

May 12, 2010



Tests Indicate Exposures in Dish Similar to U.S. Population

Biological test results from a Texas Department of State Health Services investigation in Dish, Texas, indicate that residents' exposure to certain contaminants was not greater than that of the general U.S. population.

In response to community concerns about potential health effects of natural gas drilling, DSHS collected biological samples from 28 Dish residents in late January to determine whether the levels of Volatile Organic Compounds, or VOCs, in their blood were higher than those measured in the broader population.

"In Dish, we found no pattern to our test results indicating community-wide exposure to any of these contaminants," said Dr. Carrie Bradford, the DSHS toxicologist who led the investigation. "We were looking to see whether a single contaminant or a handful of contaminants were notably elevated in many or all of the people we tested. We didn't find that pattern in Dish."

DSHS paid particular attention to benzene because of its association with natural gas wells. The only residents who had higher levels of benzene in their blood were smokers. Because cigarette smoke contains benzene, finding it in smokers' blood is not unusual.

Some residents had test results that were at or below expected levels for various VOCs. Others had results that were slightly higher than the levels found in the U.S. population data. However, the type of slightly elevated VOC varied considerably from individual to individual, indicating no particular pattern. Many of these compounds are found in a wide array of commonly used products.

While the purpose of this investigation was to determine whether people were being exposed to specific contaminants, it does not determine specific exposure sources, nor does it provide an assessment of possible long-term exposures.

DSHS health officials will have a community meeting to discuss these results at the Dish town hall from 7 to 8:30 p.m. May 18. They also will be available from 5 to 6:30 p.m. to speak with residents. The full Dish exposure investigation report can be found at <http://www.dshs.state.tx.us/epitox/assess.shtm>

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Final Report

DISH, Texas Exposure Investigation **DISH, DENTON COUNTY, TEXAS**

May 12, 2010



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Summary

In response to citizen concerns and preliminary environmental sampling results, the Texas Department of State Health Services (TxDSHS) collected blood and urine samples from 28 people living in and near the town of DISH. DISH is located over the Barnett Shale, a large geologic formation that is one of the largest onshore natural gas fields in North America. Over the last several years the increased number of gas wells and compressor stations has caused concern among some residents.

Blood Sample Results

The blood samples were analyzed for volatile organic compounds (VOCs) to determine whether people living in and around DISH had higher levels of these contaminants in their blood than 95% of the general United States (U.S.) population. Although a number of VOCs were detected in some of the blood samples, the pattern of VOC values was not consistent with a community-wide exposure to airborne contaminants, such as those that might be associated with natural gas drilling operations.

Other sources of exposure would explain many of the findings. For instance, all four people who had higher levels of benzene in their blood were cigarette smokers. Cigarette smoking was verified both by a chemical marker in the blood (2,5-dimethylfuran) and by answers provided on an exposure survey. Cigarette smokers also had higher levels of ethylbenzene, styrene, toluene, and xylene in their blood.

A few individuals had higher levels of bromoform, chloroform, and dibromochloromethane in their blood than 95% of the U.S. population. These are disinfectant by-products associated with the chlorination of public drinking water systems. All of these individuals were on the same public water system.

The other compounds that were found in a few people at higher levels than 95% of the general U.S. population included 1,2-dichloroethane, tetrachloroethene, 1,4-dichlorobenzene, trichloroethene, and 1,1,1-trichloroethane, which are chemicals commonly found in consumer products. For instance, 1,4-dichlorobenzene is commonly used in moth balls and space deodorizers. Tetrachloroethene, 1,2-dichloroethane, trichloroethene, and 1,1,1-trichloroethane are sometimes used in the home or at work as metal cleaners, degreasers, and lubricants.

Urine Sample Results

Urine was analyzed for biological breakdown products of some VOCs. The urinary metabolite for benzene was detected in three people, two of whom were smokers and the third person had a value just slightly above the detection limit. Overall, the values were similar to those reported from other studies of smokers and non-smokers.

Urinary results for the breakdown products of 1,3-butadiene and toluene were similar to the levels measured in TxDSHS staff in Austin. The levels of the urinary metabolite for N,N-dimethylformamide (DMF), found in DISH non-smokers were similar to those found both in TxDSHS staff and other non-smokers from the published literature. The range of values in DISH

smokers overlapped with those from other smokers; however, the maximum value found in DISH smokers was higher.

Tap Water Samples

TxDSHS also collected tap water samples from 27 participant homes. Trihalomethanes exceeded the health-based regulatory limit in one home. This sample had a level of total trihalomethanes that exceeded the Environmental Protection Agency's (EPA's) Maximum Contaminant Level (MCL). Trihalomethanes are disinfectant by-products that form when chlorine is used to keep the drinking water safe by removing harmful biological organisms. In general, the risks associated with these chemicals are outweighed by the benefits associated with removing the harmful biological organisms from the water. However, because high levels can result in excessive exposure, DSHS worked with the Texas Commission on Environmental Quality (TCEQ) to identify the water supplier so that the supplier could correct the problem. The water supplier will make modifications and monitor and control the levels of these contaminants in this portion of the water system. Other contaminants, including ethylbenzene, methyl tert-butyl ether, styrene, toluene, and xylene, were detected in some of the water samples but at levels that were between 60 and 44,000 times lower than the contaminant specific regulatory limits.

Limitations

This investigation did have limitations. First, VOCs only stay in the body for a short time (several hours); therefore these measurements only reflect ongoing or recent exposures, and not historical exposures. Second, this was a one time sampling event; thus it could not consider variations in factors such as season, temperature, wind conditions, and natural gas operations. Third, we could not identify with any degree of certainty a source for all of the exposures. Fourth, the urinary metabolite AMCA is not completely specific and can form through other metabolic pathways. Lastly, it was not possible to determine potential health risks based on the levels found in the blood.

Conclusions

The information obtained from this investigation did not indicate that community-wide exposures from gas wells or compressor stations were occurring in the sample population. This conclusion is based on the pattern of VOC values found in the samples. Other sources of exposure such as cigarette smoking, the presence of disinfectant by-products in drinking water, and consumer or occupational/hobby related products could explain many of the findings.

Purpose and Health Issues

The Texas Department of State Health Services (TxDSHS) received a request to test people living in the Town of DISH for volatile organic compounds (VOCs). Specifically, TxDSHS was asked to test people's blood to see if they were being exposed to chemicals associated with gas wells and gas compressor stations. In response to this request, the TxDSHS Environmental and Injury, Epidemiology and Toxicology Unit (EIET) conducted an exposure investigation to measure various VOCs in the blood from residents living in the DISH area (DISH). The blood test results were compared to those previously obtained from the general United States (U.S.) population. The findings of the investigation are presented in this report. A full list of the acronyms and abbreviations used in this report are included in Appendix A.

Background

Site Description

DISH, Texas is located over the Barnett Shale, a large geologic formation spanning 5,000 square miles over 23 counties in north Texas. The Barnett Shale is one of the largest onshore natural gas fields in North America. Since 2000 there has been an exponential rise in the number of wells from 726 wells in 2000 to 13,740 wells in 2009. Over the last several years the increased number of gas wells and compressor stations in and around DISH has caused concern among some residents.

In response to residents' concerns about unpleasant sulfur-like odors, the Town of DISH hired a consultant to conduct air quality tests near the compressor stations. The tests, which were conducted in August 2009, found sulfur compounds and elevated levels of VOCs in the air samples. The presence of one of the VOCs, benzene, at 78 parts per billion (ppb)¹ was of particular concern to the mayor and the community because of its classification as a known human carcinogen [2].

The Texas Commission on Environmental Quality (TCEQ) Toxicology Division (TD) reviewed the data presented in the consultant's report and concluded that if the results were representative of normal and prolonged ambient conditions, the reported levels of benzene could result in long-term health risks to residents. They recommended additional air sampling [3]. The TCEQ Mobile Monitoring Team (MMT) conducted additional air sampling throughout the Barnett Shale area during August, October, and November 2009.

The TCEQ TD reviewed the MMT data and concluded that short-term benzene levels exceeded TCEQ's long-term health-based comparison value at sampling locations on Clark Airfield Road (located in DISH, approximately 0.2 to 0.35 miles from the compressor stations) and Jim Baker Road (southwest of DISH, approximately 0.1 miles or less from possible emission sources).

¹The TCEQ has developed a set of health-based Effects Screening Levels (ESLs) for air permitting. Exceeding the ESL for a given contaminant does not indicate a problem, only that more in-depth review is needed. The short-term (1-hour averaging period) ESL for benzene is 54 ppb. The long-term (annual averaging period) ESL is 1.4 ppb [1].

Because short-term levels of benzene contribute to long-term cumulative exposure levels, the TD recommended additional long-term air monitoring [4].²

In October 2009, the TxDSHS was asked by the mayor of DISH to test people in the community for the contaminants that had been identified by the environmental consultant. The TxDSHS, in collaboration with the Centers for Disease Control and Prevention (CDC)/National Center for Environmental Health (NCEH), designed an exposure investigation to determine whether residents living in and around DISH have higher levels of VOCs in their blood than 95% of the general U.S. population.

Site Visits

EIET staff visited the DISH area on December 21 and 22, 2009 and noted approximately 60 households within the DISH city limits and 200 or so additional households in the immediate surrounding area. Staff distributed flyers to residents to notify them of the exposure investigation; they also mapped neighborhoods and spoke with residents and the mayor about community concerns. Staff noted a large number of gas wells, storage tanks, and compressor stations located in close proximity to homes. Odors consistent with natural gas production, as well as noise, were noted in residential areas near the compressor stations.

The sampling portion of the exposure investigation was conducted in the DISH area on January 22 through 24, 2010. Staff collected blood, urine, and tap water samples and had each participant complete an exposure survey. Odors and noise were again noted in the residential areas near the compressor stations with the odors being more intense when the wind was blowing from the southeast and as temperatures warmed during the day.

Exposure Investigation

The purpose of this investigation was to try to determine whether people living in DISH consistently have higher levels of VOCs in their blood than 95% of the general U.S. population. Because the investigation required invasive procedures, the investigation focused on adults living in the DISH area rather than involving children. Additionally, the lack of national comparison values for children would have made interpreting the sample results from the children difficult. Because residents were concerned about possible community-wide airborne exposures, staff determined that they could obtain the necessary information by sampling adults.

Exposure Investigation Design

Prior to conducting the investigation measures were taken to ensure that the safety, rights, and welfare of the people involved in the investigation. The protocol was reviewed and approved by the TxDSHS Institutional Review Board (IRB). IRB approval for these types of exposure investigations ensures that participants are adequately protected.

² In addition, the VOC ethane exceeded TCEQ's short-term comparison value at sampling locations on Jim Baker Road. The TD concluded that while ethane can cause asphyxiation, it would not be likely to occur in an outdoor environment [4].

Staff sent letters to 66 randomly selected homes in the DISH area asking for one adult volunteer from the home to complete a brief exposure survey and provide blood and urine samples. A copy of the exposure survey is available in Appendix B. Twenty-nine people volunteered to participate; however, blood and urine samples were collected only from 28 of the 29 participants because one participant was dehydrated and was not able to provide samples. Staff collected a tap water sample from each of the participating homes because questions had been raised about possible groundwater contamination and residents in this area primarily obtain their drinking water from groundwater. To ensure the results of this investigation were representative of residential exposures, staff asked participants to remain in the vicinity of their homes for a minimum of four hours prior to the collection of the biological samples.

Each participant signed an informed consent form outlining the purpose of the investigation; the procedures involved; the expected time commitment; any reasonably foreseeable risks or discomforts; potential benefits to the participant or to others; how their information will be kept confidential; and who they may contact with any questions or concerns regarding the consent form or the specimen collection procedures.

Biological Sampling

Biological samples were collected using validated procedures and materials so that the reported results were not biased by contamination or loss. The blood samples were collected from participants in their homes by a TxDSHS registered nurse who placed the blood into a 10 milliliter (ml) hermetically sealed VOC-free blood collection tube. The samples were packed on ice and shipped cold to the CDC/NCEH laboratory for analysis. Specially-treated glass urine cups and specimen collection instructions were distributed to participants at least one day prior to their appointment. Participants were asked to collect the first morning void on the day of their appointment and place the sample in the freezer until TxDSHS's arrival. Urine samples were packed on ice and shipped frozen to the CDC/NCEH laboratory for analysis. A brief description of the analytic procedures is available in Appendix C. A complete list of contaminants that were analyzed in the blood and urine is included with the results in Appendix D.

Voluntary blood and urine samples were collected from five TxDSHS employees. The samples were collected in Austin prior to leaving for DISH, and again in DISH, after spending 2 to 3 days conducting the investigation. These samples were sent to the CDC/NCEH laboratory, along with the other samples, to serve as a blind internal methodological control. All of the samples from TxDSHS staff and DISH residents were sent to the CDC/NCEH laboratory without personal identifiers.

Tap Water Sampling

In most cases, the tap water sample was collected from the participant's kitchen sink (non-filtered). Cold water was allowed to flow at high volume for approximately 1 minute. Water flow was then reduced to minimum volume before the sample was collected. The water samples were collected in pre-treated 5 ml vials with no headspace to prevent the volatilization of VOCs out of the sample. Samples were packed on ice and shipped cold to the CDC/NCEH laboratory for analysis. A brief

description of the analytic procedures is available in Appendix C. A list of the contaminants that were analyzed in tap water is included with the tap water results in Appendix D.

Data Analysis Procedures

Because the purpose of this investigation was to compare the levels of VOCs in the blood from DISH residents to those measured in the general U.S. population, descriptive statistics and tests of significance were used to compare the DISH blood results with data from National Health and Nutrition Examination Survey (NHANES). Staff determined ranges of values for each of the contaminants and, where possible, compared the DISH median to weighted reference median values obtained from NHANES. The statistical analyses for this investigation are included in Appendix E.

Results and Discussion

Blood

The aggregate results for the 28 blood samples that staff collected from DISH residents are presented in Appendix D; Tables 1a and 1b. Table 1a presents the results for all 33 of the contaminants measured while Table 1b only presents results for the 15 contaminants that were found above the reference values. The substance specific reference values represent the 95th percentile values from NHANES. For each contaminant 5% of the people tested in the U.S. had values above the 95th percentile reference value.

It is important to note that having a blood level above any of the reference values does not mean that there will be actual harm; it only indicates that the person was exposed to more of the substance than 95% of the general U.S. population. Appendix D; Table 1b provides information on common sources of exposure for each of the contaminants detected above the reference value. Although the blood data alone cannot be used to identify how the person was exposed, the responses to the exposure survey served to identify the most likely sources of exposure.

Although a number of VOCs were detected in blood from some of the participants, the pattern of detection is consistent with exposures to consumer products (e.g., cigarette smoke and home maintenance products).

Three of the compounds found in a few of the participants were disinfectant by-products associated with chlorinated drinking water systems. All of these participants obtained their drinking water from the same public drinking water system which uses chlorine as a disinfectant to remove harmful infectious agents. Additional information on disinfectant by-products is presented with the tap water results.

Benzene and styrene were found above the reference value in four people, all of whom were smokers as verified by the presence of 2,5-dimethylfuran (a biomarker for smoking) in their blood and by their survey responses. Ethylbenzene, styrene, toluene and xylene also were found in a few people, most of whom were smokers. Levels of **benzene**, **toluene**, **ethylbenzene**, **xylene** (o-xylene and m-/p-xylene), and styrene (together, commonly referred to as BTEXS compounds) and 2,5-

dimethylfuran showed a dose-response relationship between the levels measured in the blood and the time since the last cigarette. Based on the survey results, the few other people who had these compounds in their blood above the respective reference values may have been around other known sources of exposure. DSHS staff statistically compared the median values for benzene, toluene, and m-/p-xylene with weighted reference median values obtained from NHANES; the medians for these compounds for DISH were not significantly different than NHANES at the $p=0.05$ level (Appendix E).

There were two compounds (1,2-dichloroethane and 1,4-dichlorobenzene) commonly used in the home or workplace environments for which there were no likely sources. 1,2-Dichloroethane is used to make vinyl chloride, which is then used to make a variety of plastic and vinyl products such as polyvinyl chloride (PVC) pipes and other construction materials, packaging materials, furniture and automobile upholstery, wall coverings, house wares, and automobile parts. In the past, 1,2-dichloroethane was found in products used to clean cloth and remove grease from metal; it has been used in some household products such as cleaning solutions, pesticides, glue for wallpaper and carpeting, and paint, varnish, and finish removers [5]. 1,4-Dichlorobenzene is commonly used in moth balls and deodorant blocks for trash cans and restrooms, as well as to help control odors in animal-holding facilities. Most human exposures to 1,4-dichlorobenzene occur from the use of mothballs and toilet-deodorizer blocks in the home [6].

Appendix F provides a list of links to Public Health Statements for the contaminants that were detected above the reference range. Each Public Health Statement includes information about the contaminant and the potential health effects of exposure. Most of the potential health effects have been observed in occupational settings, with exposure to VOCs at levels much higher than what is seen in the general population. While measuring VOCs in blood and VOC metabolites (what the VOCs are changed to by the body) in urine can tell us whether people were recently exposed to these contaminants, there are no standards available which would allow us to determine whether the measured levels would put anyone at an increased risk for adverse health effects. This information is being included for informational purposes only and should not be used to make causal relationships between any individual's health and VOC levels measured in the body.

TxDSHS Staff Results

Aggregate results for blood samples collected from TxDSHS staff before leaving Austin headquarters and after several days in DISH are included in Appendix D; Table 2. There were no observable differences in the levels of contaminants in TxDSHS staff blood samples before and after spending time in DISH to conduct the investigation.

Urine

Urine was analyzed for the following compounds:

- PMA (N-acetyl-S-(phenyl)-L-cysteine): A urinary metabolite of benzene. Benzene is a component of gasoline and is commonly found in automobile exhaust, tobacco smoke, and a number of household consumer products [7].
- DHBM (N-acetyl-S-(3,4-dihydroxybutyl)-L-cysteine): A urinary metabolite of 1,3-butadiene. Common sources of exposure to 1,3-butadiene are vehicle exhaust, tobacco

smoke, wood burning, burning of rubber and plastic, forest fires, accidental or intentional release at manufacturing plants, the production of rubber and plastics, in plastic or rubber of food containers, or from touching or breathing gasoline [8].

- BMA (N-acetyl-S-(benzyl)-L-cysteine): A urinary metabolite of toluene. Toluene is a component of gasoline and is commonly found in automobile exhaust, tobacco smoke, and a number of household consumer products [9].
- AMCA (N-Acetyl-S-(N-methylcarbamoyl)-L-cysteine): A non-specific urinary metabolite of N,N-dimethylformamide or DMF. DMF is a solvent used in the production of electronic components, pharmaceutical products, textile coatings, and synthetic fibers [10]. Since this is a non-specific metabolite it is possible that its formation could be due to chemicals other than DMF.

The aggregate results for the urine samples collected from DISH residents are presented in Appendix D; Tables 3a and 3b and Figures 1-4. Results are presented as micrograms per liter ($\mu\text{g/L}$) in Table 3a and as micrograms per gram creatinine ($\mu\text{g/g-creatinine}$) in Table 3b; expressing the data per gram creatinine is often used to normalize the results for differences in hydration. Although general U.S. population comparison values for the chemicals that were measured in the urine do not exist, values detected in other people in several published analytical method papers are presented for a rough comparison. Results for urine samples collected from TxDSHS staff before leaving Austin headquarters and before leaving DISH also were used for comparison.

PMA, the urinary metabolite for benzene, was detected in three people, two of whom were smokers. The other person had a value of PMA in the urine just slightly above the detection limit. PMA results were well within the range presented in published reports for both smokers and non-smokers.

Urinary results for DHBM (the urinary metabolite for 1,3-butadiene) and BMA (the urinary metabolite for toluene) were similar to the levels measured in TxDSHS staff in Austin.

The levels of AMCA, the urinary metabolite for DMF, found in DISH non-smokers was similar to those found both in TxDSHS staff and other non-smokers from the published literature (Figure 4). The levels found in smokers were higher than those found in non-smokers. Although there was significant overlap between the levels found in DISH smokers and other smokers, the maximum level found in the DISH smokers was higher. One DISH non-smoker had a level similar to that of smokers; the reason for this is unknown. While staff cannot identify the source of the AMCA exposures with any degree of certainty, it is clear both from these results and those in the published literature that the levels are higher in smokers. DMF is used commercially as a solvent in vinyl resins, adhesives, pesticide formulations, and epoxy formulations; for purification and/or separation of acetylene, 1,3-butadiene, acid gases, and aliphatic hydrocarbons; and in the production of polyacrylic or cellulose triacetate fibers and pharmaceuticals. AMCA also is a non-specific metabolite and may be due to exposure to other compounds.

TxDSHS Staff Results

Aggregate results for urine samples collected from TxDSHS staff before leaving Austin headquarters and before leaving DISH, after the sampling portion of the investigation was complete, also are included in Appendix D; Tables 3a and 3b and Figures 1-4. The pre-trip and post-trip levels of metabolites in TxDSHS staff urine samples before and after the investigation were similar and showed no consistent pattern of change between the two sampling dates.

Tap Water

Aggregate results for the tap water samples collected from 27 homes in the DISH area are presented in Appendix D; Table 4. One tap water sample was collected from two participants who shared a private well. Another participant had a whole house water filter; thus, staff was not able to collect an un-filtered tap water sample.

The results of the tap water samples were compared to Environmental Protection Agency's (EPA's) Maximum Contaminant Levels (MCL). MCLs are contaminant specific regulatory standards representing the maximum concentration of a chemical that is allowed in a public drinking water system under the Federal Safe Drinking Water Act.

Only one tap water sample had trihalomethanes that exceeded the MCL. Trihalomethanes (bromoform, bromodichloromethane, chloroform, and dibromochloromethane) are disinfectant by-products that form when chlorine is used to keep the drinking water safe by removing harmful biological organisms. In general, the risks associated with these chemicals are outweighed by the benefits associated with removing the harmful biological organisms from the water. Exposure to high levels of trihalomethanes in water can lead to excess exposure through ingestion, skin contact, and the inhalation of vapors. Because of this potential exposure, TxDSHS staff worked with TCEQ to identify the water supplier for this household. The supplier noted that this house was at the end of their system where levels can sometimes be higher and agreed to add a flush valve and total coliform/disinfectant residual sample location to the water line to monitor and control the levels of these contaminants in this portion of the water system. It is important to note that all of the individuals who had higher levels of disinfectant by-products in their blood than 95% of the U.S. population were on the same water system.

Other contaminants, ethylbenzene, methyl tert-butyl ether, styrene, toluene, and xylene, were detected in some of the water samples; however, the levels were very low with the maximum detected values ranging from 60 to 44,000 times lower than their respective MCLs.

Community Health Concerns

As part of the exposure investigation we asked participants and other residents about their health concerns. Many voiced concerns about headaches, respiratory problems, itchy and watery eyes, and other allergy-type symptoms. The symptoms noted are relatively non-specific with multiple possible causes including infectious agents, allergies, and environmental pollutants. DSHS staff cannot state with any degree of certainty the cause of any individuals stated health concerns and

recommended that any individuals with specific health problems should consult their family physician.

Many residents reported concerns about odors, noise, and gas well and compression station operations. Although staff did not measure noise levels or collect ambient air samples they did note the presence of both odors and noise during our visits to the site. Both odors and noise can affect quality of life and often are governed by local ordinances. Information about city ordinances can be found on the Barnett Shale Energy Education Council website and the Town of DISH website.

Limitations

This investigation was designed to answer a specific question; do the people living in the DISH area have unusually high levels of VOCs in their bodies resulting from natural gas extraction as compared to the general U.S. population. Although, the investigation was not designed to specifically determine the source of additional exposures, the investigation was designed to evaluate patterns of VOCs in the blood that indicated potential community-wide exposures from natural gas extraction. As with any investigation there are limitations; below are some of the limitations.

- It only captured information about recent exposures. VOCs have a short half-life in the body (hours); therefore, unless exposures are known to be on-going, the levels found in the body only represent recent exposures.
- It was a one time sample event; thus, it could not consider external factors that could have affected the results such as temperature, wind conditions, and variations in the natural gas operations.
- Staff was limited in the types of comparisons that we could make with respect to the urinary data; staff compared the participants' results to levels found in the literature and to those of the TxDSHS staff. The information necessary to compare them to the levels normally found in the U.S. population was not available.
- In most instances staff was not able to definitively identify exposure sources.
- It is not possible to determine potential health risks based on the levels found in the blood.

Conclusions

Based on the information obtained from this investigation staff has concluded that:

1. For the majority of the participants, the levels of VOCs measured in blood were similar to those measured in the general U.S. population suggesting that their exposures to these contaminants were not different than those received by people living in other areas of the U.S.
2. Although some VOCs were found in some people, the pattern of these findings was not consistent with community-wide exposures. Based on the pattern of the exposures and the participants' responses to the exposure survey, many of the exposures were most likely due to other factors such as smoking or exposure to disinfectant by-products in the drinking water or home maintenance products.
3. The only residents with elevated levels of benzene in their blood were smokers. Smoking status was verified both by the exposure survey and by the presence of 2,5-dimethylfuran in the blood. Also, there was an apparent dose response relationship between the levels measured and the time since the last cigarette. Tobacco smoke contains benzene and is a major contributor to blood benzene levels.
4. Although general U.S. population comparison values for the urinary metabolites are not available, the levels of these metabolites measured in the urine from DISH residents were similar to those of TxDSHS staff and those obtained from several papers published on the analytical methods. One metabolite, AMCA was higher than the levels measured in the TxDSHS staff and the levels published in the analytical methods papers. The reason for this difference is not known.
5. Except for one sample, the VOCs measured in the tap water were at levels well below the contaminant specific MCLs. For this sample, the level of trihalomethanes was above the MCL. Trihalomethanes are disinfectant by-products formed from the chlorination of drinking water at the water distribution center.
6. Residents voiced concerns about headaches, respiratory problems, itchy and watery eyes, and other allergy-type symptoms. Because these are non-specific symptoms with multiple possible causes, staff could not state with any degree of certainty the cause of any individual's health concern.
7. Many residents reported concerns about odors, noise, and gas well and compression station operations. Staff did not measure the noise levels or collect ambient air samples; however, staff did note the presence of both odors and noise during our visits to the site. Both odors and noise can affect quality of life and are generally governed by local city ordinances.
8. Other than smoking, for which there is a biological marker, DSHS staff cannot state with any degree of certainty as to the exact nature of the exposures. Our estimations are based on a combination of the pattern of the exposures as well as on the participants' responses to the exposure survey.

Recommendations

Based upon the results of this investigation DSHS recommends that:

1. If the environmental data collected by TCEQ indicate a potential for exposure and if funds are available this investigation should be repeated during the summer months when the temperatures are higher and when people indicate that the odors are greatest.
2. People with individual health concerns should consult with their family physician. If their physician thinks that their condition could be due to some type of environmental exposure they can contact the TxDSHS office at epitox@dshs.state.tx.us with DISH EI in the subject line and their specific request in the body of the message.
3. Residents with concerns about noise should work with their local officials to determine whether any local ordinances apply.

Actions Planned

1. TxDSHS will make this final report available to participants, concerned citizens, and other interested parties through hard copies and the TxDSHS website.
2. TxDSHS will continue to answer community questions regarding this investigation. Questions regarding this document may be sent to epitox@dshs.state.tx.us with DISH EI in the subject line.
3. TxDSHS will present the results of the investigation at a community meeting to residents in DISH.
4. TxDSHS will provide information on the location of this report and information about the community meeting to all DISH residents and other interested parties.

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Appendix A: Acronyms and Abbreviations

AMCA	N-Acetyl-S-(N-methylcarbamoyl)-L-cysteine
BMA	N-acetyl-S-(benzyl)-L-cysteine
BTEXS	benzene, toluene, ethylbenzene, xylene, and styrene
CDC	Centers for Disease Control and Prevention
DHBM	N-acetyl-S-(3,4-dihydroxybutyl)-L-cysteine
DISH	DISH, Texas and surrounding areas
DMF	N,N-dimethylformamide
EIET	Environmental and Injury Epidemiology and Toxicology Unit
EPA	Environmental Protection Agency
ESL	Effect Screening Level
GC-MS	gas chromatography and mass spectrometry
IRB	Institutional Review Board
MMT	Mobile Monitoring Team
MCL	Maximum Contaminant Level
mL	milliliter
µg/g-creatinine	micrograms per gram creatinine
µg/L	micrograms per liter
NCEH	National Center for Environmental Health
ND	Not Detected
NHANES	National Health and Nutrition Examination Survey
PMA	N-acetyl-S-(phenyl)-L-cysteine
ppb	parts per billion
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
SPME	solid phase microextraction
TCEQ	Texas Commission on Environmental Quality
TD	Toxicology Division
TxDSHS	Texas Department of State Health Services
U.S.	United States
VOC	volatile organic compound

Appendix B: Exposure Survey

Control No. _____

Texas Department of State Health Services DISH Exposure Investigation Survey

Interviewers Name: _____ Date and Time: _____

Participant Information:

First Name: _____ Last Name: _____ MI: _____

Street Address: _____ Zip: _____

Mailing Address (if different): _____ Zip: _____

Phone #: (Home) _____ (Work) _____ (Cell) _____

Email Address: _____

Gender: M F Date of Birth: mm/dd/yy _____

What is your ethnicity? _____ What is your race? _____
(Hispanic or non-Hispanic) (Caucasian, African-American, Asian, Pacific Islander, etc.)

(If female) Are you pregnant? If yes, what trimester? _____

General Information:

How many people currently live in your home fulltime? _____

If there are children (under 18) in the home what are their ages? _____

How long have you lived at this address? _____ *(If < 1 year ask next question)*

Was your previous address in this area? If so, what was it? _____

Occupation: *(Surveyor: if these questions pertain to more than the person being interviewed ask for each person not participating)*

Which best describes your current employment status?

Work outside of home Work at home Student Unemployed Retired/Disabled

In what city/area do you work? _____

Control No. _____

What is your occupation? _____

Do you work primarily inside or outside? _____

Do you have contact with chemicals at your current job? Yes / No

Please describe the chemicals and their use. _____

Do you wear protective equipment (gloves, dust mask or respirator, hood) at work? Yes / No

What type of equipment is worn? _____

Do you shower and/or change clothes before coming home from work? Yes / No / Sometimes

Are there other occupants in the household that may have contact with chemicals at work? Yes / No

Do they wear their work clothes home or take a shower or change clothes before coming home?

Yes / No / Sometimes

Home Structure Information:

About when was this house built? _____

Does the home have an attached garage directly connected to living space? Yes / No

If so, is a car usually parked in the garage? Yes / No

What type of heating and ventilation systems do you have in the home? _____

In the last 6 months have you or anyone else renovated your home in any way? Yes / No

indoor painting refinishing floors adding rooms to the house

laying new carpet (glue or tacked down) stripping cabinets

Other (Specify): _____

How often do you leave your windows open? _____

Control No. _____

Do you use any air purification devices? Yes / No

If yes, what type of device is used? Is it a device using activated carbon? _____

How far would you say your home is from an oil or gas well, condensate tank, or compression station?

Indoor Air:

Do you smoke? Yes / No How many cigarettes /cigars / pipes per day? _____

Do use chewing tobacco? Yes / No How often do you chew tobacco (times per day)? _____

Are there any (*other*) smokers in the household? Yes / No

If yes:

How many? _____

Do they smoke inside the home? _____ How many cigarettes per day? _____

How many cigars a day? _____ How many pipes per day? _____

When was your last cigarette (relative to blood sample collection)? _____

Have you or others in your household noticed odors in your home or in common areas where you spend most of your time (bedroom, living room, kitchen)? If yes, please describe the odors, their location, when they occur (time of day, day of week, season), and for how long.

Fuels Used Indoors:

Do you use any of the following in your home?

Natural Gas Propane Gas Kerosene Coal Wood Burning Stove Gasoline Artificial Logs

Are there any chemicals or open containers stored in or near the living spaces of your home? Yes / No

Control No. _____

Do you store gasoline, diesel, fuel oils, or kerosene in any room or basement of your home or in an attached garage or carport? Yes / No

Are any devices with gasoline or diesel engines such as lawn mowers being stored in any room or basement of your home or in an attached garage or carport? Yes / No

Are any paints, varnishes, woodworking solvents, paint stripping fluids, or adhesives being stored in any room or basement of your home or in an attached garage? Yes / No

Water:

Do you get your water from the public water supply or do you have a private well?

Name of company _____

Has it been tested, when was it tested, who did the testing, what it was tested for, and what was the result? _____

What is your main source of **drinking water**? _____

What is your main source of water used for **cooking**? _____

Do you have any water treatment devices for your home?

None Charcoal Filter/GAC Ceramic Filter Reverse Osmosis

Water Softener Boil Water Distillation Aerator

Water Filter System (Brita, Pur, etc)

Other (Specify): _____

If you have filters, do you regularly replace and maintain them? Yes / No

Hobbies:

What hobbies do you or your household members engage in? _____

Control No. _____

Recent Exposures:

The following questions will be used to determine if there are possible exposure sources you may have been exposed to yesterday and today.

Did you spend 10 or more minutes near a person who was smoking? _____

Have you used any cleaning products? (air fresheners, bleach, toilet bowl cleaner, degreasers, etc)?
Yes / No

If so, what did you use? _____

Have you used any auto products such as brake fluid, de-icer, lubricant, sealant, etc? Yes / No

If so what type? _____

Did you spend any time at a swimming pool or in a hot tub? How long ago, in hours? _____

Did you breathe fumes from diesel fuel or kerosene or spend any time at a gas station or auto repair shop?

Did you pump gas into your car or other motor vehicle yourself? If yes, how long ago, in hours, did you pump gas into a car? _____

Were you in a car when another person was pumping gasoline? If yes, how long ago, in hours, was the gas pumped? _____

Did you drive in traffic or in a parking garage? How long ago, in hours? _____

Use any other gasoline or diesel-powered equipment? _____

Have you used any home maintenance products (caulk, grout, insulation, paint, putty stain, glues, adhesives, varnishes, stains, paint thinner, brush cleaner, or furniture stripper)? Yes / No

If so, what types and how long ago did you use them? _____

Did you breathe fumes from fingernail polish or fingernail polish remover? _____

Have you used cologne, perfume, aftershave, or other fragrances? _____

Have you been in contact with any other fumes or strong smelling chemicals? _____

Control No. _____

Health Questions:

Do you have any health issues? Yes / No

Please describe: _____

Are you under a physicians care for any conditions? Yes / No

Describe conditions: _____

Do these issues get better or worse in the winter months? Yes / No

Explain: _____

What types of treatments if any are you currently taking? _____

Are you currently taking any prescription medications or over the counter medications such as vitamins or supplements (herbal and nutritional)? Yes / No

What are they? _____

Control No. _____

Communication:

Before being notified about this investigation were you aware of the environmental concerns in the DISH area? Yes / No

If so, how did you find out about it? _____

Is there anything you want us to know that we did not ask about?

Surveyor Gather Following information through observation only:

Describe the general weather conditions: _____

Building type: Apartment Townhouse Single Family Home Mobile Home Other

What is the overall condition of the home? _____

Note general direction of closest station or general location of house relative to known areas of contamination. _____

Appendix C: Analytic Procedures

VOCs were measured in whole blood using headspace solid phase microextraction (SPME) coupled with gas chromatography and mass spectrometry (GC-MS) [11]. The blood samples were spiked with stable isotope-labeled internal standards and analyzed within 4 weeks of collection. This method can detect blood VOC levels in the parts-per-trillion range. Benzene and other fuel components, chlorinated solvents, and other volatile organics sometimes found in consumer products were measured in the blood. Because smoking significantly increases the levels of some VOCs in blood, the samples were also analyzed for 2,5-dimethylfuran, a biomarker for smoking.

VOC metabolites were measured in urine by liquid chromatography coupled with electrospray ionization tandem mass spectrometry [12]. Analytes were quantified based on relative response to stable isotope labeled internal standards. This method can detect VOC metabolites in the parts-per-trillion range. Urine creatinine was measured in the urine samples to compensate for hydration level in each individual. Normalization of the results per gram creatinine is a standard practice in medicine when presenting urine test results.

VOCs and trihalomethanes were measured in tap water using the same SPME-GC-MS technique outlined above for blood samples [11].

Appendix D: Tables and Figures

Table 1a. Aggregate results for the blood samples collected from 28^a DISH area residents.

Contaminant	Detection Limit (µg/L)	Range (µg/L)	Number Detected	Reference Value (µg/L) ^b	Number Above Reference Value
2,5-Dimethylfuran	0.011	ND-0.634	5	0.13	3
1,1-Dichloroethane	0.01	ND	0	ND	0
1,2-Dichlorobenzene	0.1	ND	0	ND	0
1,1-Dichloroethene	0.009	ND	0	ND	0
1,2-Dichloroethane	0.01	ND-0.055	2	ND	2
cis-1,2-Dichloroethene	0.01	ND	0	ND	0
1,1,1-Trichloroethane	0.01	ND	0	ND	0
1,2-Dibromo-3-chloropropane	0.1	ND	0	ND	0
trans-1,2-Dichloroethene	0.01	ND	0	ND	0
1,3-Dichlorobenzene	0.05	ND	0	ND	0
Tetrachloroethene	0.048	ND-0.39	3	0.14	1
1,1,1,2-Tetrachloroethane	0.01	ND	0	0.017	0
Bromoform	0.02	ND-0.233	3	ND	3
Bromodichloromethane	0.014	ND	0	ND	0
Benzene	0.024	ND-1.45	6	0.25	4
Chlorobenzene	0.011	ND	0	ND	0
Chloroform	0.011	ND-0.066	10	0.050	2
Dibromochloromethane	0.005	ND-0.047	4	0.007	2
Carbon tetrachloride	0.005	ND	0	ND	0
1,4-Dichlorobenzene	0.12	ND-12.6	4	3.1	1
Dibromomethane	0.03	ND	0	ND	0
1,2-Dichloropropane	0.008	ND	0	ND	0
Ethylbenzene	0.024	ND-0.437	8	0.10	3
Hexachloroethane	0.011	ND	0	ND	0
Methylene chloride ^c	0.15	ND	0	ND	0
Methyl tert-butyl ether ^c	0.01	ND	0	0.17	0
Nitrobenzene	0.32	ND	0	ND	0
o-Xylene	0.024	ND-0.186	7	0.089	3
Styrene	0.03	ND-0.525	13	0.10	4
Trichloroethene	0.012	ND-0.013	1	ND	1
1,1,1-Trichloroethane	0.01	ND-0.095	1	ND	1
Toluene	0.025	ND-3.25	18	0.68	5
m-/p-Xylene	0.034	ND-1.32	15	0.33	4

^a One participant was dehydrated and was not able to provide a blood and urine sample.

^b Reference Value was obtained from the NHANES, 2003-2004 Laboratory Files, Lab 04 Volatile Organic Compounds in Blood and Water (August, 2008) and represents the 95th percentile.

^c Due to failed Quality Assurance/Quality Control (QA/QC) in the laboratory, there are no results for 2 samples for methylene chloride and 1 sample for methyl tert-butyl ether.

Table 1b. Summary results for the blood samples collected from 28^a DISH area residents. Only those compounds that had values above the reference range are presented.

Contaminant	Range (µg/L)	Number Detected	Reference Value (µg/L) ^b	Number Above Reference Value	Common Exposure Sources	Comments
2,5-Dimethylfuran	ND (non-smokers) 0.026-0.634 (smokers)	0 (non-smokers) 5 (smokers)	0.13	0 (non-smokers) 3 (smokers)	Biomarker for smoking	Only elevated in smokers
1,2-Dichloroethane	ND-0.015 (non-smokers) ND-0.055 (smokers)	1 (non-smokers) 1 (smokers)	ND	1 (non-smokers) 1 (smokers)	Found in paint, varnish, finish removers, metal degreasers	Source currently not known; however, not commonly associated with gas wells
Tetrachloroethene	ND-0.39 (non-smokers) ND (smokers)	3 (non-smokers) 0 (smokers)	0.14	1 (non-smokers) 0 (smokers)	Solvent in a number of auto products, cleaners, degreasers, lubricants. Not unusual in people who work with machinery or motors.	Based on the exposure survey this is likely an occupationally related exposure
Bromoform	ND-0.233 (non-smokers) ND (smokers)	3 (non-smokers) 0 (smokers)	ND	3 (non-smokers) 0 (smokers)	Water system disinfectant by-product.	All individuals were on the same chlorinated water supply
Benzene	ND-0.027 (non-smokers) 0.045-1.45 (smokers)	1 (non-smokers) 5 (smokers)	0.25	0 (non-smokers) 4 (smokers)	Common in cigarette smoke, gasoline, home maintenance, and auto products.	Only elevated in smokers. Dose response relationship between blood level and time from last cigarette
Chloroform	ND-0.066 (non-smokers) ND-0.014 (smokers)	8 (non-smokers) 2 (smokers)	0.050	2 (non-smokers) 0 (smokers)	Water system disinfectant by-product.	All individuals were on the same chlorinated water supply.
Dibromochloromethane	ND-0.047 (non-smokers) ND (smokers)	4 (non-smokers) 0 (smokers)	0.007	2 (non-smokers) 0 (smokers)	Water system disinfectant by-product.	All individuals were on the same chlorinated water supply.
1,4-Dichlorobenzene	ND-12.6 (non-smokers) ND-0.123 (smokers)	3 (non-smokers) 1 (smokers)	3.1	1 (non-smokers) 0 (smokers)	Commonly found in moth repellent (moth balls) and space deodorizers.	Source currently not known. Based on the exposure survey may be an occupational exposure.

Table 1b. Continued.

Contaminant	Range (µg/L)	Number Detected	Reference Value (µg/L) ^b	Number Above Reference Value	Common Exposure Sources	Comments
Ethylbenzene	ND-0.124 (non-smokers) ND-0.437 (smokers)	4 (non-smokers) 4 (smokers)	0.10	1 (non-smokers) 2 (smokers)	Common in cigarette smoke, gasoline, home maintenance, and auto products.	The two highest values were found in smokers with a dose response relationship between blood level and time from last cigarette. Based on the exposure survey, third elevation likely due to occupationally related exposure.
o-Xylene	ND-0.118 (non-smokers) ND-0.186 (smokers)	3 (non-smokers) 4 (smokers)	0.089	1 (non-smokers) 2 (smokers)	Common in cigarette smoke, gasoline, home maintenance, and auto products.	The two highest values were found in smokers with a dose response relationship between blood level and time from last cigarette. The source of the third elevation unknown; however, claimed to spend a lot of time in vehicle.
Styrene	ND-0.068 (non-smokers) 0.045-0.525 (smokers)	8 (non-smokers) 5 (smokers)	0.10	0 (non-smokers) 4 (smokers)	Common in cigarette smoke, gasoline, home maintenance, and auto products.	Only elevated in smokers
Trichloroethene	ND-0.013 (non-smokers) ND (smokers)	1 (non-smokers) 0 (smokers)	ND	1 (non-smokers) 0 (smokers)	Home maintenance and auto products. Solvent used for metal cleaning and degreasing	Based on the exposure survey this is likely an occupationally related exposure
1,1,1-Trichloroethane	ND-0.095 (non-smokers) ND (smokers)	1 (non-smokers) 0 (smokers)	ND	1 (non-smokers) 0 (smokers)	Metal degreaser and lubricants	Based on the exposure survey this is likely an occupationally related exposure

Table 1b. Continued.

Contaminant	Range (µg/L)	Number Detected	Reference Value (µg/L) ^b	Number Above Reference Value	Common Exposure Sources	Comments
Toluene	ND-0.839 (non-smokers) 0.174-3.25 (smokers)	13 (non-smokers) 5 (smokers)	0.68	1 (non-smokers) 4 (smokers)	Common in cigarette smoke, gasoline, home maintenance and auto products.	Four highest values were found in smokers with a dose response relationship between blood level and time from last cigarette. Based on the exposure survey results, fifth elevation likely due to occupationally related exposure.
m-/p-Xylene	ND-0.389 (non-smokers) 0.084-1.32 (smokers)	10 (non-smokers) 5 (smokers)	0.33	2 (non-smokers) 2 (smokers)	Common in cigarette smoke, gasoline, home maintenance and auto products.	Two highest values were found in smokers with a dose response relationship between blood level and time from last cigarette. Based on the exposure survey results, third elevation likely due to occupationally related exposure. Forth exposure source unknown but claimed to spend a lot of time in vehicle.

^b Reference Value was obtained from the NHANES, 2003-2004 Laboratory Files, Lab 04 Volatile Organic Compounds in Blood and Water (August, 2008) and represents the 95th percentile.

Table 2. Aggregate results for the contaminants detected in blood samples collected from five TxDSHS staff. Pre-trip samples were collected before traveling to DISH. Post-trip samples were collected after being in DISH to conduct the exposure investigation.

Contaminant ^a	Detection Limit (µg/L)	Pre-Trip Range (µg/L)	Pre-Trip Number Detected	Post-Trip Range (µg/L)	Post-Trip Number Detected	Reference Value (µg/L) ^b	Pre-Trip Number Above Reference Value	Post-Trip Number Above Reference Value
2,5-Dimethylfuran	0.011	ND-0.035	1	ND-0.035	1	0.13	0	0
Benzene	0.024	ND-0.054	1	ND-0.044	1	0.25	0	0
Chloroform	0.011	ND-0.023	4	ND-0.018	2	0.050	0	0
Dibromochloromethane	0.005	ND-0.013	4	ND	0	0.007	3	0
1,4-Dichlorobenzene	0.12	ND-0.177	2	ND-0.197	2	3.1	0	0
Ethylbenzene	0.024	ND-0.031	1	ND	0	0.10	0	0
Styrene	0.03	ND-0.04	2	ND	0	0.10	0	0
Toluene	0.025	ND-0.162	2	ND-0.128	1	0.68	0	0
m-/p-Xylene	0.034	ND-0.083	2	ND-0.067	2	0.33	0	0

^a TxDSHS staff blood results were analyzed for the same contaminants as the participant blood samples. For TxDSHS staff, only those contaminants detected in at least one blood sample are listed.

^b Reference Value was obtained from the NHANES, 2003-2004 Laboratory Files, Lab 04 Volatile Organic Compounds in Blood and Water (August, 2008) taken as the 95th percentile value.

Table 3a. Aggregate results for the urine samples (reported in $\mu\text{g/L}$) collected from 28^a DISH area residents, data obtained from published analytical method papers, and TxDSHS staff pre-trip and post-trip urinary results.

Metabolite	Range	Number Detected	Published and TxDSHS Staff Ranges ^c
PMA	ND ^b -0.606 $\mu\text{g/L}$ (non-smokers) ND ^b -2.85 $\mu\text{g/L}$ (smokers)	1 (non-smokers) 2 (smokers)	ND-0.26 $\mu\text{g/L}$ (non-smokers) [12] ND-37.7 $\mu\text{g/L}$ (smokers) [12] ND (TxDSHS staff pre-trip) ND (TxDSHS staff post-trip)
DHBM	153-1730 $\mu\text{g/L}$ (non-smokers) 611-1410 $\mu\text{g/L}$ (smokers)	23 (non-smokers) 5 (smokers)	ND-329 $\mu\text{g/L}$ (non-smokers) [12] 19.4-2,500 $\mu\text{g/L}$ (non-smokers) [13] 113-1,830 $\mu\text{g/L}$ (smokers) [12] 15.4-1,959 $\mu\text{g/L}$ (smokers) [13] 237-610 $\mu\text{g/L}$ (TxDSHS staff pre-trip) 364-856 $\mu\text{g/L}$ (TxDSHS staff post-trip)
BMA	1.32-32.3 $\mu\text{g/L}$ (non-smokers) 5.19-45.9 $\mu\text{g/L}$ (smokers)	23 (non-smokers) 5 (smokers)	4.46-43.7 $\mu\text{g/L}$ (TxDSHS staff pre-trip) 6.88-11.8 $\mu\text{g/L}$ (TxDSHS staff post-trip)
AMCA	30.1-743 $\mu\text{g/L}$ (non-smokers) 140-1870 $\mu\text{g/L}$ (smokers)	23 (non-smokers) 5 (smokers)	38.9-498 $\mu\text{g/L}$ (non-smokers) [10] 122-1,453 $\mu\text{g/L}$ (smokers) [10] 61-251 $\mu\text{g/L}$ (TxDSHS staff pre-trip) 72.2-316 $\mu\text{g/L}$ (TxDSHS staff post-trip)

^a One participant was dehydrated and was not able to provide a blood and urine sample.

^b The detection limit for PMA was 0.6 $\mu\text{g/L}$.

^c Currently, comparison information for urine that is representative of the general U.S. population do not exist. For your information, we included information on these contaminant levels measured in people from several published papers. These papers focused on developing analytical methods for measuring these compounds in urine, not on obtaining information representative of any population. These values should not be used to make any predictions regarding the potential for adverse health effects. Results for urine samples collect from 5 TxDSHS staff before and after the exposure investigation also are included.

Table 3b. Aggregate results for the urine samples (reported in $\mu\text{g/g}$ -creatinine) collected from 28^a DISH area residents. Urine creatinine was measured in the urine samples to allow the normalization of the results.

Metabolite	Range	Number Detected	Published and TxDSHS Staff Ranges ^c
PMA	ND ^b -0.40 $\mu\text{g/g}$ -creatinine (non-smokers)	1 (non-smokers)	ND-0.45 $\mu\text{g/g}$ -creatinine (non-smokers) [12]
	ND ^b -2.79 $\mu\text{g/g}$ -creatinine (smokers)	2 (smokers)	ND-18.4 $\mu\text{g/g}$ -creatinine (smokers) [12] ND (TxDSHS staff pre-trip) ND (TxDSHS staff post-trip)
DHBM	275-1792 $\mu\text{g/g}$ -creatinine (non-smokers)	23 (non-smokers)	ND-582 $\mu\text{g/g}$ -creatinine (non-smokers) [12]
	980-1419 $\mu\text{g/g}$ -creatinine (smokers)	5 (smokers)	166-1,092 $\mu\text{g/g}$ -creatinine (smokers) [12] 501-1,505 $\mu\text{g/g}$ -creatinine (TxDSHS staff pre-trip) 388-1,125 $\mu\text{g/g}$ -creatinine (TxDSHS staff post-trip)
BMA	2.02-40.6 $\mu\text{g/g}$ -creatinine (non-smokers)	23 (non-smokers)	2.4-81.4 $\mu\text{g/g}$ -creatinine (non-smokers) [14]
	5.1-46.2 $\mu\text{g/g}$ -creatinine (smokers)	5 (smokers)	1.7-31.2 $\mu\text{g/g}$ -creatinine (smokers) [14] 10.9-50.7 $\mu\text{g/g}$ -creatinine (TxDSHS staff pre-trip) 6.67-25.05 $\mu\text{g/g}$ -creatinine (TxDSHS staff post-trip)
AMCA	53-770 $\mu\text{g/g}$ -creatinine (non-smokers)	23 (non-smokers)	47.3-449 $\mu\text{g/g}$ -creatinine (non-smokers) [10]
	225-1882 $\mu\text{g/g}$ -creatinine (smokers)	5 (smokers)	196.4-1153 $\mu\text{g/g}$ -creatinine (smokers) [10] 103-307 $\mu\text{g/g}$ -creatinine (TxDSHS staff pre-trip) 67-300 $\mu\text{g/g}$ -creatinine (TxDSHS staff post-trip)

^a One participant was dehydrated and was not able to provide a blood and urine sample.

^b The detection limit for PMA was 0.6 $\mu\text{g/L}$.

^c Currently, comparison information for urine that is representative of the general U.S. population do not exist. For your information, we included information on these contaminant levels measured in people from several published papers. These papers focused on developing analytical methods for measuring these compounds in urine, not on obtaining information representative of any population. These values should not be used to make any predictions regarding the potential for adverse health effects. Results for urine samples collect from 5 TxDSHS staff before and after the exposure investigation also are included.

Figure 1. Urinary results for PMA (reported in $\mu\text{g/g}$ -creatinine) for DISH participants compared to TxDSHS staff and published analytical method papers. Information on interpreting this graph is provided in Appendix E.

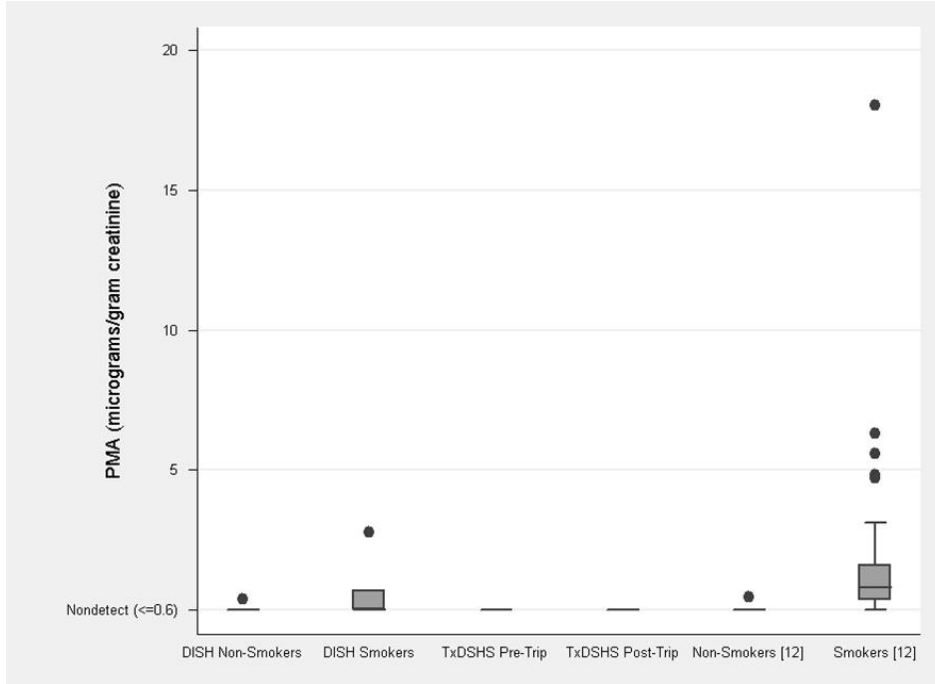


Figure 2. Urinary results for DHBM (reported in $\mu\text{g/g}$ -creatinine) for DISH participants compared to TxDSHS staff and published analytical method papers. Information on interpreting this graph is provided in Appendix E.

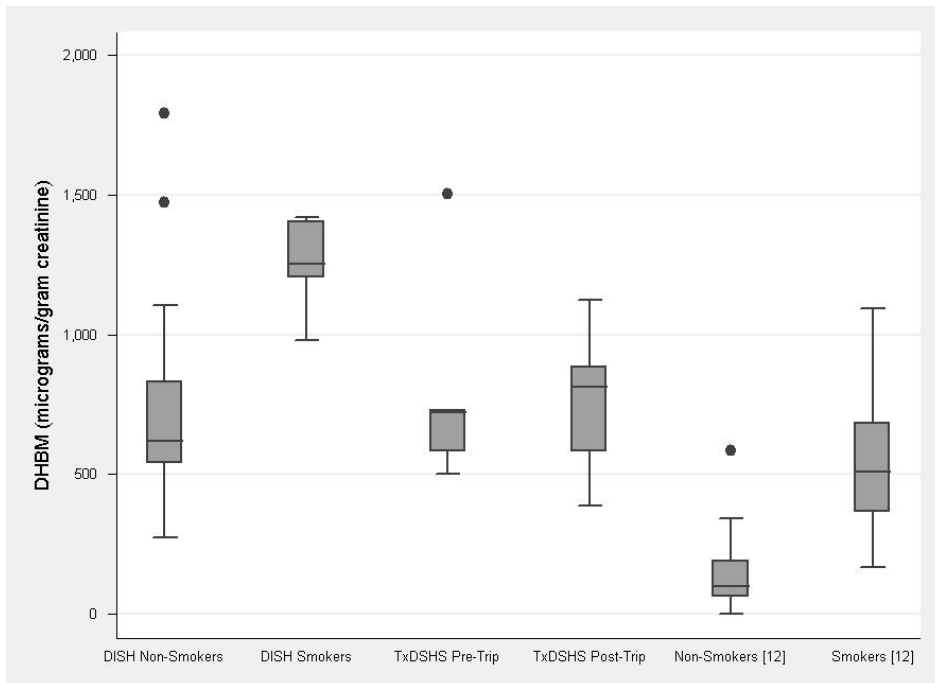


Figure 3. Urinary results for BMA (reported in $\mu\text{g/g}$ -creatinine) for DISH participants compared to TxDSHS staff and published analytical method papers. Information on interpreting this graph is provided in Appendix E.

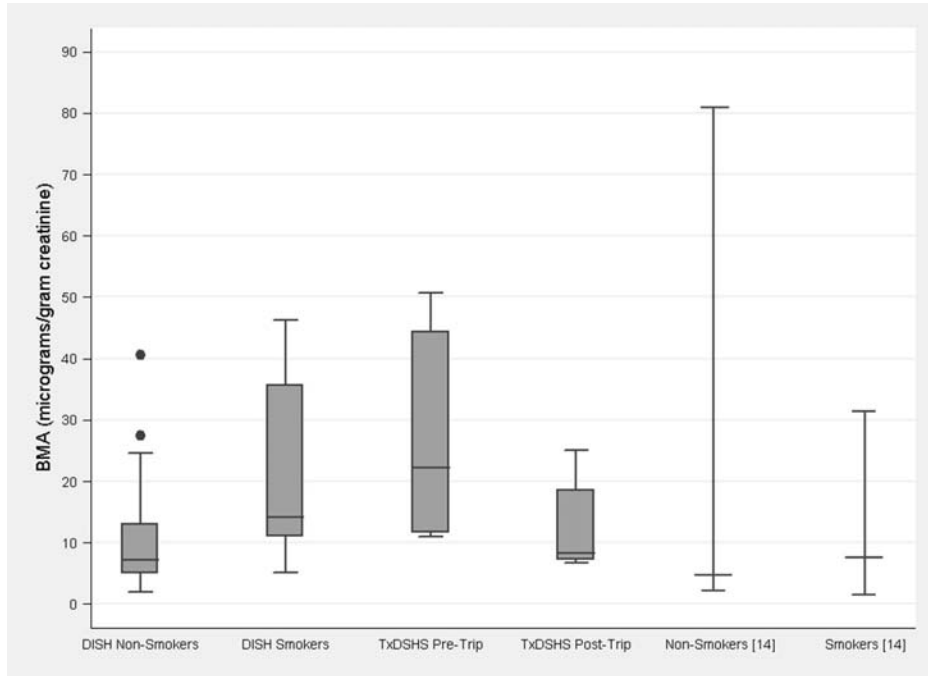


Figure 4. Urinary results for AMCA (reported in $\mu\text{g/g}$ -creatinine) for DISH participants compared to TxDSHS staff and published analytical method papers. Information on interpreting this graph is provided in Appendix E.

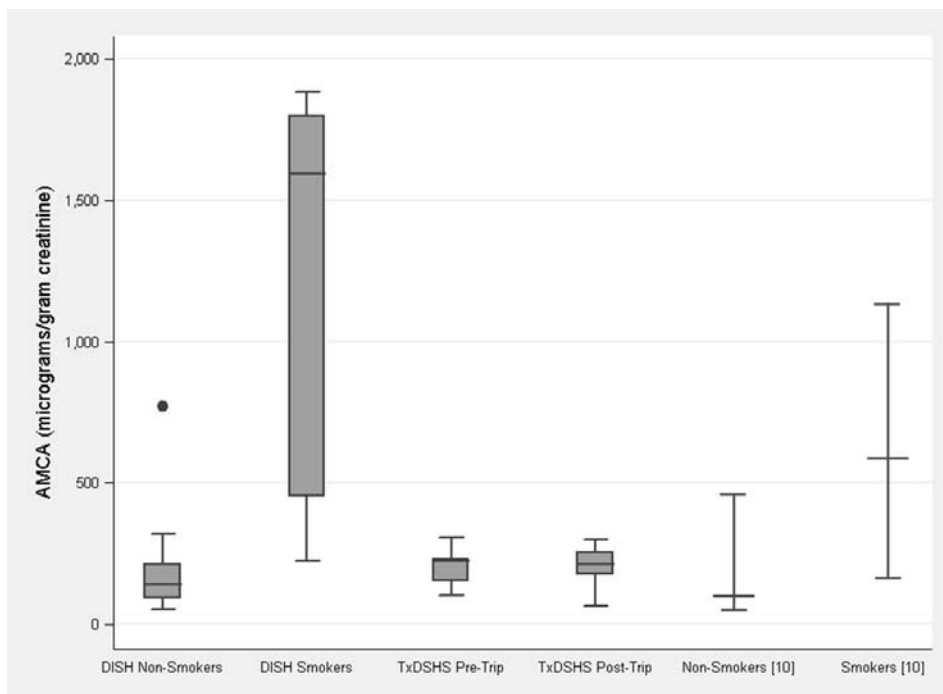


Table 4. Aggregate results for the tap water samples collected from 27^a DISH area resident's homes.

Contaminant	Detection Limit (µg/L)	Range (µg/L)	Number Detected	MCL (µg/L) ^b	Number Above MCL
Total Trihalomethanes ^c		ND-354		80	1
Bromoform	0.02	ND-228	13		
Bromodichloromethane	0.01	ND-19.7	16		
Chloroform	0.1	ND-0.592	4		
Dibromochloromethane	0.1	ND-106	13		
Benzene	0.05	ND	0	5	0
Ethylbenzene	0.01	ND-11.6	14	700	0
Methyl tert-butyl ether ^d	0.01	ND-0.068	3	3,000 ^e	0
Styrene	0.02	ND-0.351	16	100	0
Toluene	0.1	ND-0.186	1	1,000	0
Total Xylenes ^f		ND-30.4		10,000	0
o-Xylene	0.005	ND-10.4	17		
m-/p-Xylene	0.015	ND-20.4	15		

^a Two participants shared a private well. One tap water sample was collected for these two participants. Another participant had a whole house water filter and we were not able to collect an un-filtered tap water sample.

^b The maximum legal amount of a chemical that is allowed in public drinking water under the Federal Safe Drinking Water Act.

^c The MCL for total trihalomethanes is based upon the sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane.

^d Due to failed QA/QC in the laboratory, there are no results for 5 samples for methyl tert-butyl ether.

^e The federal government has not established an MCL for methyl tert-butyl ether. A health-protective comparison value was used to evaluate the tap water results for this compound.

^f The MCL for total xylenes is based upon the sum of o-xylene and m-/p-xylene.

Appendix E: Statistical Analyses

Data Analysis Procedures

Because the purpose of this investigation was to compare the levels of VOCs in the blood from DISH residents to those measured in the general U.S. population, descriptive statistics and tests of significance were conducted to compare the DISH blood results with data from NHANES. Ranges of values were determined for all contaminants and where possible, DISH median values were compared with weighted reference median values obtained from NHANES.

Statistical Analyses

Median values were compared with weighted reference median values (obtained from NHANES) for benzene, m-/p-xylene, and toluene. A test of medians was used because the blood sample results were not normally distributed. Nonparametric tests of significance only could be conducted on contaminants that had a median in the reference data set. These values were not available for the remaining contaminants because of a large number of non-detect values (greater than 50%) in the reference data set. Medians for benzene, toluene, and m-/p-xylene were not significantly different than the reference group at the $p=0.05$ level.

Statistical comparison of DISH blood sample results with the general U.S. population reference values.

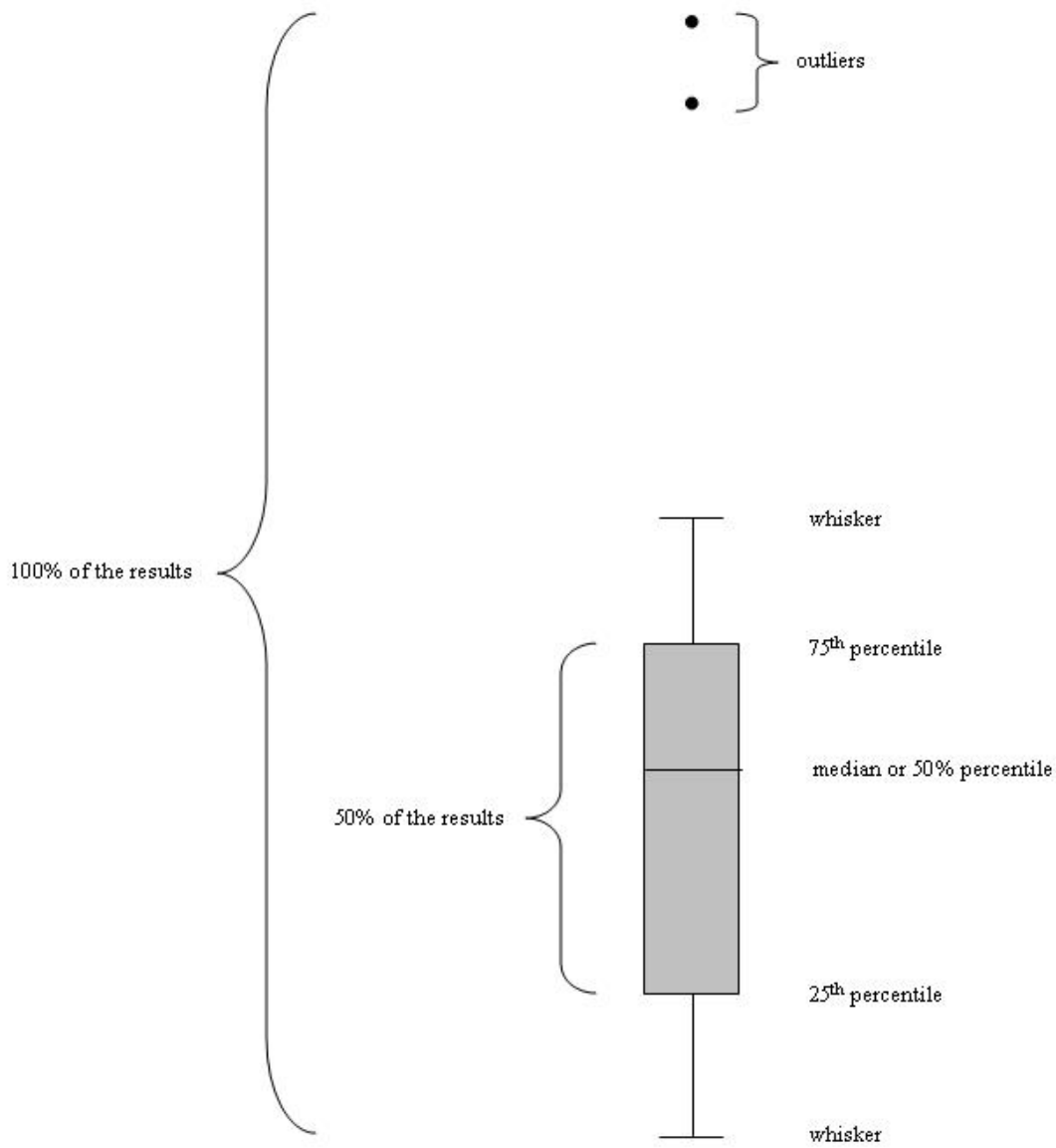
Contaminant ^a	DISH Median	Reference Median	Comparison Outcome ^b
Benzene	ND	0.027	DISH median is not significantly different than the reference median
Toluene	0.045	0.096	DISH median is not significantly different than the reference median
m-/p-Xylene	0.041	0.12	DISH median is not significantly different than the reference median

^a The median is not available for contaminants that have 50% or more non-detect values in the reference data set (NHANES). A test of significance could only be completed for the contaminants in the table.

^b A p-value of 0.05 was used for statistical comparisons.

Interpretation of Graphs of Urinary Results

Below is an example of the graphs that we used to present the urinary results. The shaded area represents the middle 50% of the urinary results and the line through the shaded box represents the median or 50th percentile of the data. The top and bottom borders of the shaded box represent the 75th and 25th percentile, respectively. The horizontal lines (or “whiskers”) above and below the box represent maximum and minimum values that are no more than 1.5 times the range of values between the 25th and the 75th percentiles. Individual points on the graphs were identified as outliers (values that deviate markedly from other members of the group). Tukey defined outliers as values that are more than 1.5 times the interquartile range beyond the lower or upper quartile.



Appendix F: Public Health Statements

Below is a list of links to Public Health Statements for the contaminants that were detected above the reference range. Each Public Health Statement includes information about the contaminant and the potential health effects of exposure. Most of the potential health effects have been observed in occupational settings, with exposure to VOCs at levels much higher than what is seen in the general population. While measuring VOCs in blood and VOC metabolites (what the VOCs are changed to by the body) in urine can tell us whether people were recently exposed to these contaminants, there are no standards available which would allow us to determine whether the measured levels would put anyone at an increased risk for adverse health effects. This information is being included for informational purposes only and should not be used to make causal relationships between any individual's health and VOC levels measured in the body.

1,2-Dichloroethane: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=590&tid=110>

Tetrachloroethylene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=263&tid=48>

Bromoform: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=711&tid=128>

Benzene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=37&tid=14>

Chloroform: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=51&tid=16>

Dibromochloromethane: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=711&tid=128>

1,4-Dichlorobenzene: <http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=126>

Ethylbenzene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=381&tid=66>

o-Xylene and m-/p-Xylene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=293&tid=53>

Styrene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=419&tid=74>

Trichloroethene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=171&tid=30>

1,1,1-Trichloroethane: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=430&tid=76>

Toluene: <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=159&tid=29>