

H2903

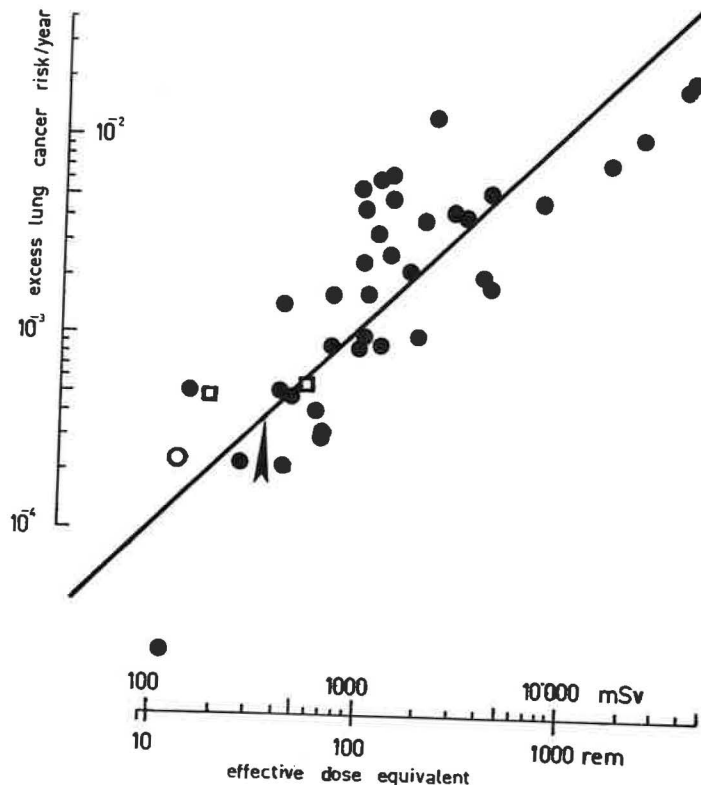


Figure 4: Human epidemiological data on radon induced lung cancer. Each point (●) denotes a population of miners from the USA, Canada, Czechoslovakia or Sweden, respectively. Risk factors from A-bomb survivors (○) and from Ankylosing spondylitis patients (□) are similar. Compiled from Archer (16), BEIR III (6), Cohen (7), Radford (17) and Snihs (18).

BEIR I (20) $6.5 \times 10E-6/WLM-a$ (as used in this paper)

dose received over 30 years in an indoor environment with a Rn level of 370 Bq/m³ (10 pCi/l) (based on UNSCEAR82 (10) assumptions for breathing rate, lung deposition pattern, time spent indoors, equilibrium factor)



#2903

PREVALENCE OF FORMALDEHYDE CONCENTRATIONS IN RESIDENTIAL SETTINGS



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During the past five years, the New York State Health Department as with other Federal/State agencies received an extraordinary number of public inquiries and complaints expressing concern for residential indoor air exposure to formaldehyde gas. In New York State 20,000 residential homes have been foamed with Urea-Formaldehyde Foam Insulation UFFI. In accordance with the 1980 U.S. Census, there are 119,417 mobile homes statewide. This represents an estimated population of 358,251 persons. While the population of UFFI homes is not expected to increase (current estimate 70,000), mobile home populations between 1970 and 1980 increased 39% and continued growth is expected. The department established services for the collection and analysis of indoor air samples for formaldehyde gas concentrations. Such services were provided if, (1) a household occupant (patient) was under the care of a physician and (2) the physician's written report indicated that formaldehyde exposure may be related to the personal health condition of the patient. Reports of indoor air analysis were provided to both individuals upon completion.

Concentrations of formaldehyde were measured for 2,318 indoor air samples and represent 2,272 separate residential settings. The frequency distribution of formaldehyde concentrations are given for the following categories of residential settings, (1) Complaint Mobile Homes, (2) Permanent Residential UFFI Homes with Complaints, (3) Permanent Residential Complaint Homes without UFFI, (4) Permanent Residential Non-Complaint Homes without UFFI. For all categories 83.5% of all indoor air samples analyzed for formaldehyde concentrations were less than 0.10 ppm and 6.3% were less than the detection limit of 0.02 ppm.

The purpose of this presentation is to review and compare by category the indoor air concentrations of formaldehyde gas present at the time of sample collection within residential settings in New York State.

A large number and variety of sources may contribute to the presence of formaldehyde gas within residential homes. Much of the information to date is limited for both permanent and mobile homes. Even less information is available which validates specifically a direct relationship between symptoms reported and the presence of airborne formaldehyde at various concentrations. Most studies available are not statistically designed and therefore may not constitute a representative evaluation.

Table I summarizes the relative average concentration of formaldehyde for the household settings evaluated for both permanent and residential mobile home settings. A comparison of the Wisconsin mobile home studies suggests a reduction in average concentrations when statistical methods are applied. The number of units having values less than 0.10 ppm significantly increased from 4.4% (complaint) to 15.5% (random). For these studies the range of average concentrations for mobile homes was found to be 0.24 to 0.65 for all three studies.

The Washington study of urea-formaldehyde insulated households showed an average concentration of 0.39 ppm of formaldehyde gas at 39 homes. Of these 36.4% had concentrations of less than 0.10 ppm. The remaining six studies relates to non-foamed residences where construction materials, adhesives and/or furnishings were the primary sources of formaldehyde.

For the Lawrence Berkeley Laboratory study, four home sample analyses showed (13) concentrations less than 0.10 ppm and an average of 0.05 ppm. A Geomet study of one home having an average concentration of 0.05 ppm showed the presence of formaldehyde in all 17 samples and all concentrations were less than 0.10 ppm.

In New York State a considerable number of indoor air measurement for formaldehyde has been accumulated since September, 1979. Analyses performed represent the following categories of residential settings:

A. Permanent Residences

- Complaint with UFFI
- Complaint without UFFI
- Non-Complaint without UFFI

B. Mobile Homes

- Complaint without UFFI

All samples were collected and analyzed by Department of Health personnel. Indoor air sample collection and analysis procedures were in accordance with the following:

An air sample is passed through an absorbing solution of distilled, deionized water in a single bubbler at a minimum rate of one liter per minute for a minimum of one hour. Actual collection time ranged from 60 to 120 minutes for a range of total volume collected of 67 to 130 liters. The absorbing solution is returned to the laboratory and analyzed using the chromotropic acid method.

This procedure was validated by Department of Health laboratory personnel to a detection limit of 0.02 ppm by performing studies using known dynamic gas standards and parallel analysis of real samples by pararosaniline and chromotropic acid methods. (Note: The NIOSH P and CAM 125 method has been only validated to a detectable limit of 0.1 ppm formaldehyde)

Standard procedures for preparation of the household were adopted and implemented with the cooperation of the occupant. Every effort was made to standardize the condition under which the indoor air sample was collected. It is, however, doubtful that all samples were collected at all times in a manner consistent with all of the following site preparation conditions:

1. A minimum of one indoor air sample is collected from each household. The choice of location within a home should be qualified as:
 - a. living space, e.g., not unfinished attic or cellar.
 - b. living area of reported concern and/or symptomatic complaint, e.g., bedroom, or southside of dwelling or location of known and visible deterioration.
 - c. at floor level and room center.
2. For a minimum of 12 hours prior to air sample collection, the following preparation procedure was requested of the householder:

DO NOT:

- a. open any windows, fireplace opening or vents
- b. operate ventilation fans
- c. produce smoke by frying or broiling
- d. smoke in the house
- e. paint
- f. use gas stoves, fireplace or any combustion equipment
- g. operate automobile in attached garages
- h. reduce air temperature below 20° (preferably set higher)
- i. operate furnace during sample collection period
- j. make measurements if windspeed is greater than 15 miles/hour (25 Km/hr)
- k. operate air conditioners with less than 100% recirculation

During the course of each air sample collection period, additional information was collected related to the general physical characteristics of the residence, air temperature and relative humidity.

Concentrations of formaldehyde were measured for 2,318 indoor air samples (approximately 2% of the samples are repeat samples) and represent 2,272 separate residential households. The frequency distribution of formaldehyde concentrations is shown by category of residential settings - Table II-VII. A special effort was made to reduce the range of formaldehyde concentrations to the lowest practical increments and to establish the number of samples below the detectable limit of 0.02 ppm. In addition, these increments were selected to show the number and percentage of analysis which were below 0.10 ppm - a concentration sometimes used as a guideline of acceptability for indoor air quality but related only to the level of irritation, below which most persons would not be affected.

COMPLAINT MOBILE HOMES

Table II representing complaint mobile homes shows the highest prevalence and concentrations of formaldehyde of all compared residential categories. The average concentration was found to be 0.18 ppm and is lower than the average reported for studies in Wisconsin and Washington. Forty-one percent of the mobile homes evaluated contained less than 0.10 ppm. A maximum value of 1.61 ppm is indicated.

It is known that emissions or out-gassing of formaldehyde from a particular product containing urea-formaldehyde may decrease as a function of time. For this reason, the age of the mobile home data was compared to the range of formaldehyde concentrations for 161 samples as shown in Table III. The average of the concentration decreases with age interval. However, the range of concentrations for the same interval indicates that values greater than 0.10 ppm may be experienced regardless of age interval.

PERMANENT RESIDENTIAL UFFI HOMES WITH COMPLAINTS

The results of analysis of 1954 air samples in Table IV shows a lower distribution of formaldehyde concentrations to a maximum of 0.49 ppm. While 95% showed the presence of formaldehyde, 86.1 percent were less than 0.10 ppm. The average value for all samples was 0.06 ppm. A preliminary evaluation of foam age versus concentration has shown that reduction of concentration in time is inconsistent. While there is a general overall decrease in average concentrations less than detectable levels (less than 0.02 ppm), values greater than 0.15 ppm may still be experienced in the total range of age available, e.g., less than one year to seven years. It cannot be concluded, however, that this is directly related to degradation of the foam material. Additional sources of formaldehyde since the original installation of urea-formaldehyde foam may be a factor. In addition, structural deterioration resulting in water damage may be a factor in foam degradation.

PERMANENT RESIDENTIAL COMPLAINT HOMES WITHOUT UFFI

The establishment of an indoor air quality program by the department provides for centralized management of reported indoor air problems particularly in residential settings. When complaints could be suspected of being associated with formaldehyde in residential air as related to man-made wood products or other significant consumer products, assistance was provided to the occupant. To January 1, 1984, measurements were made and 153 household air samples were analyzed for formaldehyde. The results of these analyses are shown in Table V. Eleven percent of these residences contained concentrations of less than 0.02 ppm and 89.6% experienced concentrations of 0.10 ppm or less. The maximum value of 2.60 ppm was an extraordinary concentration. This sample was collected at normal temperature (72°F) with no ventilation in a single room enclosed on six sides by interior particle board sheathing within a residential basement area. Generally, this category of residential homes indicates the prevalence of formaldehyde gas in complaint homes without urea-formaldehyde foam.

PERMANENT RESIDENTIAL NON-COMPLAINT HOMES WITHOUT UFFI

During 1983, a limited sampling program was initiated to determine the distribution of formaldehyde concentrations in non-complaint, non-foamed households. Fifty department employees were solicited to participate in this evaluation. The results of these analyses are shown in Table VI. While forty-four percent of these households showed no detectable concentration of formaldehyde, over half indicated the presence of formaldehyde gas to a maximum of 0.11 ppm. Ninety-eight percent of all concentrations were less than 0.10 ppm.

COMPARISON OF FORMALDEHYDE ANALYSIS BY HOUSEHOLD SETTING

The comparisons made in Table VII are not intended to provide conclusions for differently defined residential circumstances. In the absence of appropriate statistically designed studies, the comparisons only suggest the extent to which formaldehyde gas may be prevalent. The data presented suggest that;

1. For complaint residences, mobile homes can be expected to yield higher average concentrations of formaldehyde gas in indoor air than any other category.
2. Complaints associated with indoor air may be related to residences with and without UFFI and formaldehyde gas may have been a contribution.
3. Detectable concentrations of formaldehyde gas from other sources may be expected in non-complaint residences without UFFI.
4. Detectable concentrations of formaldehyde may be expected to be found intermittently if not consistently in residences regardless of the age of a mobile home or UFFI insulated residence.
5. For all 2,318 samples analyzed for all categories 83.5% were less than 0.10 ppm and 6.3% were less than the detection limit of 0.02 ppm.

SUMMARY

It is evident that formaldehyde is widely associated with a large number of industrial and consumer products. Numerous surveys have shown that as a gas, it is prevalent at low concentrations in a variety of indoor air environments at commercial, residential and industrial settings.

Several reports nationally and internationally, have assessed the occurrence of formaldehyde gas within residential places. The evaluation of similar information in New York State indicates that for residential settings formaldehyde is prevalent and persistent in its occurrence. It may be expected that concentrations are generally greater indoors than outdoors. Indoor concentrations found in New York State housing has been observed to be less than concentrations found by other studies.

Until properly designed statistical studies are initiated and completed which address the carcinogenicity and irritant effects at low concentrations with prolonged exposure within residential places, issues regarding formaldehyde gas exposure will continue to be controversial.

REFERENCES

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2. "Formaldehyde - An Assessment of Its Health Effects," Committee on Toxicology, National Academy of Sciences, Washington, D.C., March 1980
3. "Release of Formaldehyde from Consumer Products," Insulation Toxicology Research Institute, Lovelace Biomedical and Environmental Research Institute, Albuquerque, N.M., February, 1982.
4. "Population Exposures to Atmospheric Formaldehyde Inside Residences," SRI International, Project No. EGU-5794, Washington, D.C., January, 1980
5. Unpublished Data, Concentrations of Formaldehyde Gas Within Households in New York State, NYS Department of Health, Albany, 1979-1982.

This presentation entitled, "Prevalence of Formaldehyde Concentrations in Residential Settings" has been based upon a review of the above publications. Any conclusions based on these publications and an evaluation of the analytical results representing household settings are not necessarily the views of the New York State Department of Health.

TABLE I. SUMMARY OF ATMOSPHERIC FORMALDEHYDE CONCENTRATIONS FOUND IN MOBILE AND CONVENTIONAL HOMES

| Monitoring Program | No. of Homes | Average Concentration (ppm) ^a |
|--|--------------|--|
| Wisconsin mobile homes, random sample | 65 | 0.24 |
| Wisconsin mobile homes, complaint sample | 45 | 0.65 |
| Washington mobile homes | 334 | 0.40 |
| Wisconsin foam-insulated conventional houses | 7 | 0.11 |
| Wisconsin "particleboard" conventional houses | 8 | 0.13 |
| Washington UF-insulated | 39 | 0.39 |
| Lawrence Berkeley Laboratory energy-efficient houses | 4 | 0.05 |
| Geomet conventional house-17 samples | 1 | 0.05 ^b |
| Danish conventional houses | 25 | 0.52 |
| Swedish conventional houses | 319 | 0.58 |
| Swiss conventional houses | 3 | 0.06 |
| German conventional houses | 3 | 0.12 |

^a ppm = 1.24 mg/m³ for atmospheric formaldehyde concentrations.

^b Assumes that the indoor formaldehyde constitutes 60% of the total indoor aldehydes.

Source: Population Exposures to Atmospheric Formaldehyde Inside Residences; SRI International for USEPA, January 1980

TABLE II. FREQUENCY DISTRIBUTION OF FORMALDEHYDE GAS IN INDOOR AIR RESIDENTIAL COMPLAINT* MOBILE HOMES WITHOUT UFFI SAMPLING PERIOD, SEPTEMBER 1979 - JANUARY 1984

| Range of Formaldehyde Concentration (ppm) | No. of Mobile Homes Sampled | Percent of Total Mobile Homes | Cumulative Percent |
|---|-----------------------------|-------------------------------|--------------------|
| Less than 0.02** | 8 | 5.0 | 5.0 |
| 0.02 - 0.05+ | 35 | 21.7 | 26.7 |
| 0.06 - 0.09 | 23 | 14.3 | 41.0 |
| 0.10 - 0.14 | 23 | 14.3 | 55.3 |
| 0.15 - 0.19 | 31 | 19.3 | 74.6 |
| 0.20 - 0.24 | 6 | 3.7 | 78.3 |
| 0.25 - 0.29 | 9 | 5.6 | 83.9 |
| 0.30 - 0.39 | 8 | 5.0 | 88.9 |
| 0.40 - 0.49 | 7 | 4.8 | 93.7 |
| 0.50 - 0.59 | 2 | 1.2 | 94.9 |
| 0.60 - 0.69 | 4 | 2.5 | 97.4 |
| 0.70 - 0.79 | 1 | 0.6 | 98.0 |
| 0.80 - 0.89 | 1 | 0.6 | 98.6 |
| 0.90 - 0.89 | 3 | 1.9 | 100.5 |

TOTAL 161 100.5
 Maximum = 1.61 ppm Average = 0.18 ppm

*Complaint means assumed association with formaldehyde exposure, e.g., man-made wood products, carpeting, fabrics, furnishings, etc.

**Includes (2) values of 0.01 ppm

+ Includes (1) value of less than 0.03 ppm

TABLE III. DISTRIBUTION OF FORMALDEHYDE GAS IN INDOOR AIR FOR COMPLAINT MOBILE HOMES BY AGE OF STRUCTURE SAMPLING PERIOD, SEPTEMBER 1979 - JANUARY 1984

| Age Range (MOS.) | No. of Air Samples | Average Concentration (ppm) | Range Concentration (ppm) | No./Percent of Samples | | |
|------------------|--------------------|-----------------------------|---------------------------|------------------------|---------------|-----------------------|
| | | | | LT 0.02 (ppm) | LT 0.10 (ppm) | 0.10 OR GREATER (ppm) |
| 1-12 | 35 | 0.28 | | | | |
| 13-24 | 21 | 0.31 | 0.02-0.92 | 0/0% | 3/9% | 32/91% |
| 25-36 | 14 | 0.20 | 0.31-0.83 | 0/0% | 3/14 | 18/86 |
| 37-48 | 13 | 0.20 | 0.11-0.43 | 0/0% | 0/0 | 14/100 |
| 49-60 | 7 | 0.13 | 0.02-0.29 | 0/0% | 3/23 | 10/77 |
| 61-72 | 7 | 0.15 | 0.04-0.43 | 0/0% | 2/29 | 5/71 |
| 73-84 | 5 | 0.08 | 0.01-0.22 | 2/29% | 4/57 | 3/43 |
| GT-84 | 46 | 0.06 | 0.04-0.09 | 0/0% | 5/100 | 0/0 |
| | | 0.05 | 0.01-0.17 | 6/13 | 40/87 | 6/13 |
| TOTAL | 148 | 0.17 | 0.01-0.92 | 8/5 | 60/41 | 88/59 |
| UNKNOWN AGE | 13 | 0.29 | 0.02-1.61 | 0/0 | 6/46 | 7/54 |

LT - Less Than

MOS. - Months

TABLE IV. FREQUENCY DISTRIBUTION OF FORMALDEHYDE GAS IN INDOOR AIR PERMANENT RESIDENTIAL UFFI HOMES WITH COMPLAINTS* SAMPLING PERIOD, SEPTEMBER 1979 - JANUARY 1984

| Range of Formaldehyde Concentration (ppm) | No. of Homes Samples | Percent of Total Homes | Cumulative Percent |
|---|----------------------|------------------------|--------------------|
| Less than 0.02** | 100 | 5.1 | 5.1 |
| 0.02 - 0.05+ | 1015 | 51.9 | 57.0 |
| 0.06 - 0.09 | 568 | 29.1 | 86.1 |
| 0.10 - 0.14 | 192 | 9.8 | 95.9 |
| 0.15 - 0.19 | 41 | 2.1 | 98.0 |
| 0.20 - 0.24 | 25 | 1.3 | 99.3 |
| 0.25 - 0.29 | 7 | 0.4 | 99.7 |
| 0.30 - 0.39 | 4 | 0.2 | 99.9 |
| 0.40 - 0.49 | 2 | 0.1 | 100.0 |

TOTAL 1954 100.0

Maximum = 0.49 ppm Average = 0.06 ppm

*Complaint means assumed association with formaldehyde gas exposure

**Includes the following values - two at less than 0.01 ppm

+Includes (2) values of less than 0.05 ppm

TABLE V. FREQUENCY DISTRIBUTION OF FORMALDEHYDE GAS IN INDOOR AIR PERMANENT RESIDENTIAL COMPLAINT* HOMES WITHOUT UFFI SAMPLING PERIOD MAY, 1981 - JANUARY 1984

| Range of Formaldehyde Concentration (ppm) | No. of Homes Samples | Percent of Total Homes | Cumulative Percent |
|---|----------------------|------------------------|--------------------|
| Less than 0.02 | 17 | 11.1 | 11.1 |
| 0.02 - 0.05 | 91 | 59.5 | 70.6 |
| 0.06 - 0.09 | 29 | 19.0 | 89.6 |
| 0.10 - 0.14 | 8 | 5.2 | 94.8 |
| 0.15 - 0.19 | 3 | 2.0 | 96.8 |
| 0.20 - 0.24 | 1 | 0.7 | 97.5 |
| 0.25 - 0.29 | 1 | 0.7 | 98.2 |
| 0.30 - 0.39 | 1 | 0.7 | 98.9 |
| Greater than 0.9 | 2 | 1.3 | 100.2 |

TOTAL 153 100.2

Maximum = 2.60 ppm Average = 0.38 ppm

*Complaint means assumed association with formaldehyde exposure, e.g., man-made wood products, carpeting, fabrics, furnishings, etc.

**Includes one value of 0.01 ppm

TABLE VI. FREQUENCY DISTRIBUTION OF FORMALDEHYDE GAS IN INDOOR AIR PERMANENT RESIDENTIAL NON-COMPLAINT* HOMES/APARTMENTS WITHOUT UFFI SAMPLING PERIOD FEBRUARY THROUGH APRIL, 1983

| Range of Formaldehyde Concentration (ppm) | No. of Household Samples | Percent of Total Households | Cumulative Percent |
|---|--------------------------|-----------------------------|--------------------|
| Less than 0.02 | 22 | 44.0 | 44.0 |
| 0.02 - 0.05 | 22 | 44.0 | 88.0 |
| 0.06 - 0.09 | 5 | 10.0 | 98.0 |
| 0.10 - 0.14 | 1 | 2.0 | 100.0 |
| TOTAL | 50 | 100.0 | - |

*Non-Complaint consisted of NYS Dept. of Health Employees' Households

Maximum Value 0.11 ppm

Average Value 0.03 ppm

TABLE VII. COMPARISON OF INDOOR AIR SAMPLES ANALYZED FOR FORMALDEHYDE GAS BY HOUSEHOLD SETTING FOR CONCENTRATIONS LESS THAN 0.02 PPM AND LESS THAN 0.10 PPM

| Household SETTING | Total No. of Samples in Households | No. of Samples Less Than 0.02 | % of Total | No. of Samples Less Than 0.10 | % of Total |
|-----------------------------|------------------------------------|-------------------------------|------------|-------------------------------|-------------|
| Permanent Residences | | | | | |
| Complaint with UFFI | 1954 | 100 | 5.1 | 1683 | 86.1 |
| Complaint without UFFI | 153 | 17 | 3.3 | 137 | 89.5 |
| Non-Complaint without UFFI | 50 | 22 | 44.0 | 49 | 98.0 |
| Mobile Homes | | | | | |
| Complaint without UFFI | 161 | 8 | 5.0 | 66 | 41.0 |
| TOTAL | 2318 | 147 | 6.3 | 1935 | 83.5 |

IRRITANCY LEVELS AND FORMALDEHYDE EXPOSURES IN U.S. MOBILE HOMES

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Abstract

Residents of mobile homes in Wisconsin, Minnesota, and Washington states complaining of "formaldehyde" problems in their homes participated in health studies conducted by state personnel. The formaldehyde levels in the homes were determined using impinger collection tubes and the NIOSH approved chemical analysis method. The residents completed questionnaires detailing the spectrum of their symptoms. Data analysis was performed by classifying residents by the level of formaldehyde detected in their homes (grouped in 0.5 ppm intervals). For each symptom, the proportion of residents in each exposure group reporting that symptom was calculated. No pattern of increasing prevalence of symptoms with increasing level of formaldehyde was observed over the range of 0 to more than 2 ppm, with the possible exception of an increased prevalence of eye complaints in the Minnesota study. Symptom prevalences at exposures of greater than 1.5 ppm were generally no different than prevalences at 0-0.5 ppm. Further, exposure levels in mobile homes of complainants did not differ from those in randomly chosen mobile homes, after adjusting the data for the age of the home, based on data from a Wisconsin study. Symptoms appear to be no more frequent among residents with higher levels of formaldehyde exposure than among those with lower levels, and residents complaining of symptoms appear to have no greater level of exposure than do residents not complaining. Thus, it is not clear that mobile home residents with upper respiratory symptoms have those symptoms from these levels of formaldehyde exposure.