). These daily exposure doses are estimated amounts not expected to result in adverse noncarcinogenic health effects. The chronic (>365 days) and intermediate (>14-364 days) MRLs for barium are the same at 0.2 milligrams of barium per kilogram body weight per day (mg/kg/day). Based on standard exposure assumptions, some guidance values are presented as screening concentrations. The chronic soil Environmental Media Evaluation Guide (EMEG) comparison values for barium were 10,000 milligrams of barium per kilogram of soil (mg/kg) for a child and 140,000 mg/kg for an adult. Intermediate EMEGs for barium were the same as the chronic values. An additional guideline for barium for a child with pica eating disorder was set at 400 mg/kg (ATSDR 2007). EPA also developed health comparison values for barium. EPA's soil comparison values are called Regional Screening Levels (RSLs). The residential RSL for barium was 1,500 mg/kg (EPA 2014b). A mg/kg is equivalent to a ppm. Table 1 lists soil ingestion health guidance values.

**Table 1. Health Guidance Values for Barium in Residential Soil, July 2014.**

| ATSDR MRL<br><br>soil | ATSDR EMEG<br>adult<br>soil | ATSDR EMEG<br>child<br>soil | EPA RSL<br><br>soil |
|---|---|---|---|
| 0.2<br>mg/kg/day | 140,000<br>mg/kg | 10,000<br>mg/kg | 1,500<br>mg/kg |

mg/kg = milligram per kilogram
MRL = minimal risk level
EMEG = environmental media evaluation guide
RSL = residential screening level

Health guidance values are also derived for the ingestion of liquids. The standard assumption is children ingest 1 L of water per day and adults 2 L per day. ATSDR's chronic EMEG tap water screening level for barium was 2,000 micrograms of barium per liter of water (µg/L) for children and 7,000 µg/L for adults. EPA's RSL for tap water was 290 µg/L. EPA's drinking water Maximum Contaminant Level (MCL) established the highest level of a chemical allowable in public drinking water. EPA's MCL for barium is 2,000 µg/L. A µg/L is equivalent to a ppb. A summary of these drinking water health guidance values is shown in Table 2.

**Table 2. Health Guidance Values for Barium in Drinking Water, July 2014.**

| ATSDR EMEG adult water | ATSDR EMEG child water | EPA RSL water | EPA MCL water |
|---|---|---|---|
| 7,000 µg/L | 2,000 µg/L | 290 µg/L | 2,000 µg/L |

Barium has not been shown to cause cancer in humans or in experimental animals drinking barium in water. The Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) have not classified barium as to its carcinogenicity (NTP 2005, IARC 2004). EPA has determined barium is not likely to be carcinogenic to humans following ingestion (EPA 2014a).

Barium carbonate has been used as an active ingredient in rodenticides (CDC 2014). Barium sulphide has been used in ceramic glazes to color or finish clay pieces (Thomas et al 1998). Barium chlorate has been used in fireworks to produce green color (Rhyee and Heard 2009).

## Questionnaire Preparation

Various resources were used as templates for questions in our exposure survey. Questionnaires for heavy metals, lead, and other chemical exposures from the Centers for Disease Control and Prevention (CDC) and ATSDR were used as the basis for our survey. Questions were added based on our understanding of the situation and feedback from the patient's medical doctor, ATSDR, EPA, TDEC, and TPC. The 82-question barium exposure survey was used during a scheduled telephone call with the family.

The survey attempted to discover possible sources of barium in the individual's daily routine or environment. Questions were asked about the individual's household, occupational, medical, social, and travel histories as well as behaviors, family habits, food habits, environmental conditions, water source and use, and neighborhood. Specific questions were asked about what the individual and their family did the day before and on the day of his most recent illness onset.

The exposure questionnaire took more than 90 minutes to administer. After extensive questioning and conversation, no obvious potential sources of barium exposure were identified. The individual did not have a history of anything with known barium exposure potential including their diet, habits, work, or hobbies. With encouragement from the medical doctor and no leads from the questionnaire, it was decided a site visit would be useful to rule out the home as a potential source of environmental exposure.

**Home Investigation and Environmental Media Sampling**

Our investigation team coordinated with the family to schedule the environmental investigation of their home. The home investigation was conducted by staff from EEP, TDEC, EPA, and EPA's contractor. An access agreement was signed by the homeowners to allow access to the home, testing, and confirmatory media sampling.

Before arriving at the site, satellite imagery, such as what is available on Google Earth (2014), was viewed to determine past and present land use. Our environmental regulatory agency checked for hazardous waste sites, permitted industries, or past incidents that might have released barium in the geographic area. No historical waste sites, industries, or incidents were identified nearby as potential sources of barium.

Our team of investigators noted characteristics of the home including:

- Construction type
- Foundation type: slab, crawlspace, or basement
- Age of home
- Yard: soils, grass cover, and drainage
- Water source: drinking, cooking, cleaning, washing, and bathing

EPA's contractor used a portable x-ray florescence (XRF) detector to analyze household items for barium. The unit was pre-calibrated. When a sample is measured using XRF, each element present in the sample emits its own unique fluorescent x-ray energy spectrum. By simultaneously measuring the fluorescent x-rays emitted by the different elements in the sample, the detector can rapidly determine those elements present in the sample and their relative concentrations – in other words the elemental chemistry of the sample. Although the XRF measured several elements at once, for this investigation we only were interested in barium.

Our purpose of testing inside and outside the home was to rule out possible source(s) of environmental exposure. With access to the entire property, we thoroughly went through the home and garage, opening all doors to rooms, closets, and cabinets. Based on the number of household items to test, we spent more time in the garage and kitchen. Our team thoroughly searched for potential sources of barium. We tested many foods, spices, cookware, plates, cups, medicines, toys, furniture, bedding, decorations, painted walls and ceilings, hunting and fishing gear, outdoor items, vacuum cleaner dust, air filter, and dryer lint. Items that were unlabeled or resembled a crystalline or powdery substance were tested.

The XRF was used outside the home. We tested the car seats and floor mats in the family's vehicles checking for traces of barium. We collected several samples of soil from around the property to test. Native soil was tested. Fill soil, likely brought in as top soil, was also tested. Table 3 lists the barium content measured in some household items and building materials tested. The results were reported in ppm which is equivalent to mg/kg.

**Table 3. Barium content of Household Items reported in parts per million by XRF.**

| Household item | measurement in ppm | ± error amount |
|---|---|---|
| textured wall | 80 | ± 30 |
| smooth ceiling | 130 | ± 34 |
| decorative rocks | 760 | ± 35 |
| ceramic floor tile | 580 | ± 35 |
| kitchen countertop | nd | ± 15 |
| kitchen floor tile | 690 | ± 37 |
| dinner plate | 280 | ± 26 |
| stoneware cup | 70 | ± 26 |
| cooking pan | 120 | ± 26 |
| iodized table salt | 470 | ± 39 |
| sea salt | 490 | ± 40 |
| corn flour | nd | ± 16 |
| classic roast coffee | nd | ± 18 |
| sugar | nd | ± 14 |
| car floor mat | 180 | ± 28 |
| fishing bait | nd | ± 22 |
| vacuum cleaner dirt | nd | ± 25 |

Many household items contained little to no barium, as measured by the XRF. The household items with highest barium content included salts, decorative rocks, kitchen floor tile, and dinner plates. These results were not surprising as barium is present in nature in salts and clays.

### Environmental Sampling Results

The XRF worked well to provide instantaneous information. A few confirmatory media samples were sent to our state laboratory for more traditional analysis. We collected and analyzed a sample of drinking water from the kitchen tap. Two five-point composite soil samples were collected from the yard. One representing original soils and one representing soils used to fill and grade. We also collected household dust and debris from the family's vacuum cleaner. The amount of barium measured in each environmental sample is listed in Table 4. All confirmatory media results were appropriately low compared to the health guidance values presented in Tables 1 and 2.

**Table 4. Barium test results for confirmatory media samples analyzed by the Tennessee Department of Health's Laboratory Services.**

| Sample | Tap Water | Surface Soil 1 | Surface Soil 2 | Vacuum Cleaner Dust |
|---|---|---|---|---|
| Barium | 20 µg/L | 40 mg/kg | 40 mg/kg | 190 mg/kg |

mg/kg = milligram per kilogram
MRL = minimal risk level
EMEG = environmental media evaluation guide
RSL = residential screening level

## Conclusion

While Public Health agencies work most often at the population health level, sometimes we need to work at a much smaller level. Our two-part exposure investigation, using an extensive questionnaire and site visit, was a thorough effort to attempt to identify potential sources of barium in a home environment or social behaviors. Our exposure investigation did not find any environmental sources of barium that would lead to an elevated blood barium level in a person. Our methodology could not rule out potential exposure sources beyond the home nor any type of intentional exposure.

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# Certification

This *White Paper: Barium Exposure Investigation* was prepared by the Tennessee Department of Health's Environmental Epidemiology Program. It was prepared in accordance with the approved methodology and procedures that existed at the time the health document was begun.

Director of EEP, CEDEP, TDH

# Barium Exposure Questionnaire

1. Age: _____ Sex: _____ Date: _____

**Household Questions:**

2. Do you rent or own your home? ☐ Rent ☐ Own

3. Please list all of your residence(s) for the past 5 years.

| Date of Residency | Rent or Own | Address | Approximate Age of Dwelling | General Condition of Dwelling |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

4. Did you change your residence because of a health problem?
   ☐ Yes ☐ No
   *If yes*, explain the health problems. _____

5. If yes, how long did you live in the home where your symptoms began?
   _____

6. How old is the house and any out buildings?
   _____

7. Did you have similar symptoms in any of your previous residences? ☐ Yes ☐ No

8. Have you ever renovated an old house? ☐ Yes ☐ No

9. Have you recently acquired new furniture or carpet, refinished furniture, or remodeled your home?
   ☐ Yes ☐ No ☐ Don't know

10. Which of the following do you have in your home?
    ☐ Air conditioner ☐ Air purifier ☐ Central heating/cooling ☐ Gas stove
    ☐ Electric stove ☐ Fireplace ☐ Wood stove ☐ Humidifier

11. How often do you change your air filters? _____

12. Did you notice anything unusual in your home?
☐ Yes ☐ No ☐ Don't know
*If yes*, please explain:
_____

13. Have you weatherized your home recently?
☐ Yes ☐ No ☐ Don't know

14. Do you plant a garden each year?
☐ Yes ☐ No
*If yes*, do you eat vegetables from this garden?

*Is there anything else you'd like to tell us about your household?*

_____

_____

_____

_____

**Occupational History**

15. What is your occupation or job?
_____

16. Where do you work currently?
_____

Please describe your current job duties: _____

17. How long have you been employed in your current job?
a. 0-5 years
b. 6-10 years
c. 11-15 years
d. 16 years or more

18. What were your previous jobs:

| Previous Job(s) | Dates of Employment | Nature of Jobs |
|---|---|---|
| | | |
| | | |
| | | |

19. Have you ever worked in manufacturing or fabricated metals, plastics, petroleum, rubber, textiles, glass, ceramics, paper, electronics, hot-type printing, batteries, or fiberglass?
☐ Yes ☐ No ☐ Don't know

*Is there anything else you'd like to tell us about your work history?*

_____

_____

_____

_____

_____

**Medical History**

20. What kinds of medicine have you taken?

_____

_____

_____

21. Do you use any alternative medicines (such as herbs or natural supplements)?
☐ Yes ☐ No ☐ Don't know
*If yes*, provide details.
_____

22. Do you take dietary supplements (such as vitamins, diet pills, etc.)?
☐ Yes ☐ No ☐ Don't know
*If yes*, what are they?
_____

23. Have you had any operations or surgeries?

☐ Yes ☐ No
*If Yes*, Please list and give approximate year:

_____

_____

24. Are you immunocompromised?
☐ Yes ☐ No ☐ Don't know

25. Before you became sick did your doctor perform any medical tests or take X-rays?
☐ Yes ☐ No ☐ Don't know

26. Did you drink a liquid or medicine before one or more X-rays?
☐ Yes ☐ No ☐ Don't know

27. Did you have any medical procedure such as hip implant or knee replacement?
☐ Yes ☐ No

28. Before you got sick, were you on any kind of special or restricted diet for medical reasons? Weight loss reasons? Religious reasons? Allergen reasons? Any other reasons?
☐ Yes ☐ No ☐ Don't know

*If yes*, describe: _____

_____

**Behavior Questions:**

29. What are the average number of hours each day that you spent?

| **Indoors** | **Outdoors** |
|---|---|
| Kitchen: _____ | Vehicle: _____ |
| Office: _____ | Garden: _____ |
| Home: _____ | Exterior Sheds/Buildings: _____ |
| Other: _____ | Other: _____ |

30. What type of outdoor activities did you participate in?

| Activities | Where did they take place? |
|---|---|
| | |
| | |
| | |
| | |

31. Do you handle fireworks? Did you buy fireworks to celebrate Christmas/New Year?
☐ Yes ☐ No ☐ Don't know

*If yes*, please describe what and when: _____

32. What did you do with them and where are they? _____

33. Do you have any pets?
☐ Yes ☐ No

34. Have you ever eaten non-food items such as dirt, paint, plaster, and/or clay?
☐ Yes ☐ No ☐ Don't know

35. Are pesticides or herbicides, such as bug or weed killers, flea and tick sprays, collars, powders, or shampoos, used in your home or garden or on pets?
☐ Yes ☐ No ☐ Don't know

36. Have you been exposed to fertilizers, paints, thinners, wood or paper preservatives, batteries, alloys, or dyes?
☐ Yes ☐ No ☐ Don't know

37. Have you used rat poison?
☐ Yes ☐ No ☐ Don't know
*If yes*, what kind, when and where was it applied, and where is it stored?

_____

_____

38. Do you have containers or bait stations around your home or out building containing rat/mouse poison?
☐ Yes ☐ No ☐ Don't know
*If yes*, explain.

_____
*If yes*, what kind, when and where was it applied, and where is it stored?

_____

39. Do you (or any household member) have a hobby or craft?
☐ Yes ☐ No ☐ Don't know
*If yes*, please describe: _____

40. Have you used hair dye?
☐ Yes ☐ No ☐ Don't know

41. Do you work on your own car?
☐ Yes ☐ No ☐ Don't know
Other's cars?
☐ Yes ☐ No ☐ Don't know

42. Have you done health service maintenance (such as working on medical devices), chemical processing, electroplating, soldering, welding, metal cutting, leather tanning, fireworks, metal smelting, or photographic dark room work?
☐ Yes ☐ No ☐ Don't know

43. Have you reloaded any types of ammunition recently?
☐ Yes ☐ No ☐ Don't know

*Is there anything else you'd like to tell us about your behavior?*

_____

_____

_____

_____

_____

**Social History:**

44. Do you smoke at home? ☐ Yes ☐ No, If yes, how many cigarettes each day? _____
at the workplace? ☐ Yes ☐ No, If yes, how many cigarettes each day? _____

45. If you don't smoke, are you exposed to secondhand smoke at home or at work?
☐ Yes ☐ No ☐ Don't know

46. Do you know of any other friends, co-workers or family members experiencing similar or unusual symptoms?
☐ Yes ☐ No ☐ Don't know

47. Before getting sick the past few times can you think of anything unusual you did in terms of drinking or eating a few days prior? Were you in a dusty environment a few days prior?

_____

_____

48. Has there been a change in the health or behavior of family pets?
☐ Yes ☐ No Don't know

49. Do your symptoms seem to be aggravated by a specific activity?
☐ Yes ☐ No ☐ Don't know

50. Do your symptoms get either worse or better at work? ☐ Yes ☐ No ☐ Don't know
at home? ☐ Yes ☐ No ☐ Don't know
on weekends? ☐ Yes ☐ No ☐ Don't know
on vacation? ☐ Yes ☐ No ☐ Don't know
at hospital ☐ Yes ☐ No ☐ Don't know

51. Has anything about your job changed in recent months (such as duties, procedures, overtime)?
☐ Yes ☐ No ☐ Don't know

52. Did you purchase ceramic ware, jewelry, food items, paint, rubber items, glass, or bricks?
☐ Yes ☐ No ☐ Don't know

53. Do you recall ever seeing a white dusty substance on any food items or drinking containers?
☐ Yes ☐ No ☐ Don't know

*If yes*, where? _____

54. Do you regularly work in dusty environments? If so, where and how often?

_____

_____

*Is there anything else you'd like to tell us about your social behavior?*

_____

_____

_____

**Food Habits:**

55. Do you drink coffee? ☐ Yes ☐ No
a. How many cups per day?
b. Ceramic/Glazed coffee mugs ☐ Yes ☐ No
c. Do you prepare your own coffee? ☐ Yes ☐ No
d. Do you drink your coffee with cream and sugar? ☐ Yes ☐ No

56. Do you drink tea? ☐ Yes ☐ No
a. How many cups per day?
b. Ceramic/Glazed tea mugs ☐ Yes ☐ No
c. Do you prepare your own tea? ☐ Yes ☐ No
d. Do you drink your tea with cream and sugar? ☐ Yes ☐ No

57. Do you regularly drink any other liquids besides tap water, bottled water, milk, tea or coffee?
☐ Yes ☐ No
*If yes*, please describe: _____

58. Do you regularly drink energy drinks?
☐ Yes ☐ No ☐ Don't know

59. Do you eat nuts, especially Brazil nuts?
☐ Yes ☐ No ☐ Don't know

*If yes*, how often? _____

How much? _____

60. Do you have a favorite cup? ☐ Yes ☐ No
A favorite eating utensil? ☐ Yes ☐ No

*If yes*, please describe:_____

Are they: handmade _____ or ceramic _____

61. Are most meals (breakfast, lunch, and dinner) you consume prepared at home?
☐ Yes ☐ No ☐ Don't know

62. Do you like to eat acidic type-foods (low pH)?
☐ Yes ☐ No ☐ Don't know
*If so*, what utensils or plates do you most often use when doing so?

_____

63. How often do you eat fish or seafood in a month?

a. Never eat fish or seafood
b. 1-2 times per month
c. 3-4 times per month
d. 5 times or more a month

64. Who does most of the cooking in your household?

_____

65. As a family, do all of you typically eat the same foods and drinks at each meal? What meals?

_____

66. Where do your foods typically come from?

_____

67. Do you get any food from directly from farmers/farms?
☐ Yes ☐ No ☐ Don't know

**Water Questions:**

68. What kind of water do you normally drink?
☐ Boiled ☐ Filtered ☐ Boiled & filtered ☐ Treated ☐ Ordinary tap water
☐ Bottled ☐ Other
*If other*, explain._____

69. Is your water source at home private or public?

_____

70. Do you receive a water bill on a regular basis?
☐ Yes ☐ No
*If yes*, from what utility?
_____

71. Is there a private well on the property used regularly or even occasionally for drinking or food preparation?
☐ Yes ☐ No ☐ Don't know
*If yes*, please describe for what purpose is it used?
_____

72. Has plumbing recently been installed or repaired in your home?
☐ Yes ☐ No ☐ Don't know

73. Did you do any of the plumbing work yourself?
☐ Yes ☐ No
*If yes*, specify: _____

74. Has the water line leading to your house been damaged, repaired, replaced, or worked on in the past 3 years?
☐ Yes ☐ No ☐ Don't know

*Is there anything else you'd like to tell us about your food and water consumption?*

_____

_____

_____

_____

**Neighborhood Questions:**

75. Are there any barium mining or processing plants near your house or work?
☐ Yes ☐ No ☐ Don't know

76. Do you know if you live next to or near an industrial plant, commercial business, dump site, or nonresidential property?
☐ Yes ☐ No ☐ Don't know

77. Have you ever lived or worked near a coal-burning power plant, mercury mine, nickel refinery, golf course, chemical plant, phosphate mine, apple or peach orchard, or a tobacco farm?
☐ Yes ☐ No ☐ Don't know

78. Do you notice any odd odors that you can't explain in your neighborhood?
☐ Yes ☐ No ☐ Don't know

79. Do you fish or hunt in your neighborhood? Do you know if you're fishing or hunting areas have ever been a dump site?

_____

_____

80. Is there an area near your house that does not look right? Stressed vegetation, settling, discoloration, etc.?

_____

**Travel Questions:**

81. Did you travel out of country prior to your illness?
☐ Yes ☐ No
*If yes*, where?
_____

82. Did you purchase any items (ceramic ware, jewelry, food items, paint, rubber items, and glass) that were brought back with you?
☐ Yes ☐ No
*If yes*, what?
_____

*Please describe, in as much detail as possible, your activities before you sought medical care. Please describe everything you did step-by-step and where you did it. Include meals, work activities, and recreational or hobby-type activities. Please describe what you ate, what you drank, what plate and cup was used, where you ate or drank it, and any salt/sugar/spices used. Did you do anything in out buildings? Was there any place you went by yourself without your family? What did you do there? Is there anything you did different on this day than you normally do? If so, what and where did you do it? Also, please describe anything that you did that your family members did not. Did you go fishing or hunting? Did you eat any fish or wildlife? If so, when? Did the rest of the family also eat? Have you noticed anything unusual? If so, what?*

_____

_____

_____

_____

_____

_____

_____