

HOUSTON EXPOSURE TO AIR TOXICS STUDY

HEATS

**Final Report to
Texas Environmental Research Consortium**

**Presented to:
Texas Environmental Research Consortium**

**By:
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Executive Summary

The Houston Exposure to Air Toxics Study (HEATS) is a two-year project that will link personal exposure measurements to ambient measurements of air toxics by evaluating exposure to populations that reside adjacent to the Houston Ship Channel, and comparing those exposures to a socio-demographically-matched population distant from the Ship Channel region. HEATS is funded by multiple sponsors at \$1.1 million. The TERC contribution is \$50,000. The study consists of four phases:

1. Laboratory testing of passive sampling devices for air toxic compounds of concern in the Houston region. This phase occurred in 2006 and the first half of 2007 and culminated in the choice of Perkin Elmer (PE) tubes as the method for collection of VOC compounds. This extensive methods development phase allowed the study team to perform an intensive evaluation of several different air toxics samplers, and to select the best overall volatile organic compounds (VOC) sampler for Houston's extreme weather conditions.
2. Recruitment of participants and field-testing of all methods on a sub-sample of the population as a pilot study. This pilot study was conducted from September 1 to October 3, 2007. This pilot study provided data and information that allowed the study team to enhance recruiting and refine questionnaires and analytical techniques.
3. Collection of personal exposure measurements during a variety of seasonal weather conditions. Collection of risk perception and self-reported health effects from the exposure study population. Phase III is in progress, and will continue through September 2008.
4. Preparation of a final report, which will be completed in early 2009.

HEATS will provide data on source contribution ratios, averaging time comparisons, and amount and duration of exposure. The results will show whether, and to what degree, actual personal exposure differs from ambient results collected at fixed-monitoring sites. The results will also elucidate similarities and differences between personal exposure in two sociodemographically-matched Houston neighborhoods that differ in terms of proximity to the Houston Ship Channel industrial and transportation emissions sources. Linking personal exposure data for air toxics to ambient air monitoring data will allow resources to be more effectively targeted in specific geographical or societal areas of concern.

The study will provide information that the Texas Commission on Environmental Quality (TCEQ), the U.S. Environmental Protection Agency (EPA) and other research organizations can use to determine the relative contribution of point, mobile and area source emissions to actual exposure, develop strategies to reduce population risks, design health effects studies that incorporate ambient and personal exposure information, evaluate the performance of currently used exposure models and develop air toxics exposure and concentration models.

This data will also be useful in other, yet to be developed applications. For example, some air toxics of concern have been decreasing at ambient monitors in industrial regions in recent years due to new regulatory, technology and voluntary programs. Data from HEATS may provide some basis for comparing older measured or modeled personal exposure data with current exposure data to determine if decreases at ambient monitors resulted in decreases in personal exposure. In addition, the key VOCs sampled in this project are also ozone precursors. As the

state and other policymakers assess ozone ambient and personal exposure data (not collected as a part of this study) and other information for the State Implementation Plan (SIP), the HEATS data may become an important adjunct data source for this analysis. If state or federal policymakers wish to assess the benefits of multi-pollutant strategies on human health, the HEATS data sets will prove unique and invaluable. Finally, this data source will be usable by other researchers, states, and the EPA policymakers for comparisons with data in other states and regions, and as a strong contribution to the body of literature on personal exposure sampler development.

Background

In September 2005, Dr. Maria Morandi and Dr. Tom Stock of the UT Health Science Center submitted a work plan for the Houston Exposure to Air Toxics Study (HEATS), requesting partial funding from the Texas Commission on Environmental Quality (TCEQ), Mickey Leland National Urban Air Toxics Research Center (the Center), and the U.S. Environmental Protection Agency (EPA). Additional funding has been supplied by the Texas Environmental Research Consortium (TERC) and the East Harris County Manufacturer's Association (EHCMA). The City of Houston and Harris County are also participating in a non-funding, consulting role.

The Houston Exposure to Air Toxics Study (HEATS) is a two-year project that will link personal exposure measurements to ambient measurements of air toxics by evaluating exposure to populations that reside adjacent to the Houston Ship Channel, and comparing those exposures to a reference population in the reference neighborhood, Aldine. The first phase of the study will be dedicated to laboratory testing of passive sampling devices. The second phase will involve recruitment of participants and field-testing of all methods on a sub-sample of the population. After the laboratory and field-testing is completed, a sampling phase will be completed. Personal exposure measurements will be collected during a variety of seasonal weather conditions. A distinct health effects survey component will seek to identify self-reported health effects from the exposure study population. The results of the health effects survey will be used to generate hypotheses about potential links between air toxics and health effects. The study will conclude with the preparation of a final report.

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Specifically, the study will provide information that TCEQ, EPA and other research organizations can use to determine the relative contribution of point, mobile and area source emissions to actual exposure, develop strategies to reduce population risks, design health effects studies that incorporate ambient and personal exposure information, evaluate the performance of currently used exposure models and develop air toxics exposure and concentration models.

The study will also have a parallel communication, outreach and education plan. This plan will help ensure that the study aims, processes and goals are adequately communicated to the study participants and greater community, which will help ensure good data quality. It will also ensure that the study results are communicated fully to the regulatory community, local leaders and the community, which will help maximize the utility of the study.

Project Status

Initial DEARS Sampler and UltraBadge Field Comparison Study: Fall 2006

One of the key study elements of HEATS is developing, testing, and certifying state-of-the-science personal exposure monitors appropriate for use in Houston's extreme weather conditions and relevant concentration ranges for a number of volatile organic compound (VOC) and carbonyl compounds. This methods development and demonstration element is key scientific enhancement of HEATS over some other recent regional studies.

A three-day comparison study between the UltraBadge and the Perkin Elmer (PE) tube sampler was performed in collaboration with EPA, Alion, and SKC. Three consecutive 24-hour samplings were undertaken from October 19 through October 22, 2006. The Clinton TCEQ site was selected because it is in the target area and has auto gas chromatograph (GC) monitoring as well as impact from mobile sources and industrial sources. Testing was performed during October 19-21. Three sets of paired PE and SKC samplers were deployed in a fixed shelter close by and a rotating shelter on the roof top of the Clinton TCEQ sampling trailer. These results were inconclusive but provided valuable information to the PIs about the relative performance expectations for each method.

Additional VOC Sampler Development Activities: Spring/Summer/Fall 2007

As part of the methods development phase of the project, the PIs collected preliminary data relating to the comparison of two different samplers, the SKC UltraBadge, and the Perkin-Elmer tubes used in the DEARS study, another large exposure assessment study that will be completed this year in the Detroit, MI region. Attachment A (the final Scope of Work for the study) to this report contains a description of the analysis techniques and data results from a side-by-side comparison of the two samplers in the Houston area, and correlates the results from both methods to ambient samples from collocated fixed measurement sites.

This side-by-side comparison of two methods in the Houston region is significant because it constitutes the most important of the methods development steps—collection of data leading up to sampler selection, and then sampler optimization. It is also significant as a contribution to the scientific literature relating to the development, field testing and verification of personal exposure samplers in extreme meteorology environments.

Selected Sampling Method

After the initial work in the summer of 2007 evaluating the two methods, the PIs with the support of the TCEQ, NUATRC, and EPA, selected the Perkin Elmer tubes (i.e., DEARS-PE tubes) that will be analyzed for the list of VOC listed in Table 7 of the SOW (May 31, 2007). DEARS-PE tubes will also be placed at the Aldine and Clinton Avenue ambient monitoring sites whenever indoor, outdoor and personal measurements are performed. Briefly, the PE tube is a passive sampling device that collects VOCs on a graphitic carbon (Carbopack). The tube is exposed for 24 hours and VOCs collected are thermally desorbed and analyzed by gas chromatography with mass spectrometry. If a method for monitoring airborne carbonyls used in the EPA DEARS study is deemed reliable after the first six months of the HEATS field study, then 24-hour measurements of airborne carbonyl concentrations will also be obtained during the repeat visits to all homes.

Residential indoor and outdoor temperature and relative humidity will be monitored using HOBOS (Onset Computer, Corp.) These are small (3 inches in diameter and one inch tall)

recording devices that have been employed in other exposure studies. Air exchange rates (AER) will be obtained using a tracer method previously employed by the University of Texas School of Public Health (UTSPH) and others for this purpose. Briefly, the method consists of releasing a perfluorocarbon tracer inside a residence and waiting a suitable amount of time for each to reach concentration equilibrium, 48 hours or longer. After that time, charcoal tubes (CATs) are placed inside the home to sample the released tracer passively. The CATs are then analyzed for the tracer by GC/MS. The tracer concentration, indoor and outdoor temperature and house volume are then used to calculate the AER. If a home has an attached garage, two different tracers will be used, one for the main living area and one for the garage.

Fixed site ambient measurements and meteorology data collected at the Aldine and Clinton sites will be obtained from TCEQ. Coordinates for house location and potential sources will be obtained in preliminary format using GoogleEarth. The location of sources will be corroborated by field personnel via direct observation.

DEARS-PE tubes are thermally desorbed and analyzed by GC/MS. The analytical procedures were in continuous development during this period, and were provided in progress reports to the NUATRC dated August 7, 2007 and October 15, 2007.

PAKS Method Modification and UltraBadge Evaluation Study

As indicated earlier, the PIs are concerned about the issue of high blanks in the PAKS that appear to be related to a temperature effect, at least in part. This issue is especially important in Houston because of the very high summer temperatures. This problem is related to the chemistry of the reaction conditions for the formation of derivatives. The PIs obtained the latest written laboratory standard operating procedures (SOPs). They followed the same coating and chemical analysis procedures focusing on three aldehydes: formaldehyde, acetaldehyde and acrolein, and incorporating the investigation of the high field blanks simultaneously with the comparison of the PAKS and UltraBadge. Experiments were conducted to investigate the following: a) Effect of temperature on the uncoated sorbent; b) Test of alternative sorbents; c) Field comparisons (using both the fixed and rotating shelters) were done at the Clinton TCEQ sampling site, where carbonyl concentrations are monitored routinely by the DNPH method; d) Laboratory evaluations were also done by placing blank samplers at temperatures to be expected outdoors in the summer (40°C) because outside conditions in November do not mimic the summertime period.

The original study design included both carbonyl and VOC sampling tracks. However, the lead sponsors were most interested in the collection of VOCs that have been identified as the compounds of primary health concern in the Houston area. As a result of the challenges encountered with methods development for carbonyls, and after discussions with the Center's Science Advisory Panel (SAP), EPA and TCEQ, the PIs have determined that they will maintain the development of the carbonyl compounds on an investigational track if time on the primary study permits.

Pilot Study and Early Field Study Methods Development Experience

A. Blanks and background concentrations of butadiene and benzene

The PIs have continued investigating and trying to reduce the background levels of butadiene, benzene, and toluene in the PE sampling tubes via repeated desorption with ultrapure helium at 320 C. Except for benzene, background concentrations are now below 1 ng/tube for all VOCs analyzed. There is variability in the benzene background. Two field blanks and one laboratory blank approached or exceeded 2 ng/tube in benzene background level; excluding these three tubes, the average background would have been approximately half. Given the need to move forward with the study, the PIs continue to clean the PE tubes in the expectation that as happened with the DEARS study, the background will continue decreasing as the tubes are continuously used.

B. Calibration

The PIs have confirmed that the methanol solvent used for preparation of standards does not contain benzene by GC/MS analysis of the solvent, and that there is no breakthrough of target VOCs when using the liquid spiking of target compounds for standard preparation. The PIs will exchange spiked tubes with Alion, Inc., to compare their chamber spiking procedure with the liquid spiking approach. The standard regression for the calibration used in the quantification of samples collected during the field study is excellent for most compounds with the notable exception of the higher molecular weight unsaturated terpenes. The PIs have observed this phenomenon earlier and suspect that it may be due to a concentration-dependent nonlinear response.

C. VOC Concentrations Monitored During the Pilot Study

Because of the need for securing permission from TCEQ to place a special shelter at the Aldine and Clinton Dr. sampling sites (to avoid the need for climbing on the rooftop of the monitoring trailers), fixed site monitoring was performed on only one of the sampling days during the pilot. Personal and indoor samples had a larger proportion of concentrations at or above detection levels than the outdoor residential levels. The concentrations for the fixed sites were mostly below detection on the only day that samplers were placed there. Importantly, some of the samples had loads that exceeded the upper range of the calibration curve, specifically for toluene and p-dichlorobenzene. There was evidence of saturation of the detector for one of the toluene personal samples. Qualitative evaluation of the chromatograms also indicated occasional high exposure to other compounds such as ethyl acetate.

Development of HEATS Exposure-Related Questionnaires

The PIs have developed draft, HEATS-specific questionnaires in both English and Spanish. The instruments from RIOPA/NHEXAS have been modified to reflect findings from RIOPA-TEXAS that could bear on differential exposures in these communities.

Based on the experiences of the investigators in the field use of the exposure-related questionnaires, all of these instruments have been revised for ease of use and improved logical flow of questions.

During this phase, UTMB made revisions to the existing HEATS Environmental Health Symptom Survey, based upon the recommendations of the Scientific Advisory Panel of the NUATRC. This original survey has been modified to include questions from the NHIS questionnaire, as well as the American Thoracic Society's respiratory questionnaire. Using this compilation of many large and well-tested instruments means that most of the questions have already gone through rigorous field-testing, and validation. The instrument has been professionally translated into Spanish.

Pilot Study Issues and Progress

Recruitment Activities and Results

Recruitment of participants is accomplished through a subcontract with RTI International under the supervision of Drs. Roy Whitmore and Michael Phillips. RTI hired four local, experienced recruiters through an employment agency they used when they've needed local canvassers for other survey studies conducted in the Houston area. The recruiters have social science training and also work for local government agencies; two of the recruiters are fluent in Spanish. RTI had conducted a recruitment training session in May, 2007; a refresher training session was conducted on August 25, 2007. This refresher training session was attended also by the HEATS UTSPH investigators and staff. The recruiters started canvassing the two study areas on the weekend of August 25-26, 2007, with the goal of recruiting five homes in each area to perform the pilot study. An initial mailing of 100 (50 per area) HEATS introduction letter and study brochures was sent to selected addresses in mid-August, 2007. A second mailout to 20 addresses in each area was sent in mid-September, 2007 in order to obtain more participants for the pilot study.

A summary of the enrollment outcomes is presented in Table 1. Approximately 66% of the enrollment visits were completed in Aldine, and 68% in the Ship Channel area. Enrollment visits are considered complete when the occupant of the household is contacted by the recruiter and there is an outcome in terms of eligibility, refusal, or enrollment as potential participant. The most frequent reason for incomplete enrollment visits was not finding anyone at home after multiple visits; this occurred in approximately one quarter of the 50 addresses in each area. An addition 10% of the addresses in Aldine and 18% in the Ship Channel were found to be vacant. Of the completed visits, the most frequent reason for non-enrollment was the presence of at least one smoker in the household.

Table 1. Summary of Pilot Study Recruitment Outcomes

REASON	ALDINE	SHIP CHANNEL
Access denied	1	1
Vacant	5	9
Not visited-unknown status		5
Unable to locate	1	
No one home	12	11
Moving within next 12 months		
Refusal	6	1
Smoker	9	10
Language barrier	5	2
Enrolled adult	7	3
Enrolled 1 adult + 1 child	4	4

Approximately 27 and 29% of the homes with completed visits had smokers in Aldine and the Ship Channel, respectively. A total of seven homes that were contacted could not be enrolled because of language barriers (the recruiter who made the contact did not speak Spanish in six cases, and in one case the adult spoke only Vietnamese). Only one of the eligible potential participants refused to enroll in the Ship Channel, but approximately 18% of eligible homes with completed enrollment visits refused to participate in Aldine. The final potential enrollment for the pilot study consisted of 11 homes (including 4 adult-child pairs) in Aldine and 7 (also including 4 adult-child pairs). Four of 18 total homes were not contacted for actual participation because they were recruited late during the first week of October and inclusion would have delayed the implementation of enrollment for the main phase of HEATS. Thus, a total of 14 enrolled homes were followed up for implementation of the HEATS field protocol.

Table 2 presents a summary of the gender and race/ethnicity of the 13 homes contacted post-enrollment. Nine of the 13 enrolled adults were female, and the same proportion, 9 of the 13 households, were Hispanic. Only one non-Hispanic white English speaker was enrolled, two African-Americans and one Asian participant (Korean).

The field recruiters provided the list of the potential participants' names, addresses, contact phone number(s), language(s) spoken, and their preferred time of the day to be called to the UTSPH-HEATS staff and investigators via e-mail secured with a password (all electronic communications containing information on participants were done using a security password).

Table 2. Characteristics of Adults Enrolled

GENDER/RACE/ETHNICITY	ALDINE	SHIP CHANNEL
GENDER		
Male	3	1
Female	5	4
RACE/ETHNICITY		
White (English speaker)	1	
African-American	2	
Hispanic (Spanish/bilingual)	4	5
Asian (English Speaker)	1	
4 children also enrolled in each area		

Staff and investigators then proceeded to contact each adult enrolled by phone. Once contacted, the potential participant was: 1) informed again about the nature of the study and time commitment; 2) if still interested in participation, the subject was asked about time availability for the four home visits required by the field protocol; and 3) an appointment was made for the first home visit. The time of the first and second visits was always made at the convenience of the participant, even if he/or she would only be available at night (at 9 pm in one case).

A major difficulty in recruitment of the participants during follow up was non-response to repeated phone calls in spite of multiple attempts during the day and late evening. Both the staff and the investigators called. Some participants did not have land-lines and their spouse would take their only available cell phone. Typically, there was either no response when making a phone call or, if an answering machine was available in the home and a message was left, there was no attempt by the participant to call back (except in one case). One of the potential participants could not be contacted at all after repeated phone calls. One potential participant indicated that he could not participate because of on-going illness that required him to be in the hospital for treatment frequently. Five indicated that they did not wish to participate; of these five, three had asked to be called at a later time when first contacted, but then indicated they did not want to participate when called at the date and time requested. The other two indicated that they would consult with their spouse regarding participation and later decline after consultation. Six of the 13 homes were effectively recruited for the exposure monitoring component of the study and completed at least the first home visit, with five completing the three exposure visits and four completing all the protocol. In one case, the adult randomly selected was the male working spouse of the household and he declined to undergo personal monitoring while his wife wanted to participate. In consultation with RTI, it was decided that for the purpose of the pilot study it would be acceptable to have her be the adult participant.

The NUATRC SAP, TCEQ and EPA have reviewed the results of the pilot study in detail. These sponsors have provided recommendations to the PIs, and endorsed the PIs recommendations to increase recruitment and retention in the full study. These

recommendations included an increase in the incentive payment to participants, a targeted communications strategy for the neighborhood, additional staff hiring and development, and several other recommendations. These strategies have been implemented in the full study, and implementation and recruitment continues.

Communication, Outreach and Education Plan

The NUATRC and TCEQ have contracted with CarreñoGroup, a local communications and public affairs company, to provide the initial phases of the communication, outreach and education plan. The initial focus of these efforts is to support recruitment and retention of study participants, communication with the study neighborhoods, and outreach to the local elected officials, stakeholder groups and opinion leaders throughout the neighborhood and larger Houston communities. Implementation of the elements of this plan will begin the week of December 3, 2007.

Related Analyses/Approval/Planning Issues

Formulation of Data Analysis Plan

Dr. Harrist, the PIs and the RTI consultants have data analysis plan that is integrated with the objectives and hypotheses of the study. The final plan is still in progress, and the major elements are in place as described in the July 2007 final scope of work (Attachment A)

Purchase and Installation of Equipment

The thermal desorption unit (Gerstel, Inc. model TDS 3) was installed on September 26, 2006. Certain other equipment and training costs have been paid by the UT-SPH, and not charged to the project.

Informed Consent

The PI's have obtained UT SPH, UTMB, RTI, and EPA IRB approval. The project PIs went back to the UT SPH IRB to request an increase in the project participation incentive payment, which was granted. This increase in incentives is expected to increase project recruitment and retention.

Participant Screening

Participant screening forms have been developed. The PIs received copies of the DEARS instruments as well as advice from Dr. Michael Phillips of RTI. Recruitment of participants commenced in Summer of 2007 and will continue through the study until the target sample size for the first monitoring visit is reached. All public recruitment, participation, and consent materials have been finalized. Recruiters and interviewers have been hired and trained and are in the field.

Laboratory/Field SOPs and Quality Assurance Project Plan

Internal SOPs have been finalized. However, these documents should be considered draft until the pilot study is concluded and any results or refinements have been incorporated into the documents.

EPA requires that a Quality Assurance Project Plan (QAPP) be completed for each EPA-sponsored project. This document was completed and signed before August 31, 2007.

Scope of Work

The Scope of Work for the project was completed and signed by all primary sponsors and PIs by July 31, 2007. This SOW is final, but is considered a “living document” by all parties, because it is subject to change as the PIs reflect the lessons learned during the pilot study and early phases of the full study plan.

Contractual/Management Issues Status

All contracts and subcontracts have been signed and are being executed.

Current Project Phases/Tasks/Milestone Reports

A. Phase 3

Projected dates and duration of Phase 3: October 1, 2007 – September 30, 2008 (12 months).

The main study phase will be comprised of indoor/outdoor concentration and personal exposure measurement, and health symptom/risk perception sampling at each of up to 100 selected houses in each study area, on two different occasions approximately six months apart. For the intended sample size of up to 100 homes in each area, this would require sampling approximately 6 homes during each week of the main field component of the study.

- Administration of field surveys during 1st and 2nd sampling campaigns
- Data entry and on going QA/QC evaluation of collected data.
- Some exploratory analysis of data collected
- Mid-Phase 3 progress report due on February 28th. This report will contain a summary of project tasks completed to date, budget expended to date, the Contractor’s project management and technical judgment of the successes and difficulties encountered in the study to date (focusing on the in-practice experience of the feasibility of the first sampling period) and whether the project is on track to be completed by the required date.
- Interim report at conclusion of Phase 3.

B. Phase 4

Projected dates and duration of Phase 4: October 1, 2008-February 28, 2009 (five months).

The objective of this phase is to complete all data analyses as described in the Data Analysis Plan and prepare the Draft Final Report to be submitted for review by the funding organizations by February 28, 2009. The final report will be submitted after receiving the comments from this review.

- Final QA/QC of database
- Analysis of health symptom and risk perception surveys

- Evaluation of association of patterns between health symptom/risk perception survey results and objectives measures of concentration and exposure

Schedule of Deliverables:

The Scope of Work Elements discussed above were and/or will be delivered to the project sponsors on or before the following dates:

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|-------------------------------|--------------------|
| 1. Mid-Phase 3 Interim Report | February 28, 2008 |
| 2. Phase 3 Interim Report | September 30, 2008 |
| 3. Final Draft Report | December 31, 2009 |
| 4. Final Report | February 28, 2009 |
| 5. Database | |

Presented to Texas Environmental Research Consortium

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Date