Public Meeting
Petition HP 01-3 Requesting a Ban of Chromated Copper Arsenate (CCA)-Treated Wood in Playground Equipment

March 17-18, 2003

Oral Presentations

Monday, March 17, 2003 2:00 p.m.

Panel 1
Jack Housenger, Associate Director
Antimicrobial Division
US Environmental Protection Agency

Panel 2
Jane Houlihan, Petitioner
Environmental Working Group

Paul Bogart, Petitioner
Healthy Building Network

Jay Feldman, Executive Director
Beyond Pesticides
Washington, DC

Laurette Janak
Consumer
Colden, NY

Panel 3
The Honorable Louis Sullivan, M.D. , former Secretary
Department of Health & Human Services;
President Emeritus of Morehouse School of Medicine

Panel 4
Kenneth G. Brown, Ph.D., Kbinc
Chapel Hill, NC

Barbara D. Beck, PhD, Toxicologist, Gradient Corporation

Joyce S. Tsuji, PhD, DABT, Exponent

Floyd Frost, PhD, Epidemiologist, Lovelace Respiratory Research Institute (LRRI)

Tuesday, March 18, 2003 10:00 a.m.

Panel 5
Sharon H. Kneiss
Vice President, Regulatory Affairs
American Forest & Paper Association
Washington, DC

Debbie Burns
Vice President – Public Affairs
Southeastern Lumber Manufacturers Association, Inc.
Forest Park, GA

Scott W. Conklin
Vice President
Wood Preservation for Universal Forest Products, Inc.

Hal M. Storey
Vice-President & Chief Operating Officer
S.I. Storey Lumber Company, Inc.
Armuchee, GA

Panel 6
Seth Goldberg, Steptoe & Johnson, LLP

Angela Logomasini
Director of Risk and Environmental Policy
Competitive Enterprise Institute (CEI)
Washington, DC

Jody Clarke
Affiilated with CEI
(testifying as a mother)
Burke, VA

Testimony of Jack E. Housenger, Associate Director, Antimicrobials Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

Before the Consumer Product Safety Commission
Hearing on Chromated Copper Arsenate (CCA) Treated Wood
March 17, 2003

Introduction

First of all, I want to thank Chairman Hal Stratton for inviting EPA to provide comments today at the Consumer Product Safety Commission's (CPSC) hearing on chromated copper arsenate (CCA) treated wood. We have invested a lot of effort into the scientific review of CCA and we have worked cooperatively with the Commission on this effort. We appreciate your continued commitment to work with the Agency on this important issue.

My comments today will focus on three areas: first, I will provide the regulatory context of EPA's pesticide program and how it relates to CCA; second, I will discuss the phase-out of CCA in residential settings; and third, I will provide you with the status of our ongoing work at the Agency and in cooperation with the Commission.

Regulatory Context

EPA regulates the sale, distribution and use of all pesticides in the United States, including those chemicals that are used in agricultural crop production, those that are used around the home to control unwanted pests, repellents that protect us from biting insects, and antimicrobial products that are used to control the growth of microorganisms in our environment. Specifically, the Antimicrobials Division within EPA's Office of Pesticide Programs is responsible for the registration and reregistration activities of all antimicrobial pesticides, including those products that are used as wood preservatives. CCA falls into this category of

antimicrobial pesticides because it is used as a wood preservative to control wood-destroying microorganisms. EPA's legal authority to regulate pesticides is provided by two statutes: the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Federal Food, Drug and Cosmetic Act (FFDCA), both of which were amended by the Food Quality Protection Act of 1996. It is under the first statute, FIFRA, that we are given the authority to regulate wood preservatives like CCA. The primary enforcement tool used to regulate pesticide sale, distribution and use is the EPA-approved label. Labels are legally required to accompany every pesticide product sold or distributed in the United States and instruct the user about such things as where a pesticide product may be used, how to safely apply the product, how much product should be used, as well as warnings and safety precautions to protect health and the environment. In other words, the label is the law.

While FIFRA regulates the sale, distribution and use of the pesticide CCA, qualifying wood treated with CCA is exempt from regulation under FIFRA (40CFR152.25(a)). However, the potential risks of exposure from using treated wood is considered in our risk evaluation for the pesticide. The Agency's regulatory approach focuses on ensuring the pesticide can be used safely and that there will be no adverse effects to people or the environment provided the pesticide was used according to label directions.

CCA, which was first registered in the 1940s, is being extensively reviewed by the Agency under a rigorous program to evaluate all older pesticides that were registered for use prior to November 1984. This program, called reregistration, ensures that the older pesticides meet today's higher scientific and regulatory standards for protecting human health and the environment. Because the information and science about pesticides, and therefore our understanding of the potential risks posed by pesticides, is constantly evolving, this program is

critical to ensure the decisions made to protect human health and the environment are based on today's more stringent standards and modern scientific assessment methodologies. The reregistration process includes a multi-phase, public participation process where risk assessment documents are shared in a open and transparent manner to afford opportunities for meaningful input from all interested stakeholders.

EPA's Regulatory Decision on CCA

EPA is reviewing CCA under two different tracks which will result in the most rigorous risk assessment ever done on a wood preservative pesticide. One risk assessment is specifically considering children's exposure at residential sites, playground settings and public parks. The completion of this investigation of potential risks to children from exposure to CCA-treated wood is a priority for the Agency. The other risk assessment, being conducted under the Agency's reregistration program, focuses on the uses that are not subject to the phase-out agreement. We expect this risk assessment to be available for public comment this Spring.

EPA believes that all regulatory decisions on pesticides must be supported by the strongest scientific methods and the most scientifically sound information available to ensure we have a high level of confidence in those decisions. To that end, we have involved a number of offices at the Agency to help with the review of CCA as well as soliciting peer review from an independent FIFRA Scientific Advisory Panel (SAP) to guarantee our risk assessment techniques are grounded in sound science. The SAP met in October 2001 and recommended that the Agency conduct a probabilistic risk assessment on CCA which provides for a much more robust analysis than does a deterministic risk assessment. Probabilistic assessments have significantly strengthened the scientific credibility of our regulatory decisions. We believe that the probabilistic assessment that we are conducting will significantly reduce uncertainties associated

with our risk estimates. In addition, the SAP recommended that we seek better quality data on potential children's exposure to CCA in residential and playground settings. We have been taking steps to implement their recommendations about our risk assessment and, in 2001, the Agency began discussions with the Commission about ways to enhance the data upon which our exposure assessment would be based. The Agency is also implementing the SAP recommendations on exposure data which I will discuss a little later.

Transition to New Generation of Wood Treatment Products

In early 2002, the CCA manufacturers, or registrants as we call them, approached EPA about their individual decisions to voluntarily phase-out virtually all CCA residential uses, including CCA intended for use in treating wood destined for decks, picnic tables, landscaping timbers, gazebos, residential fencing, patios, walkways and play structures. EPA accepted the registrants' actions to phase out the residential uses of CCA which means that CCA will not be used on residential type wood after December 30, 2003. The Agency applauded the registrants' actions which will ensure that future exposures to arsenic are minimized in residential settings. Further, the voluntary actions will substantially reduce the time it otherwise could have taken for the review of CCA to go through the traditional regulatory process. In fact, many wood treatment facilities are already well along with their transitions to products other than those containing CCA for wood treatment purposes.

According to the regulations governing pesticide registration, the Agency is required to issue a final cancellation order to formally remove from CCA pesticide labels those residential uses being voluntarily terminated. [This cancellation order was signed today and is expected to be announced in the Federal Register shortly.] The final cancellation order makes it illegal to use CCA product bearing the new restrictive labels to treat wood intended for most residential uses

included in the registrants' requests after December 30, 2003. Wood products that have been legally treated with CCA will be allowed to move through channels of trade, but we believe that will occur for a relatively short period of time.

Status of Ongoing Review of CCA

Even though the Agency reached an agreement with industry to phase out the uses of CCA for treating wood used in residential settings, we are continuing the children's risk assessment process as well as our review of those remaining uses that are not part of the voluntary cancellation/use termination. It is important to note also that EPA has not concluded that CCA-treated wood poses unreasonable risks to the public for existing structures made with CCA-treated wood. We are continuing to evaluate potential risks from structures already in place and will continue to evaluate those remaining uses that are not included in the voluntary actions.

We are moving forward with our probabilistic assessment of potential cancer risks to children from exposure to CCA in residential settings and we are enhancing the information upon which we will base our decision about such risks. In particular, three studies are currently underway that will greatly benefit our understanding of the levels of exposure that may be possible from treated wood. The first study, a "surface residue bioavailability study," will examine the surface residues of arsenic on wood and estimate how much of that residue can be absorbed by the body from the wood surface. We expect final results from this study by the end of April. The second study is a "soil residue bioavailability study," which will estimate the potential arsenic dose absorbed from soil contact and incidental ingestion through the mouth by children. Those results are expected this month. The third study of importance is a "hand wipe

study" which will estimate the potential exposure to arsenic when the hand comes in contact with treated wood and correlates this physical activity with potential exposure to arsenic. Results from an interim pilot of this study have been received, but the complete study results are not expected until late May. These data will be fully evaluated in developing a draft children's risk assessment which we intend to take to our SAP for comment in December. We expect to release the draft children's risk assessment publicly several weeks prior to the SAP meeting. We intend to fully consider any recommendations made by the SAP in finalizing the risk assessment. An additional study that we are collaborating on with the Commission and our Office of Research and Development (ORD) is to develop data on the effectiveness of sealants in preventing exposure to residues of CCA on treated wood.

EPA expects to evaluate those uses that are not part of the voluntary cancellation through the standard 6-phase public participation process established for pesticide reregistration. This public process ensures active stakeholder participation throughout and the Agency intends to include the Commission in our evaluation process.

The Agency highly values its collaboration with the Commission on the assessment of CCA. As I mentioned earlier, we began collaborating with the Commission in 2001 and have maintained an open and constructive dialogue regarding the review of CCA since that time. The Commission has provided valuable assistance in reviewing the study design protocols that will generate new exposure information expected within the next several months. We were offered an opportunity to peer review the risk assessment prepared by the Commission and will consider it along with all the other information we have on CCA as we move forward in completing our risk assessment. We fully intend to consult with the Commission on our CCA risk assessments, including peer review prior to presenting the children's risk assessment to our SAP.

Again, on behalf of EPA, I appreciate this opportunity to speak before you about our review process for CCA. Given the Agency's rigorous scientific and regulatory process, as well as the actions to phase out CCA for virtually all residential uses, we look forward to assisting the Commission in any continuing work on CCA treated wood. I will be pleased to answer any questions on EPA activities.

Thank you again for inviting me here today.

Testimony before the Consumer Product Safety Commission
CCA Ban Petition HP01-3

Jane Houlihan
Vice President for Research
Environmental Working Group
Washington DC

March 17, 2003

I appreciate the extended time and the opportunity to present our viewpoints here.

My name is Jane Houlihan, and I am the Vice President for Research at the Environmental Working Group. EWG is a non-profit environmental research and advocacy organization with offices in Washington DC and Oakland, California. We are entirely foundation funded, we have no members, and we accept no industry or government money.

In May 2001 the Environmental Working Group and Healthy Building Network petitioned the Consumer Product Safety Commission to ban the use of CCA-treated wood in playground equipment, because the research available at the time showed that arsenic was a potent carcinogen, that arsenic is present at significant concentrations on CCA-treated wood and in underlying soil, and that the health risks posed by this wood are greater than previously recognized.

Since we submitted our petition, new studies show that children who regularly contact CCA-treated wood face an even greater cancer risk than previously believed. These important studies were not used by CPSC in developing the risk estimates before you today. In light of this new information, we believe CPSC has substantially underestimated the cancer risk associated with CCA-treated wood.

Given the magnitude of risk, we disagree with CPSC's recommendation to defer action on this petition. Using authority under the Federal Hazardous Substances Act, we recommend that CPSC immediately ban the use of CCA-treated wood in new playsets, a use that EPA estimates could continue for at least another year unless CPSC acts. We also recommend that CPSC immediately recall playsets on public playgrounds, and that using their authority under the Consumer Product Safety Act, Section 15(d)(3), CPSC require the treated wood industry to directly refund consumers who have purchased CCA-treated wood playsets.

1. **EPA's New Assessment of Enhanced Potency of Carcinogens in Early Life.** On March 3 2003 the EPA released cancer risk assessment guidelines showing that carcinogens are more potent in early life exposures. Through its review of 23 peer-reviewed studies of cancer incidence from the past 50 years, EPA has determined that

infants up to age two are, on average, ten times more vulnerable to carcinogenic chemicals than adults, and for some cancer-causing agents are up to 65 times more vulnerable. The Agency also found that children from age two to 15 are three times more vulnerable to carcinogens than adults.

In developing these potency factors the Agency cites as key evidence a new National Cancer Institute study of cancer incidence from early life exposures to arsenic in lab animals (Waalkes et al. 2003). Under its new guidelines, the Agency will require its staff to incorporate these potency factors when assessing early life exposures to chemicals that cause genetic damage. These factors are not safety or uncertainty factors, rather they are based on a review of the literature that showed that 82% of mutagens were more carcinogenic when exposure occurred earlier in life and the median increased potency of mutagens was 10. CPSC has not taken this new information into account in its risk assessment, resulting in an underestimate of risk by a factor of about four.

2. National Cancer Institute study shows early life susceptibility cancers caused by arsenic, and supports a linear model for cancer risk. A 2003 study conducted by the National Cancer Institute and National Institute of Environmental Health Sciences (NCI-NIEHS) found that a brief 10-day drinking water exposure to arsenic *in utero* at 42.5 and 85 parts per million (ppm) caused dramatic increases of malignant, benign and precancerous lesions at multiple sites in the mice in later life. Tumors sites included the lung, liver, adrenal gland and ovary. In addition, arsenic caused proliferative lesions to develop in the uterus and oviduct. Some of the tumor sites, such as lung and liver, overlap with known human arsenic target organs. Moreover, arsenic significantly increased the incidence of developing any type of tumor, including malignant tumors, which is also consistent with the human epidemiology findings.

Waalkes *et al.* suggest that arsenic is acting at the first stage of carcinogenesis as a tumor initiator, or mutagen, because arsenic dramatically increased tumor incidence at multiple sites following a 10-day exposure early in life. The short-term exposure argues against arsenic acting as a tumor promoter, which generally requires long-term exposure and shows reversibility of action when exposure stops. The early in life exposure argues against arsenic acting as a tumor progressor because tumor progressors typically act on cells that have already been neoplastically transformed, and progression, as a stage of carcinogenesis, is typically associated with concurrent existence of benign or malignant neoplasms. In summary, this new study supports prior decisions by various government agencies to assume that arsenic's mechanism of carcinogenicity produces a linear response.

3. New data show high and persistent arsenic residue levels on hundreds of wood structures. Since November 2001, consumers across the country have tested 598 playsets, picnic tables, decks, and treehouses across the country, and in some cases the arsenic–contaminated soil beneath them, through an at–cost testing kit sold through

EWG's website, www.ewg.org. The samples are analyzed by the University of North Carolina – Asheville's Environmental Quality Institute. The sampling method is analogous to methods used by various government agencies in conducting residue sampling, and is included in this testimony as Attachment A. The results of the consumer testing program show:

- Arsenic residue levels on 295 playsets ranged from 0 to 960 micrograms on an area the size of a four-year-old's handprint (100 cm^2), with a median value of 8.3 ug/100cm^2.

- Arsenic residue levels on 598 wood structures, including playsets, picnic tables, decks, and treehouses ranged from 0 to 2813 ug/100cm^2, with a median value of 9.0 ug/100cm^2. On ten structures the residue level exceeded 500 ug/100cm^2.

- Older decks and playsets (seven to 15 years old) expose people to just as much arsenic on the wood surface as newer structures (less than one year old). The amount of arsenic that testers wiped off a small area of wood about the size of a four–year–old's handprint (100 square centimeters) typically far exceeds what EPA allows in a glass of water under the Safe Drinking Water Act standard (EWG 2002).

- Commercial deck sealants provide no long-term reduction in arsenic levels on the surface of arsenic-treated wood. Sealants appear to reduce arsenic levels for about six months, but surface arsenic levels on wood sealed more than six months ago are statistically indistinguishable from levels on wood that has never been sealed. Just after application, sealants begin to wear off through physical abrasion and weathering. The highest arsenic level measured from 300 samples, 1053 micrograms on a 100 cm^2 wood surface, was found on a Houston, Texas structure sealed two years prior to testing.

These data show that CPSC has severely underestimated risk to some children, by not considering in their assessment the wide range of residue levels found on various structures. The data also point to the importance of CPSC giving the public comprehensive recommendations on mitigating risk from existing wood structures, including frequent sealing.

4. New study from EPA shows children put their hands in their mouths far more often than previously believed. Scientists from EPA's National Exposure Research Laboratory compiled statistics on detailed observations of mouthing behavior among more than 300 children, and found that children put their hands in their mouths at nearly twice the rate previously believed – on average 16 times per hour for children over 2 years old, and 18 times per hour for children less than 2 years old. The study recorded hand-to-mouth behavior a maximum of 48 times per hour. Also of note in this study are

two frequent behaviors that could dominate risk but are not included in CPSC's risk assessment: mouthing of playset surfaces (mean of 4 to 7 times an hour for the children studied), and mouthing of toys stores beneath playsets (such as sandbox toys), a behavior observed on average between 42 and 56 times an hour. This study is included as Attachment C.

5. New risk assessment from California shows the average residue on a hand-sized area of CCA-treated wood structure is 2000 times higher than safe levels (defined as a 1 in 1,000,000 cancer risk). On March 7 2003, California's branch of the EPA released new arsenic risk assessments that show a dramatically lower "safe" level for arsenic in drinking water than US EPA's new standard, setting their public health goal for arsenic at 0.004 micrograms per day (4 parts per trillion in water), 2500 times lower than EPA's new standard of 10 parts per billion, and 2000 times the average arsenic residue level on 100 cm^2 of wood. California's risk assessment adds to the growing number of public health agencies that have confirmed the cancer-causing potential of very low doses of arsenic.

6. Risk assessment incorporating new findings shows average excess lifetime cancer risk of 1 in 500 for children who play on CCA-treated wood three times a week. In 2001 EWG constructed a risk assessment model incorporating Monte Carlo techniques that account for variability in arsenic residue levels, behavior patterns, and size of a child, and that compute the spectrum of risk across the population. We presented this model to the EPA's Scientific Advisory Panel in October 2001. The Panel recommended that EPA adopt this modeling technique in their assessment of risk from CCA wood, and the Agency is moving forward with a Monte Carlo style assessment. EWG's model methodology is attached as Attachment D. When we incorporate findings from the new studies described above, the model shows:

- One in 500 children who play on CCA-treated playsets three times a week are expected to develop cancer from these exposures.
- Ten percent of children who regularly play on CCA-treated playsets face an excess lifetime cancer risk greater than one in 100.

Conclusion and Recommendations. CCA in existing play structures is a public health problem very similar in magnitude and certainty to lead paint. Both present significant health risks that last long after regulatory action banning their sale and use. Both have been found to pose a greater health risk than believed when they were first sold. Both disproportionately affect children. In each case the regulated industries fought remedial action after the ban, and in each case, failing to take this remedial action would have very nearly completely undermined the effectiveness of ban. Imagine the unnecessary harm to children that would have occurred had their been no remedial action to reduce lead exposures after the ban on lead in paint. The same level of harm will result from a failure

on the part of commissioners to force remedial action to recall CCA-treated play structures on playgrounds.

We recommend that:

- CPSC immediately ban the use of CCA-treated wood for new playsets.
- CPSC immediately recall all play structures on public playgrounds, because these facilities clearly present the greatest long-term risk to children because of their long life and heavy use.
- Using authority under the Consumer Product Safety Act, Section 15(d)(3), CPSC require the treated wood industry to directly refund consumers who have purchased CCA-treated wood playsets.
- CPSC work with EPA to expedite studies of the effectiveness of sealants, and launch an aggressive consumer education campaign designed to teach people how to mitigate risk from CCA-treated playsets and other structures.

References

California Environmental Protection Agency. 2003. Public Health Goal for Arsenic in Drinking Water. Draft. March 2003. Available online at http://www.oehha.ca.gov/public_info/press/AsPress.html

Consumer Product Safety Commission. 2003. Briefing Package. Petition to ban chromated copper arsenate (CCA)-treated wood in playground equipment (Petition HP 01-3). February 2003.

Environmental Protection Agency (EPA). 2003. Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens (External Review Draft). USEPA EPA/630/R-03/003. 28 Feb 2003. U.S. Environmental Protection Agency. Risk Assessment Forum, Washington, DC, 86 p. Available online at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=55446.

Tulve NS, JC Suggs, T McCurdy, EA Cohen Hubal, J Moya. 2002. Frequency of mouthing behavior in young children. Journal of Exposure Analysis and Environmental Epidemiology. 12, 259-264.

Waalkes MP, JM Ward, J Liu, BA Diwan. 2003. Transplacental carcinogenicity of inorganic arsenic in the drinking water: induction of hepatic, ovarian, pulmonary, and adrenal tumors in mice. Toxicology and Applied Pharmacology. 186, 7-17.

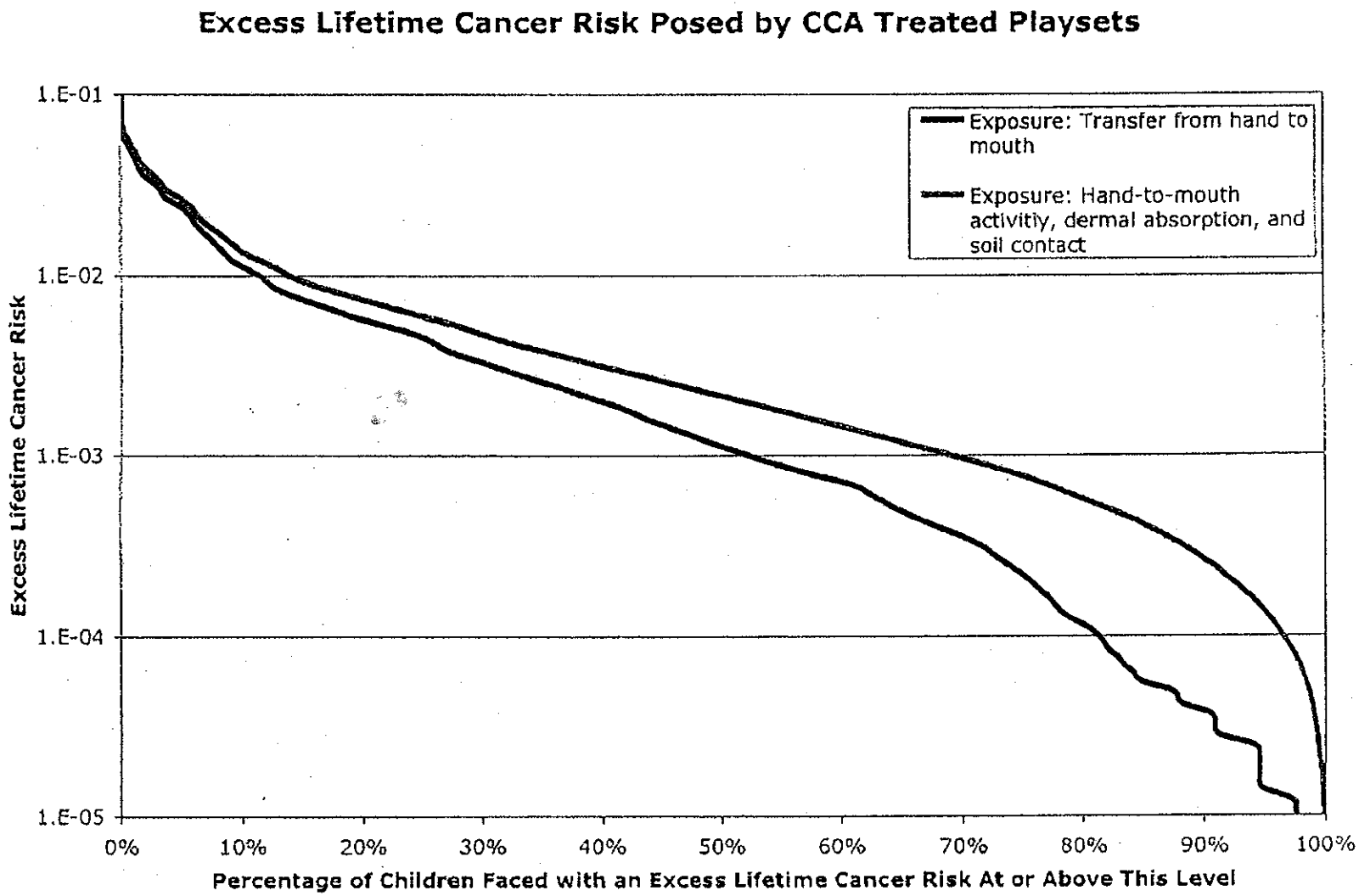
Attachments

Attachment A. EWG's Sampling Instructions, Home Testing Kit for Arsenic Treated Wood.

Attachment B. Waalkes MP, JM Ward, J Liu, BA Diwan. 2003. Transplacental carcinogenicity of inorganic arsenic in the drinking water: induction of hepatic, ovarian, pulmonary, and adrenal tumors in mice. Toxicology and Applied Pharmacology. 186, 7-17.

Attachment C. Tulve NS, JC Suggs, T McCurdy, EA Cohen Hubal, J Moya. 2002. Frequency of mouthing behavior in young children. Journal of Exposure Analysis and Environmental Epidemiology. 12, 259-264.

Attachment D. Model Methodology. Cancer Risks from Children's Exposures to Arsenic-Treated Wood: Methodology for Monte Carlo Style Risk Analysis



Testimony before the Consumer Product Safety Commission
CCA Ban Petition HP01-3

Environmental Working Group
March 17, 2003

Attachment A

Arsenic treated lumber: an unnecessary risk

"Pressure treated" lumber is used to build nearly all outdoor wooden structures. This wood is infused with a chemical called chromated copper arsenate, or CCA, a potent pesticide that is 22 percent arsenic. Arsenic is easily rubbed off the surface of the wood for the entire life of the structure. Arsenic also leaches from the wood to contaminate the soil below. It sticks to children's hands when they play on the wood or in the soil. It absorbs through skin into the body. And children put their fingers and hands in their mouth frequently and can ingest potentially dangerous amounts of arsenic.

Arsenic is on the EPA's very short list of chemicals known without a doubt to cause cancer in humans – lung, bladder and skin cancer. Luckily, you can do some simple things to reduce your family's risk. The first step is to test your wood. Two to three weeks after returning your samples, you will receive your test results and important information explaining your results. Before then, you can take the simple steps, described on the back of this pamphlet, to reduce your family's exposure to arsenic from your deck, playset or other structure.

More test kits are available at *www.ewg.org* or *www.healthybuilding.net*. Available kits:

- Wipe kit to test for arsenic on the wood surface
- "Hot spot" soil testing kit that can identify medium and high arsenic contamination
- "Detailed" soil testing kit that can identify low levels of contamination undetectable by the "hot spot" test

This Home Testing Kit Contains:

__Prepaid __Optional Wood Wipe Kits
__Prepaid __Optional Soil Sampling Kits

Materials provided

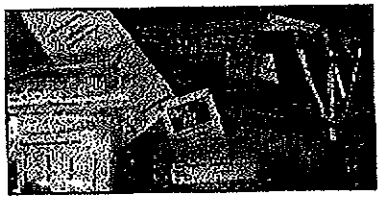
1 research questionnaire
1 return address label

Each wood wipe kit contains

1 clear plastic template with stickers
1 pair laboratory gloves
1 pre-moistened wipe
1 plastic vial for completed sample

Each soil sampling kit contains

1 pair laboratory gloves
1 soil sampling cup in a labeled bag
gardening tool not included



Instructions

Follow the procedures printed inside this pamphlet for each test you have prepaid, then return the completed samples and unused optional kits with the research questionnaire in the envelope this kit came in using the provided mailing label.

Optional: Additional samples completed with the provided materials may be returned to the lab with a payment of $15 per sample analyzed, payable to *"Environmental Working Group"*.

Your results will arrive in two to three weeks. Meanwhile, please refer to the simple steps printed on the back of this pamphlet to help reduce your family's exposures to arsenic.

Simple safety steps

If possible, replace your arsenic treated wood structures with safer alternatives (wood with arsenic-free preservatives, naturally pest and rot resistant cedar, or recycled plastic composites). Short of that, you can take a few simple steps to reduce arsenic exposures:

- **Seal the wood at least once a year.** Standard deck treatments, like latex paint or polyurethane, may reduce the amount of arsenic that rubs off the wood surface.
- **Wash your hands and your children's hands after every exposure to arsenic treated wood, especially before eating.**
- **Do not store toys or tools under the deck.** Arsenic leeches from the wood when it rains and may coat things left there.
- **Keep children and pets away from the soil beneath and immediately surrounding arsenic treated wood structures.**
- **Cover arsenic treated picnic tables with a table cloth before using.**

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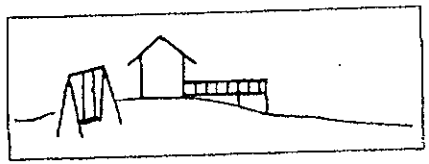
Instructions

Home Testing Kit for ARSENIC Treated Wood



Helping consumers reduce childhood exposure to arsenic.

Instructions for arsenic treated wood and soil sampling kit

ENVIRONMENTAL WORKING GROUP HEALTHY BUILDING

WOOD WIPE INSTRUCTIONS

Wood Wipes: Overview

This simple wipe method allows you to sample any structure built of wood treated with chromated copper arsenate (CCA), such as a deck, playground structure, picnic table, or patio furniture, by wiping the enclosed laboratory wipe in a very specific fashion (details below) on the wood surface.

1. Choose a place to wipe

Pick a single place on your outdoor structure (deck, playset, or picnic table) that is:

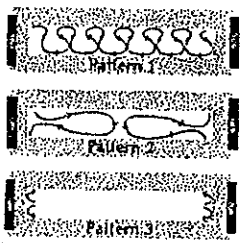
- used often
- touched frequently

Some homeowners choose to sample multiple structures or to do a "before" and "after" sample (waterproofing the deck between samples). A second, optional kit has been provided. If you choose to collect a second sample, be sure to include a check for $15 per sample.

2. Review these general guidelines

Please follow these simple steps to be sure that your wipe sample reflects the amount of arsenic just within the area you've chosen to sample.

- Always wear gloves when handling wipes.
- Do not touch the wood with the glove.
- Do not touch the outside of the glove, except the wrist area as needed to put them on.
- For multiple samples, use a new pair of gloves for each one.



Sampler wipes arsenic treated wood.

3. Sample the wood

a. WASH YOUR HANDS before beginning.
b. Carefully PLACE THE PLASTIC TEMPLATE on the wood surface. TAPE the template to the wood surface using the provided stickers.
c. PUT the gloves on. Do not touch the wood directly until the sampling is complete.
d. Remove and UNFOLD the wipe.
e. WIPE the area inside the template in an overlapping "S" pattern while applying steady, even pressure to the fingertips. (Pattern 1.)
f. REMOVE splinters in the wipe and FOLD the wipe in half with the sampled side folded in.
g. WIPE the area inside the template again. This time, wipe in a direction 90 degrees rotated from Pattern 1. (Pattern 2)
h. REMOVE splinters and FOLD the wipe again, with the sampled side folded in.
i. WIPE the corners of the template. (Pattern 3)
j. REMOVE splinters and FOLD the wipe a final time, with the sampled *side* folded in.
k. PLACE the completed sampling wipe in the plastic vial and fill out the label.
l. FILL OUT the research questionnaire with information about your wood structure.

4. Mail the sample back

Reuse the envelope this kit came in and attach the provided return address label. Please return all unused "optional" kits. Include all completed samples and a check if you collected optional samples ($15 each). *Maximum estimated postage is $1.70 (or 5 – 34¢ stamps) for completion of all samples in the kit.*

SOIL SAMPLING INSTRUCTIONS

Soil Sampling: Overview

Choose one of the following potential test types:

"Simple" (*One "hot spot" sample*) Sample one location near or under an arsenic treated wood structure. This type of test is reliable when arsenic levels are medium or high.

"Double" (*Two "hot spot" samples*) Sample two locations near or under arsenic treated wood structures.

"Detailed" (*One "hot spot" and one "background" sample*) In addition to the simple sample, collect a "background" sample from an area *at least 10 feet and not downhill from any arsenic treated structure.* This type allows low contamination levels to be identified.

Choose the option that best suits your concerns. Fill out the "hot spot" or "background" label as appropriate. Include $15 per sample for all unpaid samples returned for analysis.

1. Collect the "background" sample

(Skip for "simple" and "double" testing.)

Following the procedure in Step 3, collect a soil sample from an area *at least 10 feet and not downhill from any arsenic treated structure.* Label the sample as "BACKGROUND".

2. Choose a "hot spot" collection area

Choose one of the following potential "hot spots":

a. an area you're concerned about near or under arsenic treated wood, such as
   - play areas
   - vegetable gardens (soil or vegetables)
b. an area likely to have the highest level of arsenic, such as
   - directly under a deck
   - less sandy soils
c. an area near your playset, especially
   - wood chips or sand directly under the wood
   - an area worn down from heavy use (under swings or at bottom of slide)

Sampler collects a soil sample.

3. Collect the soil sample

a. WASH your hands and garden tool before beginning. Dry your garden tool thoroughly with a clean cloth or paper towel.
b. PUT ON an unused pair of laboratory gloves that arrived with your sampling kit.
c. With your garden tool, MARK OUT AN AREA of soil that is roughly 6 inches by 6 inches.
d. REMOVE the grass and vegetation from the area, to the *shallowest* depth possible. Some roots or vegetation may be left behind – it's more important to keep as much of the *soil* in place as possible.
e. With your garden tool, thoroughly CHOP UP AND MIX the soil in your 6 inch by 6 inch area, to a depth of about 2 inches.
f. With the sampling cup, SCOOP UP a cupful of the chopped-up soil.
g. PLACE the full sampling cup into a Ziploc bag, fill out the attached sample label, and seal the bag. It's fine if the soil falls out of the sampling cup into the bag, as long as you get about a cup's worth of soil into the bag.
h. FILL OUT the research questionnaire with important information about your wood structure and soil.

4. Mail the sample back

Reuse the envelope this kit came in and attach the provided return address label. Please return all unused "optional" kits. Include all completed samples and a check if you collected optional samples ($15 each). *Maximum estimated postage is $1.70 (or 5 – 34¢ stamps) for completion of all samples in the kit.*

Testimony before the Consumer Product Safety Commission
CCA Ban Petition HP01-3

Environmental Working Group
March 17, 2003

Attachment B

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Transplacental carcinogenicity of inorganic arsenic in the drinking water: induction of hepatic, ovarian, pulmonary, and adrenal tumors in mice

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Abstract

Arsenic is a known human carcinogen, but development of rodent models of inorganic arsenic carcinogenesis has been problema Since gestation is often a period of high sensitivity to chemical carcinogenesis, we performed a transplacental carcinogenicity study in m using inorganic arsenic. Groups ($n = 10$) of pregnant C3H mice were given drinking water containing sodium arsenite ($NaAsO_2$) (control), 42.5, and 85 ppm arsenite ad libitum from day 8 to 18 of gestation. These doses were well tolerated and body weights of the c during gestation and of the offspring subsequent to birth were not reduced. Dams were allowed to give birth, and offspring were w at 4 weeks and then put into separate gender-based groups ($n = 25$) according to maternal exposure level. The offspring receive additional arsenic treatment. The study lasted 74 weeks in males and 90 weeks in females. A complete necropsy was performed on all a and tissues were examined by light microscopy in a blind fashion. In male offspring, there was a marked increase in hepatocellu carcinoma incidence in a dose- related fashion (control, 12%; 42.5 ppm, 38%; 85 ppm, 61%) and in liver tumor multiplicity (tumors p liver; 5.6-fold over control at 85 ppm). In males, there was also a dose-related increase in adrenal tumor incidence and multiplicity. In fema offspring, dose-related increases occurred in ovarian tumor incidence (control, 8%; 42.5 ppm, 26%; 85 ppm, 38%) and lung carcinoma incidence (control, 0%; 42.5 ppm, 4%; 85 ppm, 21%). Arsenic exposure also increased the incidence of proliferative lesions of the uterus and oviduct. These results demonstrate that oral inorganic arsenic exposure, as a single agent, can induce tumor formation in rodents and establishes inorganic arsenic as a complete transplacental carcinogen in mice. The development of this rodent model of inorganic arsenic carcinogenesis has important implications in defining the mechanism of action for this common environmental carcinogen.

Keywords: Arsenic; Carcinogenesis; Transplacental; Animal Models; Mice

Introduction

Inorganic arsenic is considered to be one of the highest priority hazardous substances in the United States. This is largely because of concern with the metalloid's carcinogenic potential after environmental exposure (Bates et al. 1992; IARC, 1987; Kitchin, 2001; NRC, 1999; Pott et al. 2001; Simeonova and Luster, 2000; Smith et al., 1992). It is quite clear that exposure to inorganic arsenic in humans is etiologically linked to tumors of the skin, bladder, lung liver, prostate, and possibly other tissues (Bates et al., 1992 IARC, 1987; Kitchin, 2001; NRC, 1999; Pott et al. 2001; Simeonova and Luster, 2000; Smith et al., 1992). In addition, many studies in human populations have shown clear dose–response relationships between environmental arsenic levels and cancer incidence (Bates et al., 1992

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Kitchin, 2001; NRC, 1999; Pott et al., 2001; Smith et al., 1992).

The main source of environmental arsenic exposure in most populations is the drinking water, in which inorganic forms of arsenic predominate (Bates et al., 1992; NRC, 1999; Pott et al., 2001; Smith et al., 1992). The inorganic forms of arsenic include the trivalent form, arsenite, and pentavalent form, arsenate. Clearly, assessing the risk from exposure to inorganic arsenic in water supplies is a key issue facing the scientific community. High levels of arsenic in the drinking water can be found in areas within many countries, including Taiwan, China, Chile, India, Mexico, and Bangladesh (Bates et al., 1992; NRC, 1999; Pott et al., 2001; Smith et al., 1992), but it is becoming evident that even the more moderate levels of arsenic typically found in the United States may pose a significant health risk to humans (Lewis et al., 1999; Morales et al., 2000). Indeed, studies in humans suggest that the risk posed by arsenic in the drinking water in the United States may be comparable to that from environmental tobacco or radon (Morales et al., 2000).

An important aspect of appropriately assigning the potential degree of hazard posed by a given level of exposure to any carcinogen is a knowledge of carcinogenic mechanisms, which helps to define appropriate models for risk assessment, particularly at lower levels of exposure. Generation of tumors in animals can be an invaluable aid in defining carcinogenic mechanisms. In this regard, while exposure to inorganic arsenic in humans is clearly carcinogenic (IARC, 1987; NRC, 1999), carcinogenesis in animals resulting from exposure to inorganic arsenic, when given as a single agent, has been difficult to demonstrate convincingly (Kitchin, 2001; NRC, 1999). Indeed, it is thought that the definition of the mechanism or mechanisms of arsenic carcinogenicity has been impeded by a lack of clear rodent models (Simeonova and Luster, 2000). However, there has been some very important recent progress made in the development of rodent models of inorganic arsenic carcinogenesis involving coexposure to other carcinogenic treatments (Germolec et al., 1997, 1998; Rossman et al., 2001). This includes studies using Tg.AC (H-*ras* mutated) transgenic mice in which skin tumors are generated by coexposure to arsenite in the drinking water and dermal application of 12-*O*-tetradecanoyl phorbol- 13-acetate (TPA; Germolec et al., 1997, 1998). In addition, the incidence, multiplicity, and aggressiveness of tumors induced by ultraviolet radiation in the skin of hairless mice is markedly increased by inclusion of arsenite in the drinking water (Rossman et al., 2001). These mouse skin models (Germolec et al., 1997, 1998; Rossman et al., 2001) represent very important advances and would point to copromotional or cocarcinogenic effects of oral inorganic arsenic, both of which could be important elements in dermal carcinogenicity of the metalloid, particularly as the skin is a human target site of arsenic carcinogenesis (NRC, 1999). Nonetheless, inorganic arsenic when given alone did not result in tumors of the skin or anywhere else in either of these two model systems (Germolec et al., 1997, 1998; Rossman et al., 2001), and the requirement of coexposure to tumor-causing treatments (i.e., TPA or ultraviolet radiation) for tumor development to occur certainly complicates defining the precise contribution of arsenic in these treatment scenarios.

Inorganic arsenic is methylated in humans and most rodents, forming first a monomethylated and then a dimethylated (dimethylarsinic acid; DMA) compound (Aposhian, 1997; Kitchin, 2001; NRC, 1999; Thomas et al., 2001). In this regard, a recent series of chronic carcinogenicity studies in rats with DMA (Wei et al., 1998, 1999; Yamamoto et al., 1995; Yamanaka et al., 2000) has provided significant progress in our understanding of the carcinogenic potential of this methylated arsenic species (Kenyon and Hughes, 2001). For instance, DMA treatment can cause tumor promotion in the urinary bladder, liver, skin, and kidney in rats after initiation with a variety of potent organic carcinogens or by irradiation (Wei et al., 1998; Yamamoto et al., 1995; Yamanaka et al., 2000). Furthermore, long-term (~2 years) exposure to DMA in the drinking water can act as a complete carcinogen in rats, inducing transition cell carcinoma and papilloma of the urinary bladder (Wei et al., 1999), a target tissue in humans (NRC, 1999). However, an issue with these studies is that, although DMA is generated from inorganic arsenic in humans and rodents, it is, of course, not the actual agent to which humans are exposed, since methylated species would rarely occur in drinking water (NRC, 1999). Clearly, whether chronic oral DMA exposure precisely duplicates the pharmacokinetics or toxic manifestations of chronic oral inorganic arsenic exposure in all its target tissues is an open question (Kenyon and Hughes, 2001). In addition, there are rat-specific, blood-borne arsenic-binding proteins that are absent in humans and other rodents, such as mice, that dramatically alter biokinetics and tissue dosimetry of both inorganic arsenic and DMA (Kenyon and Hughes, 2001; NRC, 1999; Pott et al., 2001).

Thus, although significant recent progress has been made, the development of rodent models of inorganic arsenic carcinogenesis clearly deserves additional attention. In this regard, gestation in rodents is often a period of high sensitivity to chemical carcinogenesis, with a variety of maternal exposures resulting in tumor formation in the offspring. This includes transplacental carcinogenesis induced by inorganics other than arsenic, such as lead (Waalkes et al., 1995), cisplatin (Diwan et al., 1993, 1995), and nickel (Diwan et al., 1992). There is at least one case report in humans in which maternal inorganic arsenic exposure from the therapeutic use of Fowler's solution during pregnancy is suspected as a cause of multiple skin basaliomas (a typical form of skin cancer induced by arsenic) in a 32-year-old man (Aldick and Fabry, 1973). Arsenic appears to readily cross the human placenta, producing arsenic concentrations that are similar in cord blood compared to maternal blood (Concha et al., 1998). Arsenic given to maternal animals

also moves readily across the placenta and substantial concentrations of arsenic have been measured in a variety of tissues in the embryo/fetus (Lindgren et al., 1984; NRC, 1999). Significant transplacental transfer of arsenic occurs in all periods of gestation and after oral exposure in mice (NRC, 1999). Thus, the transplacental route is clearly a plausible mode of exposure in humans. Therefore, we performed a transplacental carcinogenicity study in mice in which pregnant animals were briefly exposed to well-tolerated levels of sodium arsenite in the drinking water and the offspring were subsequently examined for tumor development in adulthood. The results show that inorganic arsenic, as a single agent, induced tumors at multiple sites including the liver, adrenal, lung, and ovary after transplacental exposure and establishes inorganic arsenic as a complete transplacental carcinogen in mice.

Materials and methods

Chemicals

Sodium arsenite ($NaAsO_2$) was obtained from Sigma Chemical Co. (St. Louis, MO) and dissolved in sterile distilled water to the desired concentrations in the drinking water as parts per million arsenic.

Animals and treatments

Animal care was provided in accordance with the U.S. Public Health Policy on the Care and Use of Animals as defined in the Guide to the Care and Use of Animals (NIH publication No. 86-23). Mice were housed in a standard barrier facility, at a temperature of 68–72°F and with a relative humidity of 50 ± 5%, and a 12-h light/dark cycle. A basal diet (NIH-31 Open Formula, 6% Modified; Teklad Standard Diets, Madison, WI) and water (unmodified or modified as below) were provided ad libitum. The NCI–Frederick animal facility, where the biopsy portion of the present study was conducted, and its animal program are accredited by the American Association for Accreditation of Laboratory Animal Care. Mice were obtained from the Animal Production Area, NCI–Frederick, Animal Program, Frederick, MD.

Preliminary short-term testing to define dosage levels utilized timed pregnant C3H/HeNCr (C3H), C57BL/6NCr, and B6C3F1/NCr mice (n = 5 to 7) that received sodium arsenite ($NaAsO_2$) ad libitum in the drinking water at 75 and 100 ppm of arsenic from day 8 of gestation through to delivery (day 21). The higher dose of arsenic (100 ppm) reduced maternal water consumption (~20%) in all strains, but the lower dose (75 ppm) had no such effect. Arsenic exposure induced small depressions of newborn body weight (reduced 9.9% compared to control) and crown–rump length (reduced 4.9%) at the 100 ppm dosage only in C3H mice but not in B6C3F1/NCr or C57BL/6NCr mice. Since the C3H mice appeared to be more sensitive than the other two strains to the transplacental toxicity of inorganic arsenic, they were selected for the chronic study. In addition, since the preliminary testing indicated 100 ppm of arsenic in the drinking water during this period of pregnancy was unpalatable and provided evidence of an adverse effect (~10% reduced growth) in the resulting newborns in the C3H mice, lower doses were selected for the chronic study.

Thus, a total of 30 timed primigravid female C3H mice were randomly divided into three groups of 10 each and given drinking water containing sodium arsenite at 0 (control), 42.5, or 85 ppm arsenite ad libitum from day 8 to 18 of gestation. Dams were allowed to give birth, and litters where culled to no more than eight at four days postpartum. Offspring were weaned at 4 weeks and then randomly put into separate groups (n = 25) of males and females according to maternal exposure level. The offspring received no additional arsenic treatment. The dams were discarded after weaning and the offspring were observed for the next 78 (males) or 90 (females) weeks.

Clinical data

Individual dam body weights were recorded between days 8 and 18 of gestation. Water consumption of the dams was recorded (in ml per mouse) during the arsenic exposure period on days 16 and 18 of gestation. Individual neonatal weights were recorded at birth and at 1-week intervals thereafter until weaning (week 4). After being placed into the appropriate gender-based treatment groups, the body weights of the offspring were recorded at weekly intervals until experimental week 26 and at monthly intervals thereafter. In the offspring, clinical signs were checked daily and mice were euthenized when significant clinical signs developed or at 74 (males) or 90 (females) experimental weeks.

Assuming the pregnant animals weighed 40 g during the exposure period (measured average in control pregnant mice was 40.04 ± 1.18 g on gestation day 18) and consumed 9 ml of drinking water per day (measured average in control pregnant mice was 9.08 ± 0.25 ml on gestation day 18) the dosage levels of 42.5 and 85 ppm arsenic would have resulted in exposures of 9.55 to 19.13 mg arsenic/kg/day and a total dose of 95.6 to 191.3 mg arsenic/kg to the maternal–fetal system. With a biological half-life of inorganic arsenic estimated at about 4 days (NRC, 1999), some translactational exposure of the offspring to arsenic may have occurred with the current protocol.

Pathology

A complete necropsy was performed on all moribund animals, animals found dead, or on mice at terminal euthanasia. The following tissues were taken and processed by standard techniques for histological analysis: gonads (ovaries or testes), uterus, oviduct, liver, kidneys, lung, adrenal

spleen, thyroid, thymus, skin, and all grossly abnormal tissues. Tissues were fixed in 10% neutral buffered formalin, embedded in paraffin, sectioned at 5 μm, and stained with hematoxylin and eosin for histological analysis. All pathological assessments were performed in a blind fashion. The vast majority of all tumors observed in the current study occurred after 26 experimental weeks, well after the mice had reached adulthood.

Data analysis

Data are given as incidence (number of affected mice per total mice available for examination) or as mean ± SE, as appropriate. A probability level of $p \leq 0.05$ was considered to indicate a significant difference. In defining the incidence of mice bearing benign or malignant tumors in cases of multiple tumors in the same tissue, the animal is assigned to the appropriate group based on its most advanced lesion. Tissue-specific total tumor incidence is defined as those mice bearing at least one benign or malignant tumor in a given organ. Total proliferative lesions (TPL) are defined as the incidence of mice bearing either a tumor or a significant preneoplastic lesion (hyperplasia) in a given organ. Tumor multiplicity is defined as the number of tumors per mouse either of a particular organ or at any site. In pairwise comparison of lesion incidence, a one-sided Fisher's Exact test was used. For multiple comparisons of mean tumor multiplicity data, two-sided, unpaired Student's *t* tests with Bonferroni corrections were used. To analyze dose-related trends, a two-sided χ square test for trend was used. Survival was examined with the methods of Kaplan-Meier and Cox and only considered different from control if both tests were significant. Incidence is based on numbers of animals available for observation, and any loss of animals to observation was due primarily to autolysis that was considered too advanced for appropriate diagnosis.

Results

Pregnant C3H mice were treated with 0 (control), 42.5, or 85 ppm arsenic as sodium arsenite in the drinking water from gestation days 8 to 18 and carcinogenic response was evaluated in the resulting offspring. Maternal drinking water consumption was not altered by the inclusion of arsenic in the drinking water. For instance, on the last day of treatment (gestation day 18) control mice consumed 9.08 ± 0.25 ml per mouse ($n = 5$; mean ± SE) compared to 8.86 ± 0.27 and 8.72 ± 0.27 ml per mouse in the 42.5- and 85-ppm arsenic groups, respectively. Arsenic exposure did not alter body weight of the pregnant mice as, for example, on day 18 of gestation where control mice weighed 40.04 ± 1.18 g ($n = 5$; mean ± SE), mice receiving 42.5 ppm arsenic weighed 40.68 ± 1.01 g, and mice receiving 85 ppm arsenic weighed 41.22 ± 0.36 g. The transplacental exposure to arsenic did not reduce body weights in any group of offspring over the course of the experiment (data not shown). For instance, at 4 weeks of age (weaning) body weight in female offspring ($n = 25$ per group) was 17.3 ± 0.4 g (mean ± SE) in controls, 17.0 ± 0.9 g in the 42.5-ppm group, and 17.4 ± 0.7 g in the 85-ppm group, while in male offspring it was 20.6 ± 0.6 g in controls, 19.5 ± 1.0 g in the 42.5-ppm group, and 21.6 ± 0.9 g in the 85-ppm group. All these data establish the doses used in the present study as being well tolerated to both the maternal animal and the resulting offspring.

Because of a loss in the number of surviving animals after 52 experimental weeks in the group of male offspring exposed to the highest arsenic dose (85 ppm) during gestation, due largely to malignant hepatic tumors (see below), the study in male offspring was terminated at 74 weeks (Fig. 1A). Because survival was not different between groups, the study in female offspring was carried out to its original intended time point (90 weeks; Fig. 1B).

Transplacental exposure to arsenic induced a marked, dose-related increase in incidence of hepatocellular carcinoma formation in male offspring (Table 1). In fact, there was a 4.9-fold increase over control in hepatocellular carcinoma incidence at the highest arsenite dose (85 ppm). The incidence of hepatic adenoma was unaltered by arsenic treatment (Table 1), although many animals bearing adenomas also had carcinomas, which placed them into the latter category, as the categorization of tumor incidence was determined by most advanced lesion in the individual animal. The incidence of hepatic tumors of any type (total tumors) was also elevated 2.1-fold over control at the highest dose. Liver tumor multiplicities for adenoma, carcinoma, or total tumors were all increased at the highest dose of arsenic (85 ppm). Very strong, dose-related trends occurred for hepatocellular carcinoma incidence, total tumor incidence, and adenoma multiplicity, hepatocellular carcinoma multiplicity, and total tumor multiplicity. In female offspring liver tumor incidence and multiplicity (not shown) were unaltered by arsenic exposure. Control females ($n = 25$) had five cases of hepatic adenoma, and no carcinoma. Arsenic treated females in the 42.5-ppm group ($n = 23$) had three cases of adenoma and one carcinoma, while in the 85-ppm group ($n = 24$) three adenoma and one carcinoma occurred.

In male offspring, transplacental exposure to arsenic also induced a marked increase in adrenal cortical tumor incidence and multiplicity (Table 2). Tumor incidence and tumor multiplicity were increased 2.4- and 2.2-fold over control, respectively, at the highest dose of arsenic (85 ppm). Strong, dose-related trends occurred for both tumor incidence and multiplicity. Tumors were exclusively cortical adenomas. Only one adrenal tumor occurred in females, specifically an adrenal cortical carcinoma in the 42.5-ppm arsenic group.

In female offspring, transplacental arsenic exposure induced a marked increase in ovarian tumor incidence (Table 3). Incidence was increased 2.2- and 4.2-fold over control at the 42.5- and 85-ppm exposure levels, respectively. A

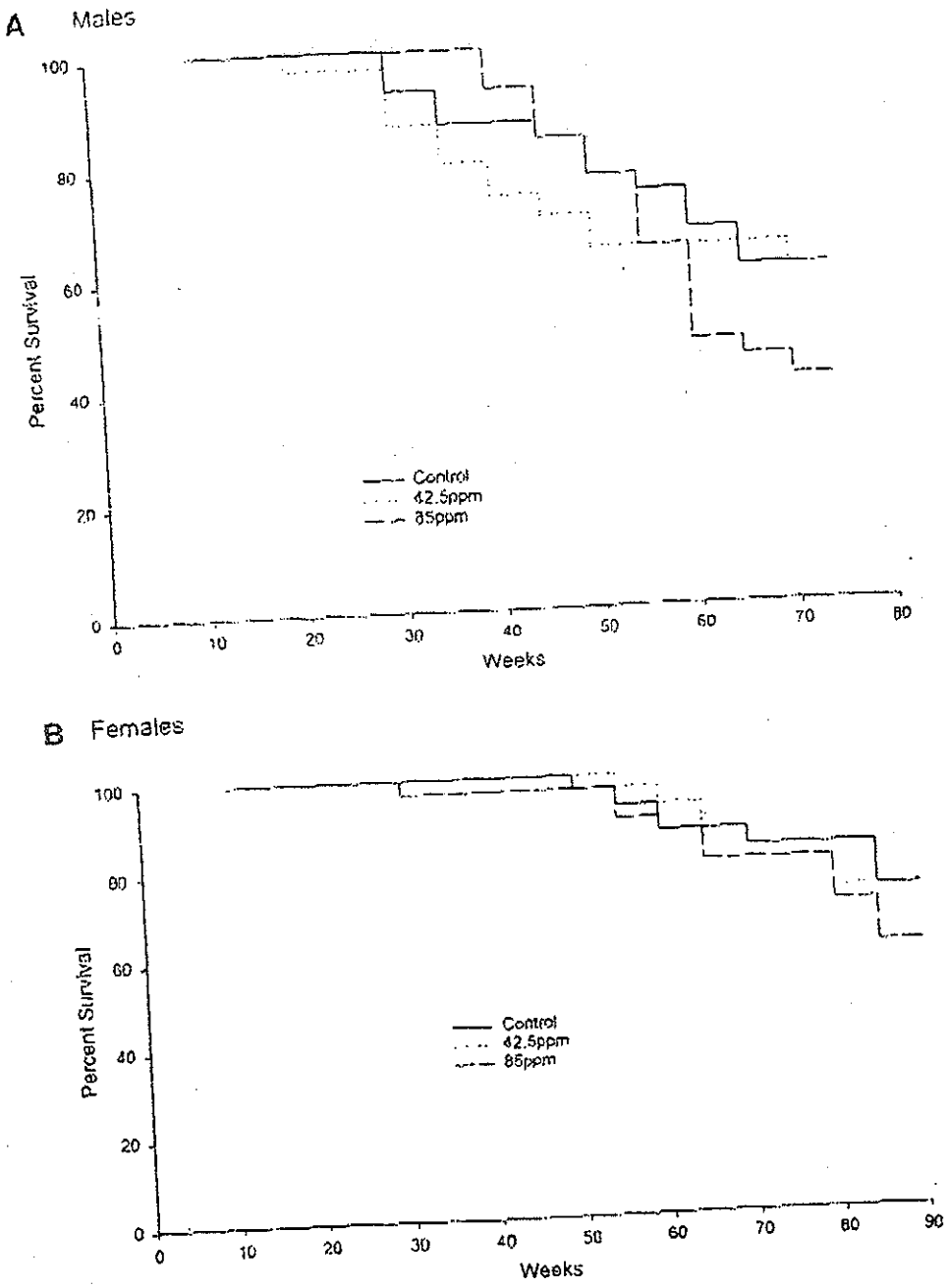

Fig. 1. Effect of transplacental arsenite exposure at 0 (control), 42.5, or 85 ppm in the maternal drinking water on survival of the resultant offspring. Mater animals were exposed during pregnancy as detailed under the Materials and methods and the offspring were analyzed for tumors. Animals were euthani when moribund or at terminal euthanasia. Results are given as percentage survival based on an initial group size of $n = 25$ for male (A) and female offspring.

strong, dose-related trend in incidence of ovarian tumors also occurred. Three of 15 tumors were carcinomas in arsenic-exposed animals. Controls had one adenoma and a benign granulosa cell tumor. The 42.5-ppm treatment group had three adenomas, one adenocarcinoma, one benign granulosa cell tumor, and one malignant granulosa cell tumor. The 85-ppm treatment group had seven adenomas, one luteoma, and one hemangiosarcoma.

Transplacental arsenic exposure enhanced lung tum development in female offspring, particularly with regard malignant tumors (Table 4). The incidence of pulmon carcinoma was significantly increased at the highest dose arsenic in females. Additionally, a strong dose-depend trend also occurred for pulmonary carcinoma incidence females. In males only three lung tumors—two pulmon adenoma and one hemangiosarcoma—occurred, all

Table 1
Liver tumors in male offspring after transplacental arsenite exposure

Group	Tumor incidence			Tumor multiplicity (tumors/mouse)		
	Adenoma	Carcinoma	Total tumors	Adenoma	Carcinoma	Total tumors
Control (n = 24)	7	3	10	0.71 ± 0.22	0.13 ± 0.07	0.87 ± 0.25
42.5 ppm (n = 21)	3	8*	11	1.43 ± 0.49	0.42 ± 0.13	1.81 ± 0.54
85 ppm (n = 23)	6	14*	20*	3.61 ± 0.78*	1.30 ± 0.28*	4.91 ± 0.92*
Trend p =	—	0.0006*	0.0016*	<0.0001*	0.0003*	<0.0001*

Note. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from days 8 to 18 of gestation and tumors were assessed in the offspring. Sample size (n) equals number of mice available for pathological analysis. In defining the incidence of benign or malignant tumors in cases of multiple tumors in the same tissue, the animal was assigned to the appropriate group based on its most advanced lesion. Total tumor incidence is defined as those mice bearing at least one benign or malignant hepatic tumor, while total tumor multiplicity includes both adenoma and carcinoma. Tumors were exclusively hepatocellular in nature.

* Significantly different from control values or a significant dose-related trend. A number of animals had both adenoma and carcinoma, including 2 cases in the control group, 6 cases in the 42.5-ppm arsenic group, and 14 cases in the 85- ppm arsenic group, making the nominal rate for adenoma 9/24 (37.5%) in control, 9/21 (42.8%) at 42.5 ppm, and 20/23 (87.0%) at 85 ppm. The nominal rate of adenoma incidence was thus significantly ($p < 0.001$) increased over control at the 85-ppm arsenic exposure level.

which were observed in the high-dose arsenic group (85 ppm). A significant trend (p = 0.0306) occurred for incidence of total lung tumors in males (control: 0 tumors/24 mice; 42.5 ppm arsenic: 0/21; 85 ppm arsenic: 3/23).

Transplacental exposure to arsenic induced a marked increase in uterine hyperplasia (moderate to severe) and in TPL (incidence of mice bearing either tumor or moderate to severe hyperplasia) at both doses (Table 5). Very strong, dose-related trends occurred in the incidence of uterine hyperplasia and TPL. Tumors included adenomas, carcinomas, and sarcomas while hyperplasia was exclusively epithelial and cystic in nature. Although age-related mild hyperplasia of the uterine epithelium was seen in control mice, more severe hyperplasia occurred only seldomly.

Following transplacental exposure to arsenic, a marked increase in hyperplasia and in TPL of the oviduct occurred at the highest dose (85 ppm) in female mice (Table 6). Strong, dose-related trends occurred in the incidence of oviduct hyperplasia and TPL. One treated (85 ppm) mouse had a large oviduct adenoma. A small oviduct adenoma also occurred in a control animal.

Table 2
Adrenal tumors in male offspring after transplacental arsenite exposure

Group	Incidence	Multiplicity
Control (n = 24)	9	0.71 ± 0.20
42.5 ppm (n = 21)	14*	1.10 ± 0.22
85 ppm (n = 23)	21*	1.57 ± 0.32*
Trend p =	0.001*	0.016*

Note. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from days 8 to 18 of gestation and tumors were assessed in the offspring. Sample size (n) equals number of mice available for pathological analysis. Total tumor incidence is defined as those mice bearing at least one adrenal tumor, while tumor multiplicity is number of adrenal tumors per mouse. Tumor were exclusively adrenal cortical adenomas.

* Significantly different from control values or a significant dose-related trend.

Thyroid tumor incidence in female mice exposed transplacentally to 42.5 ppm arsenic (7 tumors per 23 mice) approached significance (p = 0.0516) compared to the incidence in controls (2/25). Tumors were exclusively follicular cells adenomas in controls but included six adenomas and one adenocarcinoma in the 42.5-ppm arsenic group. No thyroid tumors occurred in female mice in the 85-ppm arsenic group or in male mice regardless of treatment group.

The incidence of mice bearing at least one tumor of any type or at least one malignant tumor of any type in any tissue is shown in Table 7. In male mice there were significant increases in mice bearing at least one tumor and in mice bearing at least one malignant tumor at both doses of arsenic. In fact, malignant tumor incidence of any type in male mice was markedly increased over control at 42.5 ppm arsenic (3.4-fold) and 85 ppm arsenic (4.9-fold). There were also strong dose-related trends for male mice bearing at least one tumor or at least one malignant tumor. In female

Table 3
Ovarian tumor incidence in female offspring after transplacental arsenite exposure

Group	Incidence		
	Benign	Malignant	Total tumors
Control (n = 25)	2	0	2
42.5 ppm (n = 23)	4	2	6
85 ppm (n = 24)	8*	1	9*
Trend p =	0.025*	0.456	0.015*

Note. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from days 8 to 18 of gestation and tumors were assessed in the offspring. Sample size (n) equals number of mice available for pathological analysis. Total tumor incidence is defined as those mice bearing a benign or malignant ovarian tumor. No mouse had more than one ovarian tumor. Specific tumor type is described under Results.

* Significantly different from control values or a significant dose-related trend. The comparison of total tumor incidence between control and 42.5 ppm arsenic approach significance (p = 0.098).

Table 4
Lung tumor incidence in female offspring after transplacental arsenic exposure

Group	Adenoma	Carcinoma	Total tumors
Control (n = 25)	2	0	2
42.5 ppm (n = 23)	2	1	3
85 ppm (n = 24)	1	5*	6
Trend p =	–	0.0086*	0.090

Note. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from days 8 to 18 of gestation and tumors were assessed in the offspring. Sample size (n) equals number of mice available for pathological analysis. Total tumor incidence is defined as those mice bearing a benign or malignant lung tumor. No mouse had more than one lung tumor. Specific tumor type is described under Results.

* Significantly different from control values or a significant dose-related trend. The comparison of total tumor incidence between control and 42.5 ppm arsenic approach significance (p = 0.110).

mice, there were significant increases in mice bearing at least one malignant tumor at both doses of arsenic. Malignant tumor incidence of any type in female mice was increased over control at 42.5 ppm arsenic (4.9-fold) and 85 ppm arsenic (4.2-fold). A significant dose-related trend for female mice bearing at least one malignant tumor also occurred.

Transplacental arsenic exposure also had dramatic effects on tumor multiplicity of any organ (tumors per mouse) or malignant tumor multiplicity of any organ (Fig. 2). In male mice, the average number of tumors per mouse and of malignant tumor per mouse were significantly increased at both doses of arsenic and showed strong ($p < 0.0001$) dose-related trends. In female mice, the average number of malignant tumors per mouse was significantly increased at both doses of arsenic and showed a significant ($p = 0.0082$) dose-related trend. Other tumors occurred in sites that were apparently not modified by treatment. In female mice this

Table 5
Uterine tumor and proliferative lesion incidence in female offspring after transplacental arsenic exposure

Group	Incidence		
	Hyperplasia	Tumor	Total proliferative lesions
Control (n = 25)	3	1	4
42.5 ppm (n = 23)	9*	4	13*
85 ppm (n = 24)	13*	2	15*
Trend p	0.0019*	0.597	0.001*

Note. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from days 8 to 18 of gestation and tumors were assessed in the offspring. Sample size (n) equals number of mice available for pathological analysis. No mouse had more than one uterine tumor. Tumor type is described under Results. Total proliferative lesions are defined as the incidence of mice bearing either a uterine tumor or moderate to severe hyperplasia. Hyperplasia was exclusively epithelial and cystic in nature.

* Significant difference from control values or a significant dose-related trend.

Table 6
Oviduct tumor and proliferative lesion incidence in female offspring after transplacental arsenic exposure

Group	Incidence		
	Hyperplasia	Tumor	Total proliferative lesions
Control (n = 25)	0	1	1
42.5 ppm (n = 23)	3	0	3
85 ppm (n = 24)	6*	1	7*
Trend p =	0.0081*	–	0.0145*

Note. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from days 8 to 18 of gestation and tumors were assessed in the offspring. Samples size (n) equals number of mice available for pathological analysis. No mouse had more than one uterine tumor. Tumor type is described under Results. Total proliferative lesions are defined as the incidence of mice bearing either a oviduct tumor or hyperplasia. Hyperplasia was exclusively epithelial in nature.

* Significantly different from control values or a significant dose-related trend.

included one skin sarcoma and one pituitary adenoma in control mice, three sarcomas (skin, subcutaneous, and rib cage), and one adrenal carcinoma in mice exposed to 42.5 ppm arsenic and one skin sarcoma and one pituitary adenoma in mice exposed to 85 ppm arsenic. In male mice this included one stomach sarcoma, a lymphoma, and a urinary bladder transition cell carcinoma in mice exposed to 42.5 ppm arsenic and an epididymal sarcoma in mice exposed to 85 ppm arsenic. Control male mice did not have any additional tumors beyond those already discussed above.

Discussion

The present results show that exposure of pregnant C3H mice to inorganic arsenic through the drinking water at well-tolerated levels in the later stage of gestation induces a variety of tumors in the resulting offspring. This includes aggressive epithelial malignancies, such as hepatocellular carcinoma and pulmonary adenocarcinoma, that occurred in the absence of any treatment other than inorganic arsenic. Both the liver and lung are target sites of carcinogenesis in humans after oral exposure to elevated levels of environmental inorganic arsenic (Chen and Wang, 1990; NRC, 1999; Tsai et al., 1999; Wu et al., 1989). Strong dose–response relationships occurred between the level of maternal inorganic arsenic exposure and tumors in the offspring at several sites, including malignant tumors of the liver and lung, which are similar to the dose– response relationships seen between hepatic and pulmonary cancers and oral exposure to environmental arsenic in humans (Chen et al., 1990; NRC, 1999; Wu et al., 1989). Transplacental exposure to arsenic also induced neoplasms of the adrenal gland and of the ovary, while significant progressive proliferative lesions also occurred in the oviduct and uterus. At least one study shows an association between arsenic in the drinking

Table 7
Incidence of mice bearing at least one tumor of any type or at least one malignant tumor of any type after transplacental arsenite exposure

Group	Males		Females		
	Tumor of any type	Malignant tumor	n	Tumor of any type	Malignant tumor
Control (24)	11	3	(25)	12	2
42.5 ppm (21)	17*	9*	(23)	17	9*
85 ppm (23)	22*	14*	(24)	16	8*
Trend p =	0.0006*	0.0001*		0.172	0.042*

Note. Values in parentheses are numbers of mice. Pregnant female mice were exposed to sodium arsenite at the indicated doses in ppm arsenic from day 8 to 18 of gestation and tumors were assessed in the offspring. Sample size (n) equals number of mice available for pathological analysis. Incidence of mice bearing a tumor of any type includes animals with at least one benign or malignant tumor while incidence of malignant tumors includes only those mice bearing at least one malignant tumor. In defining the incidence of any tumor or of malignant tumors in cases of multiple tumors in the same animal it was assigned to the appropriate group based on its most advanced lesion.

* Significantly different from control values or a significant dose-related trend.

water and cervical cancer in Taiwan (Tsai et al., 1999). Our previous work in Swiss mice indicated that repeated injections of inorganic arsenic markedly increased the incidence and severity of uterine proliferative lesions (Waalkes et al., 2000), supporting the present results in C3H mice. Gender-based differences in tumor response were observed in the present study that are, at present, unexplained. In addition, the present study demonstrated that arsenic had a dramatic effect on the incidence of tumors at any site, particularly malignant tumors, which parallels similar observations in arsenic-exposed humans (Chen et al., 1990; NRC, 1999; Wu et al., 1989). Overall, the present work provides convincing evidence that orally administered inorganic arsenic can be a multisite transplacental carcinogen in mice, with several sites corresponding to known human target tissues. The formation of tumors following oral inorganic arsenic exposure as a single agent is particularly important since arsenic has been viewed as a "paradoxical" human carcinogen, with strong evidence of human carcinogenic potential but limited evidence for animal carcinogenesis (Basu et al., 2001).

In the present study, a short period of exposure to inorganic arsenic in the drinking water of pregnant mice was effective in inducing tumors in the offspring once they reached adulthood. In comparison, in the study showing DMA to be a complete carcinogen after oral exposure in rats

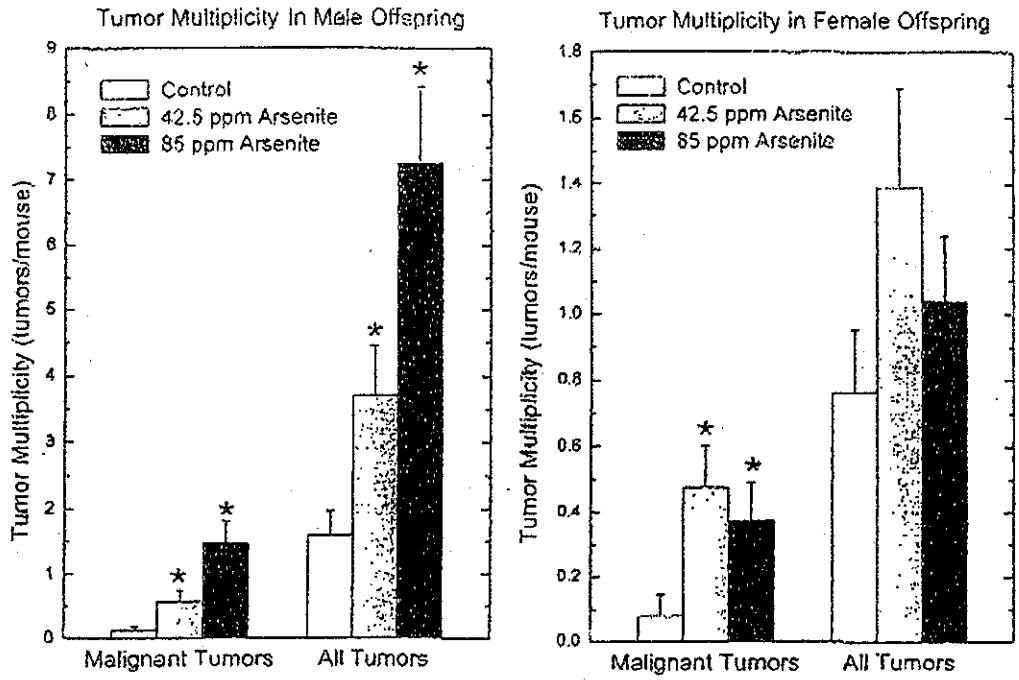

Fig. 2. Effect of transplacental arsenite exposure at 0 (control), 42.5, or 85 ppm in the maternal drinking water on tumor multiplicity in the resultant offspring. Maternal animals were exposed during pregnancy as detailed under Materials and methods and the offspring were analyzed for tumors. Results are shown for male (left) and female (right) offspring and include tumor multiplicity of any organ (average number of tumors of any kind per mouse) or malignant tumor multiplicity of any organ (average number of malignant tumors per mouse). *Significantly different ($p < 0.05$) from control.

(Wei et al., 1999), the methylated arsenical was given continuously for 104 weeks in the drinking water at levels of between 50 and 200 ppm DMA (23.5 to 93.6 ppm as arsenic) and produced urinary bladder tumors only as a late event, occurring after 97 weeks or more of treatment. This compares to the present study in which maternal arsenic dosages of 42.5 and 85 ppm (as arsenic), when given for only 10 days during gestation, were both effective in increasing the incidence of malignant and benign tumors in the offspring. In coexposure studies of skin carcinogenesis in which inorganic arsenic is given in the drinking water before and during ultraviolet radiation in hairless mice (Rossman et al., 2001) or together with TPA in H-*ras*-mutated transgenic mice (Germolec et al., 1997, 1998), the effective doses have ranged from 5.8 to 200 ppm (as arsenic), and the doses used in the present study certainly fall within this range, although the duration of exposure was much less protracted with transplacental exposure. This creates the distinct possibility that the gestational period may be a time of high sensitivity to the carcinogenic effects of arsenic, as it is with other inorganic carcinogens (Diwan et al., 1992, 1993, 1995; Waalkes et al., 1995). Looking specifically at transplacental arsenic exposure and carcinogenic effects in humans would probably prove difficult, but it stands to reason that women are exposed during pregnancy in locations where exposure to elevated levels of environmental arsenic is common. In this regard, in a recent paper on assessing the risk of internal cancers in Taiwanese populations exposed to inorganic arsenic in the drinking water, it was estimated that the dose associated with a 1% excess (1/100 exposed persons; ED_1) risk of liver cancer using a Taiwanese comparison population ranged from 0.24 to 0.89 ppm arsenic in the drinking water (Morales et al., 2000). Thus, the drinking water doses used in the present study (42.5 to 85 ppm), which resulted in up to a 61% incidence of hepatocellular carcinomas in male mice along with a 10-fold increase in carcinoma multiplicity, are only in the order of 50- to 100-fold higher than those thought to potentially pose a significant risk to humans for development of liver cancers (Morales et al., 2000). The nature of rodent carcinogenesis studies, including practicalities of restricting group sizes, typically warrants use of doses higher than those encountered by human populations. However, recent data assessing arsenic in the drinking water found levels as high as 3.4 mg/L in India and 1.3 mg/L in Nevada (Guha-Muzumder et al., 1998; Warner et al., 1994), making the lowest dose of arsenic in the present study (42.5 mg/L) only 12.5 to 32 times higher than these contemporary human exposure levels. These sorts of safety factors are hardly encouraging, particularly when one considers not only the short exposure period in the present study, but also the fact that there may be genetically based population differences in sensitivity to arsenic carcinogenesis (Basu et al., 2001).

Most of the tumor sites that were induced by arsenic in the present study showed a significant rate of spontaneous tumor incidence in control animals, including liver and adrenal gland tumors. The spontaneous occurrence of tumors is, of course, common in rodent bioassays and varies with strain and sex (Williams and Iatropoulos, 2001). In this regard, there is clear evidence that arsenic may act as a tumor promoter in some instances. This is likely the case with some models of skin cancer, in which inorganic arsenic acts as a copromoter with TPA (Germolec et al., 1997, 1998) and is clearly the case with various studies in which DMA acts as a tumor promoter in liver, kidney, skin, and urinary bladder in rats (Wei et al., 1998; Yamamoto et al., 1995; Yamanaka et al., 2000) or in skin in mice (Morikawa et al., 2000). Although the mechanism of arsenic carcinogenesis is undefined, accumulating evidence in in vitro systems indicates that it may act, at least in part, by modulating signaling pathways for cell growth (Simeonova and Luster, 2000), which could be at the level of tumor promotion. The fact that arsenic induced tumors in organs in which spontaneous tumors occur with some frequency in the present study might appear to support the conclusion it has acted as a tumor promoter. However, by definition, a classic tumor promoter requires protracted and continued exposure for effect and shows reversibility of action if withdrawn (Pitot and Dragan, 1996; Goodman, 2001). The carcinogenic effects of arsenic in the present study were manifested long after a very short period of exposure and, thus, displayed neither reversibility nor the need for protracted and continued exposure for effect, observations at odds with, and that seemingly preclude a classification as, a classical tumor promoter. This does not eliminate tumor promotion as a mode of action for arsenic in other model systems and particularly for the skin (Germolec et al., 1997, 1998; Morikawa et al., 2000). Both the initiation and progression stages of carcinogenesis are thought to (generally) involve irreversible events (Pitot and Dragan, 1996). In the present case, it could be envisioned that arsenic was affecting some pool of minimally neoplastic cells in the fetal target tissues, but, because of the obvious lack of reversibility, acting in this instance as a tumor progressor. The results of the present study, which showed an arsenic-induced enhancement of the incidence and/or multiplicity of malignant tumors in several instances, could be supportive of a role as a progressor. Indeed, continuous exposure to inorganic arsenic in the drinking water enhances the aggressiveness of skin tumors in mice resulting from ultraviolet irradiation, doubling the portion of highly invasive squamous cell carcinoma compared to animals receiving irradiation alone (Rossman, et al., 2001). Tumor progression is typically associated with irreversible changes in gene expression, including fetal gene expression, and selection of neoplastic cells for optimal growth (Pitot and Dragan, 1996). There are a variety of ways in which arsenic can alter gene expression (De Razo et al., 2001; Simeonova and Luster, 2000; Zhao et al., 1997) which can be associated with an aberrant cellular phenotype. However, progressors are thought to act on cells that have already been neoplastically transformed, and progression, as a stage in carcinogenesis, is usually a late even

associated with the concurrent existence of malignant or benign neoplasms (Pitot and Dragan, 1996). The short period of arsenic exposure ended before birth in the present study, and the very early stage and brevity of exposure argues against progressor effects, and would be more fitting for a tumor initiator. There is accumulating evidence that methylation of inorganic arsenic could generate potentially mutagenic species in in vitro model systems (Mass et al., 2001), or that a methylated metabolite may be the ultimate toxicant (Kitchin, 2001; Petrick et al., 2000; Styblo et al., 2000; Thomas et al., 2001). The strain of mice used in the present study certainly has been shown to methylate arsenic (Hughes et al., 1999), but additional study on the biokinetics and metabolism of inorganic arsenic in maternal/fetal system of C3H mice, under conditions which give rise to tumors, will be necessary to define the ultimate carcinogenic species. Regardless of the stage or stages of carcinogenesis that arsenic may have affected, it was an clearly an effective carcinogen in the present study producing, when given alone, significant increases in tumor incidence and multiplicity in several tissues, including tissues where it is carcinogenic in humans, such as the liver and lung.

In summary, this work provides an animal model of tumor development after oral exposure to inorganic arsenic as a single agent and, as such, should be an important advance in our attempts to understand the mechanisms of arsenic carcinogenesis. This study showed that the brief exposure of pregnant mice to arsenic in the drinking water resulted in the formation of a variety of malignant, benign and preneoplastic lesions in the offspring after they had reached adulthood, and after a long period without any arsenic exposure. This included induction of tumors in mice that are associated with arsenic exposure in humans, such as liver and lung malignancies. Gender-based differences in tumor response were observed that may be of mechanistic significance. The development of this model will now allow a number of critical mechanistic studies to be carried out, such as the genomic analysis of the events associated with arsenic-induced transplacental carcinogenesis.

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Testimony before the Consumer Product Safety Commission
CCA Ban Petition HP01-3

Environmental Working Group
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Attachment C

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Frequency of mouthing behavior in young children

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Young children may be more likely than adults to be exposed to pesticides following a residential application as a result of hand- and object-to-mouth contacts in contaminated areas. However, relatively few studies have specifically evaluated mouthing behavior in children less than 5 years of age. Previously unpublished data collected by the Fred Hutchinson Cancer Research Center (FHCRC) were analyzed to assess the mouthing behavior of 72 children (37 males/35 females). Total mouthing behavior data included the daily frequency of both mouth and tongue contacts with hands, other body parts, surfaces, natural objects, and toys. Eating events were excluded. Children ranged in age from 11 to 60 months. Observations for more than 1 day were available for 78% of the children. The total data set was disaggregated by gender into five age groups (10–20, 20–30, 30–40, 40–50, 50–60 months). Statistical analyses of the data were then undertaken to determine if significant differences existed among the age/gender subgroups in the sample. A mixed effects linear model was used to test the associations among age, gender, and mouthing frequencies. Subjects were treated as random and independent, and intrasubject variability was accounted for with an autocorrelation function. Results indicated that there was no association between mouthing frequency and gender. However, a clear relationship was observed between mouthing frequency and age. Using a tree analysis, two distinct groups could be identified: children ≤24 and children >24 months of age. Children ≤24 months exhibited the highest frequency of mouthing behavior with 81±7 events/h (mean±SE) (n=28 subjects, 69 observations). Children >24 months exhibited the lowest frequency of mouthing behavior with 42±4 events/h (n=44 subjects, 117 observations). These results suggest that children are less likely to place objects into their mouths as they age. These changes in mouthing behavior as a child ages should be accounted for when assessing aggregate exposure to pesticides in the residential environment.
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Keywords: *indirect ingestion exposure, mouthing behavior, young children.*

Introduction

Young children may be more likely than adults to be exposed to pesticides following a residential application as a result of hand-to-mouth and object-to-mouth contacts in contaminated areas (Cohen Hubal et al., 2000a). Characterizing and quantifying children's mouthing behaviors are important in assessing the potential for dermal and indirect ingestion of contaminants from objects, hands, and surfaces in the environment. However, data on children's mouthing activities, including between- and within-child variability, are extremely limited. As a result, default assumptions are currently used to estimate these exposures.

Mouthing is an important component in childhood development. In early development, sucking provides essential nutrients in the form of breast or bottle feeding, as well as a feeling of well being and a sense of security (Juberg et al., 2001). If infants are not allowed unrestricted breast feeding, they will suck on a pacifier, thumb (or other fingers), blanket, or toy (Groot et al., 1998). As children develop, mouthing behavior, in combination with looking and touching, allows children to explore and investigate their environment. Mouthing behavior develops into an exploratory behavior in which objects are placed into the mouth for a few seconds for purposes of discovery. During this stage of development, children will put their hands and any object that they come in contact with into their mouths (Ruff, 1984; Ruff and Dubiner, 1987; Davis et al., 1995; Groot et al., 1998).

Teething is another reason that children will mouth fingers and objects. At this stage of development, mouthing alleviates the pain and discomfort associated with teething (Groot et al., 1998). Teething usually begins at 7–8 months, but may start several months earlier or later. As with all childhood behaviors, mouthing activities vary significantly from child to child, and therefore, the impact on exposure will also be highly variable (Cohen Hubal et al., 2000a).

Pioneering videotaping studies by Zartarian et al. (1995, 1997) and Reed et al. (1999) have significantly advanced how we observe children. Zartarian et al. (1995, 1997)

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collected hand-to-mouth data, reporting the variability and differences between the left and right hands on the day of observation. Four children, two boys (2 years 10 months; 3 years 9 months) and two girls (2 years 5 months; 4 years 2 months) were videotaped with hand-held cameras for 8–10 h/day. The main objectives of this pilot study were to develop a general methodology for videotaping microactivities of a population and to collect an initial database of activity patterns for 2- to 4-year-old children of farm workers. While investigating these objectives, some hand-to-mouth data were collected. Left hand-to-mouth contacts ranged from 1 to 45 contacts/h. Similarly, right hand-to-mouth contacts ranged from 1 to 46 contacts/h. The hand-to-mouth data were also reported as the percent time that the four children spent contacting different object types with each hand during the waking hours on the day of observation. These results ranged from 1.0% to 4.4%. The time awake ranged from 6 to 11 h for the four children (Zartarian et al., 1995, 1997).

Reed et al. (1999) used a similar videotaping methodology to quantify the types and frequencies of children's hand-to-mouth activities. Twenty children in a day care center, aged 3–6 years, and 10 children in residences, aged 2–5 years, were videotaped during their waking hours for 1 day. The average hand-to-mouth frequency rate was determined to be 9.5 contacts/h (Reed et al., 1999).

Not all investigators use the videotape approach; e.g., Groot et al. (1998) employed parents as observers. In addition, research by Fagot and Hagan (1988) has shown that observers are more reliable when observing live activities than when watching videotapes of recorded activities. Fagot and Hagan (1988) caution that videotaping may not be useful for large groups of children. In all of the studies reported here, each child was individually observed. Regardless of whether the children were videotaped or their activities were recorded by an observer, the end result was only a few hours of observation time. A summary of the research related to mouthing activities is presented in Table 1.

For this paper, an unpublished data set of children's mouthing behaviors, collected by the Fred Hutchinson Cancer Research Center (FHCRC), was analyzed. The objectives of our study were to use this data set to (1) evaluate the influence of age and gender on total mouthing behavior, (2) determine the predominant types of mouthing activities and their frequency, and (3) compare our results with other literature values.

Table 1. Summary of mouthing activity research focused on exposure assessment.[a]

Reference	Age range	Number of children	Location of study	Activity collected	Method employed for data collection
Juberg et al. (2001)	0–36 months	168	Western New York	Mouthing duration, mouthing frequency, types of objects mouthed	Parental observers: 1 day; standard diary form
Reed et al. (1999)	2–6 years	30	Urban New Jersey	Hand-to-clothing, hand-to-dirt, hand-to-hand, hand-to-mouth, hand-to-object, hand-to-other items (paper, grass, pets), hand-to-smooth/textured surfaces, object-to-mouth	Videotape of waking hours; approximately 1 day of tape per child; activities were quantified from 5-min intervals and summed to give hourly frequency counts
Freeman (1999)	3–12 years	19	Minnesota	Mouthing behavior	Videotape observations
Groot et al. (1998)	3–36 months	42	The Netherlands	Mouthing duration	Parental observers; 2.5 h/day at 15-min intervals
Zartarian et al. (1995, 1997)	29–50 months	4	Salinas Valley, CA	Left and right hand contact frequency and duration for numerous categories of objects	Videotape of waking hours; approximately 1 day of tape per child; computerized translation software
Ruff and Dubiner (1987)	9–12 months	29	Undisclosed suburban location	Evaluation of young children's ability to manipulate objects and their associated behavior	Videotape of play with specified objects; trained observer; timed interactive events
Ruff (1984)	6–12 months	60	Undisclosed suburban location	Evaluation of exploratory behavior	Videotape of play with specified objects; trained observer; timed interactive events
Madden et al. (1980)	23–33 months	3	Urban Maryland	Mouth-to-body, mouth-to-object	Trained observers; interval recording system; 2–3.3 h total observation time
Lepow et al. (1975, 1974)	2–6 years	10	Hartford, CT	Mouthing frequency of hands and nonfood objects	Trained observers; 3–6 h of observation; recorded mouthing activity; given a score based on frequency

[a]Modified from Cohen Hubal et al. (2000a).

Methods

Original Data Set

Unpublished data were obtained from the FHCRC (Scott Davis and Dana K. Mirick, Program in Epidemiology, Division of Public Health Sciences, FHCRC, PO Box 19024, Seattle, WA 98109-1024). In their study, 90 children who ranged in age from 10 to 60 months were watched in their home environment by trained observers. The objective was to describe and quantify the distribution of soil ingestion values in a group of children under the age of 5 years. Observations were collected using a zero–one time sampling approach. This observational method measures both the frequency and duration of the behavior. Fifteen-second intervals are used, during which the behavior is recorded once if it occurs at all. Observers were instructed to record mouth and tongue contacts with hands, other body parts, natural objects, surfaces, and toys every 15 s for a minimum of 15 min. Observers recorded additional comments on children's activities. In the resulting data, children were actually observed between 5 and 60 min/day for 1–6 days, depending on scheduling, cooperation, etc. (Davis et al., 1995).

The Reduced Data Set

For this analysis, the original data set was coded to include children's activities (macroactivities) and locations (microenvironments). Children's activities were coded as quiet or active play based upon the observer's comments in the questionnaire. For example, sitting watching television, coloring, reading, or talking with a parent was coded as quiet play. Running around, walking, bicycling, and jumping were coded as active play. Quiet and active play are two macroactivity classifications used to categorize children's activity levels in their environment (Cohen Hubal et al., 2000b). Locations (microenvironments) were categorized as indoor or outdoor environments. This microenvironment and macroactivity classification scheme is being tested in exposure assessment to identify behavior that may make some children especially vulnerable to indirect ingestion exposure to pesticides and other environmental contaminants (Cohen Hubal et al., 2000b).

Preliminary analysis of the mouthing and tongue contacts showed no statistically significant differences between mouth and tongue. Therefore, mouth and tongue events were summed for each activity category. Total mouthing behavior was the daily frequency of both mouth and tongue contact with hands, other body parts, surfaces, natural objects, and toys. Originally, the observers were asked to collect the mouthing behavior during an awake period when the child was not eating. Therefore, in order to normalize the data, we excluded all food events from subsequent analyses. We excluded those children who were coded as engaging in active play in an indoor or outdoor environment and quiet play in an outdoor environment because there were too few to do any statistical analyses.

Our analyses, then, focused entirely upon those children who were coded as engaging in quiet play in an indoor environment. The final data set contained 72 children (37 males/35 females), ranging in age from 11 to 60 months. There were a total of 186 observations; multiple observations were available for 78% of the children. The number of observations per child ranged from 1 to 6.

Data Analyses

To evaluate the influence of a child's age and gender, a general linear model using SAS (Version 8.02; SAS Institute, Cary, NC) was fit to the log of the daily frequency of all mouthing data in the following form:

$$\begin{aligned} \text{LTOTAL} = {} & \text{GENDER} + \text{AGECLASS} \\ & + \text{GENDER} * \text{AGECLASS} \\ & + \text{ID}(\text{GENDER} * \text{AGECLASS}) \\ & + \text{RESIDUAL} \end{aligned}$$

where LTOTAL=log of the total mouthing frequencies; GENDER=sex of the child; AGECLASS=age breakdown of the child; GENDER*AGECLASS=relationship between gender and age of the child; ID(GENDER*AGECLASS)=nested relationship between gender and age of the child with respect to the identification number; RESIDUAL=error.

Each observation was treated as random and independent within the general linear model. A logarithmic transformation of the data was used to: (1) reduce multicollinearity among the independent variables, (2) reduce autocorrelation among residuals, and (3) make the distribution of measurements more symmetric.

Results

Figure 1 depicts the frequency of mouthing behavior as a function of age and gender. There is no significant difference in the mouthing/age relationship by gender. Therefore, we focused on age, without relying on gender, to explain hand-to-mouth activity. This result corresponds with data reported by Ruff (1984), Ruff and Dubiner (1987) and Groot et al. (1998) who showed that there is no statistically significant difference in mouthing events between boys and girls. There is, however, a significant relationship between mouthing and age of the child.

The age/mouthing relationships were evaluated in two ways: using age as a continuous variable, such as depicted in Figure 1, or using age as a categorical variable. If the latter approach is used, the question becomes "What age categories make sense from a statistical perspective"? Groot et al. (1998) had four age breakdowns, including: 3–6

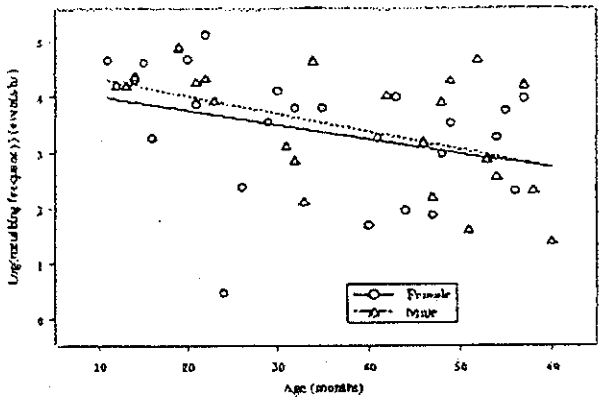

Figure 1. Linear regression of the frequency of mouthing behavior as a function of age and gender.

months, 6–12 months, 12–18 months, and 18–36 months. An EPA-sponsored workshop focused on identifying appropriate age groups for assessing exposure based on behavioral and anatomical differences in children (US EPA, 2000). In the workshop report, the subgroup that considered behavioral development proposed the following age groupings: birth to <3 months, 3 to <6 months, 6 to <12 months, 12 to <24 months, and 2 to <6 years. Based on the distribution of children's ages in this data set, we selected the following age groups for analysis: 10–20, 20–30, 30–40, 40–50, and 50–60 months. We also ran the analysis using age as a categorizing variable on the following age groups: 10–23, 24–35, and 36–60 months. Results on these analyses showed no statistical difference between 24–35 and 36–60 months. However, there was a statistically significant difference between children <24 and >24 months for this data set. This information provides additional support for the age categories as proposed in the EPA workshop report.

The best approach to determine if "natural" categories existed in the data is to use a tree analysis available in S-Plus 2000 (Version Professional Release 1, 1999). This type of model employs a recursive partitioning algorithm that successively splits the data into homogeneous subgroups. Two main age groupings were identified using this approach: ☐24 and >24 months of age (see Figure 2). Children ☐24 months mouthed the most frequently with a reported median mouthing frequency of 73 events/h (60–88 events/h, n=28 subjects, 69 observations), whereas children >24 months had a median mouthing frequency of 31 events/h (25–39 events/h, n=44 subjects, 117 observations). The data are reported as the median (95% confidence interval, n=number of subjects, total number of observations).

Table 2 reports the frequency of mouthing behavior for the entire data set for four different mouthing activities: mouth-to-body, mouth-to-hand, mouth-to-surface, and mouth-to-toy. Generally, these children mouthed toys the most frequently, followed by hands, body parts, and then household surfaces.

Children ☐24 months showed significantly more mouthing of toys, as compared to children >24 months. However, both groups of children appear to favor the mouthing of toys and hands (Table 2). Again, in both groups, other body parts and surfaces were mouthed less frequently. A summary of the frequency of mouthing behavior is presented in Table 2. Groot et al. (1998) reported similar findings to these data. Those investigators showed that for the youngest group of participants (3–6 months), fingers were most often mouthed followed by toys. In the 6- to 12-month age range, toys were mouthed most often, followed by nontoys and fingers (Groot et al., 1998). Similarly, in the 12- to 18-month age group, nontoys and fingers were mouthed most frequently, but as the children aged (18–36 months), fingers were most often placed into the mouth (Groot et al., 1998). Groot et al.'s research reports mouthing time as the total mouthing time per 24 h and then breaks the mouthing time into mouthing of certain categories of objects as a percent of the total. Though mouthing events or frequency per hour cannot be computed using their data, the data are valuable because they allow determination of the likelihood of mouthing certain objects for a group of children. In addition, their research supports our findings that hands (i.e., fingers) and toys are most likely to be mouthed.

Implications for exposure assessment

Children ☐24 months have the potential to be exposed to higher concentrations of pesticide residues due to their higher frequency of mouthing behavior as compared to children >24 months in age. Indirect ingestion exposure is generally defined as mouth and tongue contacts of an

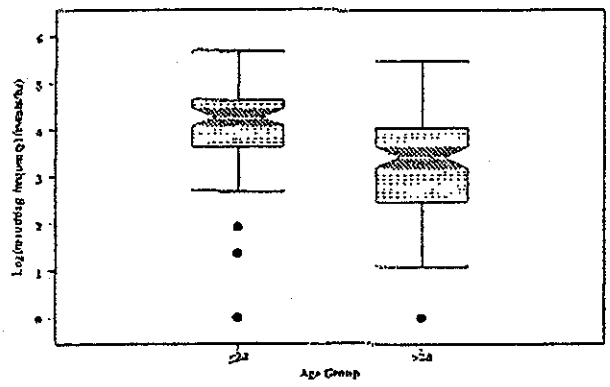

Figure 2. Box plots of total mouthing frequencies for the two age groups.

Table 2. Variability in objects mouthed for different age groups.

Variable	All subjects				≤24 months				>24 months			
	n[a]	Mean[b] (events/h)	Median (events/h)	95% CI[c] (events/h)	n[a]	Mean[b] (events/h)	Median (events/h)	95% CI[c] (events/h)	n[a]	Mean[b] (events/h)	Median (events/h)	95% CI[c] (events/h)
Mouth–body	186	8	2	2–3	69	10	4	3–6	117	7	1	0.8–1.3
Mouth–hand	186	16	11	9–14	69	18	12	9–16	117	16	9	7–12
Mouth–surface	186	4	1	0.8–1.2	69	7	5	3–8	117	2	1	0.9–1.1
Mouth–toy	186	27	18	14–23	69	45	39	31–48	117	17	9	7–12
Total mouthing events	186	56	44	36–52	69	81	73	60–88	117	42	31	25–39

[a] Number of observations.
[b] Arithmetic mean.
[c] The 95% confidence limits apply to median. Values were calculated in logs and converted to original units. See text for complete details.

individual with a contaminated object. To characterize an exposure event, information is required on the concentration of a pollutant in the exposure medium, the activities that result in a contact, and the transfer efficiency from the exposure medium to the individual (Cohen Hubal et al., 2000a). Indirect ingestion exposures usually occur via microactivities (μa_x) such as mouth-to-body, -hand, -surface, and/or -toy contacts (where the subscript, x, represents body, hand, surface, toy, or any other object that is mouthed).

Exposure can be estimated in two steps: (1) individually for each microactivity, and/or (2) summed for all activities for an exposure duration of interest (i.e., 24-h). For each microactivity resulting in indirect ingestion, exposure over a 24-h period can be defined as:

$$E_{nd} = (C_x)(TE_x)(SA_x)(EF) \quad (1)$$

where x=body, hand, surface, toy, or any other object that is mouthed; E_{nd}=indirect ingestion exposure from a specific mouthing event over a 24-h period (μa_x) [μg/day]; C_x=total contaminant loading on x [μg/cm^2]; TE_x=transfer efficiency, fraction transferred from x to mouth [unitless]; SA_x=surface area of x that is mouthed [cm^2/event]; EF=frequency of mouthing events over a 24-h period [event/day].

The total indirect ingestion exposure over a 24-h period can be estimated by summing exposures for all microactivities. For any particular microenvironment (μe) being modeled, the child's potential exposure is the sum of all exposures for all microactivities conducted in that microenvironment (i.e., indoors at home on carpet). The total indirect ingestion exposure can be described with the following equation:

$$E_{nd/total} = \sum_{\mu e} \sum_{\mu a_x} E_{nd} \quad (2)$$

where $E_{nd/total}$=total indirect ingestion exposures over a 24-h period [μg/day]; $\sum_{\mu e}$=sum over all microenvironments in which the child is located over a 24-h period; $\sum_{\mu a_x}$=sum over all mouthing events in a specific microenvironment that occur over a 24-h time period.

If the exposure duration of interest is different from 1 day, the algorithms can be adjusted accordingly.

To illustrate the use of these equations to estimate the potential indirect ingestion exposure from a pesticide via hand-to-mouth activity, we apply it to monitoring data obtained for diazinon by Lewis et al. (2001). The microenvironment is the living room of a residential dwelling where a 24-month-old female child (weight=13.5 kg) spends 4 h in the microenvironment ($\mu e.t$=LR.4 h). She is found to have 0.3 μg of diazinon residue on her hands, which have a total surface area of 310 cm^2. In this example, x=hand and C_{hand}=0.001 μg/cm^2 (diazinon loading on hand=C_{hand}/SA_{hand}). In addition, the following assumptions are made: (1) the child's mouth only comes into contact with 10% of her hand during any single microactivity event [SA_{hand}=310×0.1=31 cm^2/events]; (2) the amount of diazinon on her hand is constant as a function of time; and (3) the TE_{hand} is 50%. If we know the number of times per hour that the child puts her hand into her mouth, we can calculate her indirect ingestion exposure for diazinon from her hands. Using the data in Table 2, mouth-to-hand activity is 12 events/h. Her exposure is computed as follows:

$$E_{nd/\mu e.t} = E_{nd/LR.4[h]} = \left(0.001\left[\frac{\mu g}{cm^2}\right]\right)\left(31\left[\frac{cm^2}{events}\right]\right)(0.5)\left(12\left[\frac{events}{h}\right]\right) = 0.186\left[\frac{\mu g}{h}\right]$$

Taking into account the time in the microenvironment, the mass of diazinon to which the child is exposed is:

$$E_{nd/LR.4[h]} = \left(0.186\left[\frac{\mu g}{h}\right]\right)(4[h]) = 0.744[\mu g]$$

To obtain the per unit mass estimate for the child, divide by her body mass:

$$E_{nd/LR.4[h]} = \frac{744[ng]}{13.5[kg]} = 55.1\left[\frac{ng}{kg}\right]$$

To obtain an estimate of this child's total indirect exposure to diazinon, potential exposure from all

microactivities would have to be computed and summed (i.e., mouth-to-body, -surfaces, -toys). Given the frequency of mouthing events in small children and contaminant loadings on all types of objects that they put into their mouths, it is important to have an accurate estimate of mouthing activities in young children.

The mouthing activity data generated in this manuscript represent multiple days of observation for 72 children. As such, the data represent the intrachild mouthing variability based on microenvironments and macroactivities (in this case, quiet play indoors) for a large cohort of children <60 months in age. The most current default assumptions to represent hand-to-mouth activity are 20 events/h (short-term exposures) and 9.5 events/h (intermediate-term exposures) based on data reported by Reed et al. (1999) (Update to the Residential SOPs dated February 22, 2001; Policy 12). However, these numbers do not consider mouthing of objects other than hands. The data presented in this manuscript show that young children may mouth specific objects (i.e., toys) up to 48 events/h. The data set analyzed in this manuscript provides a distribution of mouthing contacts that can be used to improve exposure assessments for children in this age range.

Conclusions

The results reported in this study are focused on children who engaged in quiet play in an indoor environment. Analysis of the data set using a linear SAS model suggests that the mouthing data can and should be broken into two subsets based on age: □24 and >24 months. The data further showed that toys and hands were preferentially mouthed as compared to other body parts and household surfaces. We have obtained a more realistic estimate of a child's mouthing behavior by using data collected on multiple observation days. Similar data for children engaged in active play would provide additional insight into the mouthing behaviors of young children and the impact of these on indirect ingestion exposure.

Acknowledgments

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Testimony before the Consumer Product Safety Commission
CCA Ban Petition HP01-3

Environmental Working Group
March 17, 2003

Attachment D

Cancer Risks from Children's Exposures to Arsenic-Treated Wood:
Methodology for Monte Carlo Style Risk Analysis

Environmental Working Group
Washington, D.C.
March 13, 2003

The Environmental Working Group (EWG) conducted a risk assessment to quantify excess lifetime risk of lung and bladder cancer for children ages one to seven exposed to arsenic-treated lumber on play structures and decks.

The risk assessment is based on exposure parameters proposed by the Consumer Product Safety Commission (CPSC 2003) and the Environmental Protection Agency (EPA 2001), and on measured distributions of arsenic in dislodgeable residue wipe samples, and studies of soil surrounding arsenic-treated structures. Model parameters and model results are described below.

Exposure routes and pathways

We assume exposures are from a child's contact with arsenic on the surface of playsets and in the soil below:

Play structure

1. dislodgeable arsenic, ingestion
2. dislodgeable arsenic, dermal absorption
3. contaminated soil, ingestion
4. contaminated soil, dermal absorption

Body weight

In this simulation body weight varies by child and by age, and is updated monthly as the simulation progresses for each child.

Ninety-nine body weight distributions representing the 1st through 99th percentiles were created from NHANES III measurements (the Centers for Disease Control and Prevention's National Health and Examination Survey Data). Each of the 99 distributions represents a child's body weight from age 1 through age 6 (12 through 83 months). The data used to generate these weight distributions represent 6374 individuals, with measurements made between 1988 and 1994.

NHANES data are presented at an age resolution of one month. To generate the weight percentile distribution curves, we began by grouping data for each month together, with approximately 100 children's weights represented for each month. At each monthly

interval we computed a mean and standard deviation for an assumed lognormal distribution, then used these parameters to compute the 1st through 99th percentile weights at each monthly interval. Then, in essence, we connected the dots from one month to the next to generate a weight-through-time curve for each of 99 weight percentiles. Smoothing of each generated curve was conducted though an averaging algorithm that replaced each individual value with the average value of the original computed point and the corresponding weight values for the two months on either side.

NHANES does not collect data through time for an individual. Therefore, in this analysis we are constrained by the assumption that a child remains in the same weight percentile throughout the simulation period. In essence, in this simulation a small child stays small through childhood, and a large child stays large.

Body surface area

Body surface area was computed from body weight for each modeled child. For a given body weight, a single value is computed for surface area based on a regression developed from Gehan and George (1970) and NHANES body weight data.

Gehan and George (1970), as cited in EPA (1999), give body surface area as a function of height and weight. Since the method used in this model to compute body weight percentiles from NHANES data does not preserve height, we used the Gehan and George regression to translate body surface area into a function of body weight only.

First, individual height and weight data from NHANES were used in the Gehan and George regression to compute surface area for each individual represented in NHANES. Next, we computed the ratio of surface area (computed) to body weight (measured) for each child represented in the NHANES data, and plotted that ratio as a function of weight. We then performed a trend analysis for SA/BW versus BW, with a trend computed separately for up to age 2, and then for age 2 and greater, where SA = body surface area, and BW = body weight.

In the model simulations, body surface area is updated monthly for each modeled child from this computed trend, based on the monthly body weight for each of the 99 percentile weight curves represented in the model. We lose variability by fixing surface area for a given body weight. In actuality, surface area appears to vary over a range of about 10 percent for a given weight. Our values for body surface area can be considered central tendency estimates within each assumed weight percentile.

Surface area of hands, legs, and arms

In the scenarios presented here, we assume that dislodgeable arsenic and soil adhere to a fraction of a child's hands, arms, and legs. The total surface area of each modeled child's hands, arms, and legs are computed as central tendency estimates from individual body

part surface area measurements presented in EPA (1985). These best-fit curves, generated from EPA data, allow us to compute the surface area of a child's hands, arms, and legs as a function of a child's age and total body surface area.

Duration of exposure

Exposures were assumed to occur regularly over a period of six years, from age 1 through age six (12 through 83 months) (EPA 2001).

Exposure frequency

The exposure scenario presented in this document represents the subset of children who play fairly frequently on arsenic-treated wood. We assume a frequency of 3 times a week throughout the year (156 times), with each visit lasting an hour. EPA considers this to be a central tendency estimate (EPA 2001).

Soil adherence factor

The soil adherence factor refers to the amount of soil assumed to adhere to the skin when a child plays on soil. We assume a value of 0.987 milligrams of adhered soil per cm^2 of children's hands, 0.0278 milligrams per cm^2 of children's arms, and 0.354 milligrams per cm^2 of children's legs, consistent with values from Greenhouse Studies (Kissel 1998).

Dislodgeable arsenic transferred to the skin

In a study performed for the wood industry (SCS 1998), researchers finds wide variability in the different amount of arsenic transferred to wood versus hand (and arsenic in hand samples often exceed arsenic in wipe samples). The median wipe-to-hand ratio from this study is 4.6 (i.e., 4.6 times more arsenic on the wipe sample than on the hand), the value chosen for this model. We assume the same level of dislodgeable arsenic adheres to all exposed body parts (hands, arms, and legs).

Hand-to-mouth activity, arsenic removal efficiency, and bioavailability

The amount of dislodgeable arsenic ingested by each modeled child is calculated as a function of the number of times a child put portions of their hands into their mouth. From Tulve *et al.* (2002), we use the mean estimate of 16 times per hour for children over 2 years old and 18 times per hour for children less than 2 years old as the rate of hand-to-mouth activity. This value is constant for all modeled children. Our use of a central tendency estimate for all modeled children significantly underestimate risk for a substantial fraction of the population considered. Tulve et al. (2002) measured hand-to-mouth behavior a maximum of 48 times per hour.

Consistent with EPA recommendations, we assume that each hand-to-mouth event can be represented, on average, by a third of the hand (approximately 3 fingers) contacting the mouth. We also follow EPA's recommendation of assuming that only 50 percent of the dislodgeable arsenic on the hand is transferred to the mouth. We assume that 100 percent of the transferred arsenic is bioavailable (EPA 2001).

Because the model simulates active play on the wood, dislodgeable arsenic is assumed to be replenished on the hands between mouthing events. We do not model the ingestion of arsenic remaining on the hands after the one-hour play time is over and before the child washes the remaining arsenic from his or her hands.

Soil ingestion and bioavailability

We simulate children's incidental ingestion of soil contaminated with arsenic that has leached from arsenic-treated wood and construction-related sawdust. These exposures would apply to children who play near play structures, or children who play with toys that have been stored beneath play structures, such as sandbox toys.

EPA cites five key soil ingestion studies in their analysis of soil exposure factors (EPA 1999). These studies provide estimates of mg of soil ingested daily for individual children. We use all the daily ingestion values from these five studies in our model. Where EPA does not provide individual data points from the studies (in milligrams of soil ingested per day for an individual child), we generate the values from the given distribution statistics (typically from the mean and standard deviation).

In our model we give a child an equal chance of falling within any one of the five measured distributions. Then each child is randomly assumed to fall within a high, medium, or low exposure group, a categorization that is maintained throughout the simulation period. For each model day on which soil exposures are assumed to occur, a soil ingestion rate is randomly selected from within the relevant third (high, medium, or low) of the chosen distribution. We assume that all of a child's soil intake is from arsenic-contaminated areas, and that 25 percent of the ingested arsenic is bioavailable (EPA 2001).

Dermal absorption

We consider dermal absorption separately for exposures to dislodgeable arsenic and exposures to contaminated soil. For the subset of children represented in this model, we assume that an area equivalent to the palms, the back of the calves, and the back of the forearms are exposed to dislodgeable arsenic or contaminated soil. We compute these body part surface areas as half of the total hand surface area, one-quarter of the total surface area of the arms, and one-quarter of the total leg surface area.

We assume that 6.4 percent of the arsenic, either in adhered soil or in dislodgeable arsenic on the skin surface, is absorbed through the skin (EPA 2001).

Dislodgeable arsenic levels on arsenic-treated wood surfaces

In this model, childrens' exposures to dislodgeable arsenic are calculated from measured arsenic residue on 588 in-service playsets, decks, porches, sandboxes, and treehouses, including 295 playsets, from EWG's Home Sampling Program. Residue level is assumed to remain constant through the modeled years for an individual child.

Soil arsenic distribution

Measured distributions of soil arsenic used to represent contamination beneath individual arsenic-treated wood playsets are from 453 soil samples below or near in-service playsets, decks, porches, sandboxes, and treehouses sampled by homeowners as part of our Home Sampling Program.

Data are highly skewed toward sandy soil and could underestimate exposures in large parts of the country with more organic, clayey, silty soil where arsenic concentrations would likely be higher.

Cancer Potency

We compute cancer risk using the CPSC's upper bound cancer slope factor of 0.023 kg-day/µg. This value is consistent with the National Research Council's estimate of ED01 for bladder cancer alone (NRC 2002). We assume an increased potency of 10 for children less than two years old and three for children over two years old as suggested in EPA's new guidelines for cancer risk assessment (EPA 2003).

Model calculational procedures

Model results presented in this report are from a model run that incorporated one million children. In each of the one million model loops, the model creates a child that is defined by a body weight distribution (ranging from 1st through 99th percentile). Body surface area and body part areas are computed. Then the model randomly assigns four arsenic distributions to the child, one representing dislodgeable arsenic and soil arsenic for a play structure, and one representing those same distributions for a deck. The model assumes that all available measured distributions for soil and dislodgeable arsenic are equally applicable to deck and play structure exposures, since the wood used for these structures is the same.

Each child cycles through the model day by day, with 3 hours a week assumed for play structure contact time, and 3 hours a week assumed for deck contact time. Average daily doses are computed for each of the 8 possible combinations of exposure routes and pathways so the relative importance of each can be determined.

A child's body weight and body surface area is updated monthly as the model cycles each child through time. Dislodgeable arsenic and soil arsenic remain constant through the exposure period, except that a child is given a one in four chance of moving each year, at which point distributions are reassigned.

An average daily dose is computed according to standard risk assessment equations presented in EPA (2001), using exposure parameters described previously.

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Testimony of Paul Bogart, Healthy Building Network, Before the Consumer Product Safety Commission

March 17, 2003

Good afternoon, my name is Paul Bogart and I represent the Healthy Building Network. Thank you for the opportunity to testify today on the Healthy Building Network's and Environmental Working Group's petition to ban the use of CCA lumber in playgrounds. The Healthy Building Network is a national network of green building professionals, environmental groups, consumer advocates and concerned parents who are interested in promoting healthier building materials as a means of improving public health and preserving the global environment.

As you know, in May of 2001 we submitted a petition seeking a ban on the use of arsenic treated wood in playground equipment. More than thirty organizations representing hundreds of grassroots groups across the country have endorsed the petition.

Over the past two years, we have spoken to thousands of concerned parents, teachers and others about the completely unnecessary risk posed by the use of arsenic treated lumber in decks and playgrounds. In almost every case, the response has been the same: if it isn't necessary, and it is a potential hazard, let's get rid of it.

School boards, municipalities, city councils, parents – and even the playground manufacturing industry, to its credit -- have reached the common sense conclusion that regardless of the rate of arsenic leaching from the wood, or the rate of human exposure to the arsenic, prudence

dictates that children should be exposed to as little arsenic as possible in their lives, and none of it should come from their play things. Many have therefore decided to eliminate arsenic treated wood from their playgrounds, schoolyards, and park. To the best of our knowledge, not a single major playground manufacturer currently uses CCA treated wood.

Now, the Consumer Product Safety Commission has before it a staff report that confirms the obvious with scientific analysis:

- arsenic leaches from the CCA treated wood;
- it is even more toxic than previously thought;
- children are among the most vulnerable populations.

The Commission now has an opportunity to accelerate the necessary, achievable, and long overdue transition away from the use of arsenic coated wood in children's products. In so doing, it will ensure that those leaders in the affected industries, e.g. the playground companies that have already stopped using CCA treated wood, do not lose one more cent of revenue to the laggards among their competitors, who have resisted this change, and continue mislead parents into thinking that all wooden playground models are alike. The Commission has an overwhelming obligation to speak forcefully and without equivocation on this issue because if history is our guide, the arsenic lobby well represented here today will exploit any ambiguity or nuance in the Commissions statement to further mislead the public. HBN is particularly concerned about this point.

It has been 13 years since the CPSC last examined the issue of Playgrounds built with arsenic treated wood. The arsenic industry has routinely mischaracterized the rigor of your previous analysis and its conclusions, to mislead parents, consumers, municipal officials and playground equipment manufacturers. Wearing the CPSC's stamp of approval of CCA like a badge of honor, the arsenic industry caused millions of CCA playsets to be sold to consumers under false assurances of safety since 1990, even as the data which you have before you today mounted.

During the Commission's first hearing on our petition, in August, 2001, the American Wood Preservers Institute (AWPI) testified that :" An *extensive 1990 report* by the CPSC found that CCA-preserved wood is an appropriate materials for playgrounds." (PowerPoint Briefing by Scott Raminger to CPSC, 8/6/01.) In fact, your 1990 analysis contained no such "finding." The contrary it concluded: "This suggests that a possible hazard might be created when playground equipment is built with unfinished pressure treated wood from retail sources." (CPSC memorandum 8/2/90, Executive Summary.)

We have also presented the Commission with evidence that manufacturers' knowingly provided misleading information to consumers in brochures such as the one from the (Osmose corporation entitled "CCA FACTS", attached). This brochure for retail consumers features the words, all capitals, " USE IT FOR PLAYGROUNDS" next to a color illustration of a playground structure, and "CCA TREATED WOOD IS NOT HAZARDOUS" next to the color illustration of a pitnic table. (The manufacturer's Material Safety Data Sheets, attached) explicitly contradicts these statements with these warnings, among others: "This product must not come in contact with food or feed," and "Approximately 2.5oz (6 cubic inched) of treated wood dust ingested by a small child may be life threatening."

The responsibility facing this Commission may be complicated and daunting, but it is not in doubt: New playgrounds made with arsenic treated wood must be banned, and decisive steps must be taken immediately to protect children from those playgrounds already in use.

While Healthy Building Network views many of the findings stated in the Staff report as a vindication of the assertions contained in our original petition to the Commission; the recommendation that the Commission defer action until after the EPA has acted, and the impact of that action assessed, seems dangerously out of synch with their findings.

The EPA agreement, when finalized, is very limited in its ability to protect children on a number of fronts:

First, the agreement would allow any CCA lumber produced before the end of this year to be sold indefinitely, virtually assuring that despite the findings of the staff report, CCA playsets will continue to be sold to unsuspecting consumers well into next year.

If CPSC staff estimates of playground sales in the previous decade hold true, we are talking about more than a quarter of a million ADDITIONAL arsenic treated playsets sold to consumers while the CPSC and EPA wait to take decisive action based on their own science.

Second, the voluntary labeling program currently in place for arsenic treated wood only applies to retail sales of lumber. This means that despite the conclusions of the CPSC staff that use of such lumber for playsets represents a significant cancer risk well above the generally accepted level for federal action; consumers who purchase arsenic treated playgrounds will not even receive a label informing them of the presence of arsenic nor the risks involved.

Third, deferring action, as recommended in the Staff report, positions the CPSC as a roadblock to completing a transition that has already begun in earnest by a majority of playground manufacturers.

Currently, the International standards organization (ASTM), as well as the International Play Equipment Manufacturers Association (IPEMA), are awaiting CPSC action before updating their standards. Further delay on this issue not only impacts these organizations but perhaps more importantly, rewards those remaining playground manufacturers still using CCA while punishing the majority of manufacturers who have taken a leadership position on this issue.

For these reasons, as well as for the health of the tens of millions of children who play on arsenic coated playgrounds daily, deferring action on the this issue is incompatible with the findings of the Staff report.

Instead, the Commission should take the following steps:

1. HBN believes that playground equipment made from CCA wood meets the statutory definition under the Federal Hazardous Substances Act of a children's product which contains a hazardous substance in such manner as to be

susceptible of access by a child to whom such article is entrusted. On the basis of this determination, HBN requests that CPSC begin rulemaking to immediately ban new playground equipment made from CCA treated wood.

2. Given the extended service life and greater use of public and commercial playground equipment made from CCA wood, HBN requests that such equipment be recalled immediately and that CCA manufacturers pay the cost of this recall.

3. HBN requests the Commission to direct the manufacturers/retailers of CCA playground equipment to notify, in writing, all customers who purchased such equipment in the past twenty years, and for whom records exist, of the findings of the CPSC staff report and relevant EPA findings and recommend mitigation measures to reduce dislodgeable arsenic.

4. HBN requests that the Commission use aggressive means to inform the public of the findings in the staff report including increased cancer risks posed by CCA playground equipment, as well as recommended mitigation measures.
5. HBN requests that the CPSC join with the EPA in an expedited study to determine the best mitigation measures for reducing the amount of dislodgeable arsenic from CCA playground equipment AND decks.