

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
<b>TOTAL</b>	<b>50</b>	<b>100.0</b>	<b>-</b>

\*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
<b>Permanent Residences</b>					
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
<b>Mobile Homes</b>					
Complaint without UFFI	161	8	5.0	66	41.0
<b>TOTAL</b>	<b>2318</b>	<b>147</b>	<b>6.3</b>	<b>1935</b>	<b>83.5</b>

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



Lamm, S.H.  
 Consultants in Epidemiology  
 & Occupational Health, Inc.,  
 Washington, D.C. 20007

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.

## Introduction

Detectable levels of formaldehyde have been suspected as the cause of symptoms of upper respiratory irritation among residents of mobile homes ever since Breyse first proposed the hypothesis in his 1977 report from Washington state (1). Wide scale dissemination of this report by the United States media lead to numerous individual complaints and inquiries to state health departments and public requests for assessments of formaldehyde levels in mobile homes. A number of state health departments began to collect data informally as the number of complaints and inquiries increased. A few state health departments developed more formal reports. Data collected by the health departments included: formaldehyde levels inside the homes using the impinger method, the age of the home at the time of study, and information on the nature of the health complaints of the residents.

The original Breyse data from Washington, and the reports of the health departments of the states of Wisconsin and Minnesota provide a data base that allows assessment for a dose-response relationship and an analysis of factors influencing any association between exposure levels and symptoms. The data in this study came primarily from the report (2) by Geomet, Inc. and Technology and Economics, Inc. (T&E) under contract to the U.S. Department of Housing and Urban Development. The original investigators have presented their data at various public hearings and have published them in part in the references cited.

### Data Base

For the Washington State Health Department, Breyse (1) had investigated 187 mobile homes over a period of two years. Data included the age of the home; the formaldehyde level (measured in ppm) in the bedroom, the kitchen, and often another room; and a list of the specific symptoms reported by each occupant. The investigated mobile homes were generally examined within two years of their construction. The average formaldehyde level was 0.6 ppm, with the formaldehyde level inversely related to the age of the mobile home. Symptoms reported included irritation of the eyes, nose, and respiratory tract, headache, nausea and drowsiness.

The Minnesota State Health Department (3) reported data from 109 mobile homes sampled over a 9 month period following the department's educational programs instituted to inform physicians and the public about potential formaldehyde symptoms. Data included age of the mobile home, measured level of formaldehyde, and symptoms reported on a detailed questionnaire. The average age of the sampled mobile homes was less than 2 years, and the average formaldehyde level was less than 0.4 ppm. The formaldehyde levels were inversely related to the age of the mobile homes.

The Wisconsin State Health Department has reported two separate studies. The first study (4) investigated the formaldehyde levels in 65 mobile homes whose residents had complained to the state health department. The average age of the homes was under 2 years. The average formaldehyde level was 0.66 ppm, with a standard deviation of 0.65 ppm. Again, the formaldehyde level was inversely related to the age of the home. Complete investigations tended to be limited to those mobile homes where the symptoms, based on preliminary telephone information, were believed to be most likely related to formaldehyde. Symptom prevalences for the 162 residents of the investigated homes ranged up to 59% for burning eyes and to 67% for eye irritation.

The Wisconsin State Health Department also conducted an EPA-financed study (5) in which formaldehyde levels were measured in 65 randomly selected mobile homes in registered mobile home parks. The average age of the randomly selected mobile home was 6 years. The average formaldehyde level was 0.24 ppm, with a standard deviation of 0.23 ppm. As in the previous studies, the formaldehyde level was inversely related to the age of the home. These four studies provide the data base for the analysis presented in this report.

### Analysis: Distribution of Exposure Levels by Age of Home (Comparative Exposure)

Residents of mobile homes in Wisconsin, Minnesota, and Washington who complained of "formaldehyde" problems in their homes participated in health studies conducted by state health departments. In these three studies, the average formaldehyde exposure measurement ranged from about 0.4 - 0.7 ppm. The average age of the home was less than 2 years old.

In contrast, a study of randomly selected mobile homes from registered mobile home parks in Wisconsin reported an average level of 0.24 ppm and an average age of the home of over 6 years. In all four studies, the level of formaldehyde was inversely related to the age of the home.

Previous analyses of each individual study have included as analytic variables only the presence of symptoms and the level of exposure. These analyses have generally not considered as significant variables either the age of the home or the specific nature of the symptoms. However, each of the above data sets demonstrated that the formaldehyde level was inversely related to the age of the home (2). Wisconsin specifically reported that the log of the age of the home was the best environmental parameter for predicting formaldehyde levels in mobile homes (5). Other analyses have not taken that observation into consideration. Self-selection

as a complainant to the health department may reflect the recency of purchasing a new mobile home, rather than just its formaldehyde level. Attribution of complaints to the formaldehyde level alone may ignore confounding by the relationship of formaldehyde level to the age of the home. This possibility is examined graphically in Figures 1 to 3. Additionally, some yet unstudied factor, independent of formaldehyde level and associated with new mobile homes, may affect the health of the residents of new mobile homes.

Data from the two studies performed by the Wisconsin State Health Department are shown in Figure 1. Each data point indicates the level of formaldehyde measured and the age of a mobile home at the time of the sampling. The open circles represent the randomly selected homes, and the solid circles represent the complainants' homes. The solid line marks the 95% upper bound confidence limit for the random mobile homes within 2.5 year intervals. For the most part, the exposure levels in complainants' mobile homes do not appear to differ from those in randomly selected mobile homes of the same age. Only three recently constructed homes with formaldehyde exposure levels recorded at 1.5 ppm or higher stand out as exceptions.

The age distributions of random homes and complainants' homes are considerably different. 80% of the complainants' homes, but only 20% of the random homes were less than two and a half years old. Random selection of mobile homes was based upon the registry of mobile home residential parks, parks that were established years ago and tended to be occupied by mobile homes that have been there for many years. Recently constructed homes are more likely to be placed on private land already owned or used by the owner. Thus, random sampling of homes in residential parks led to an under-sampling of newer homes and an over-sampling of older homes.

The average exposure level in complainants' homes (0.66 ppm) is greater than that of the random homes (0.21 ppm). These averages reflect both the age distribution differences of the groups and the effect of a few higher measurements. The median exposure levels for both the random and the complainants' homes stratified by age of home (less than or greater than or equal to 2.5 years old) are the same, as shown in Table 1.

TABLE 1

Median Formaldehyde Concentration In Wisconsin Mobile Homes

<u>Age of Home</u>	<u>Random Homes</u>	<u>Complaint Homes</u>
< 2.5 years	0.6 ppm	0.6 ppm
> 2.5 years	0.3 ppm	0.3 ppm

It is seen that, within each age range of the two groups, the median exposures are the same for complainants' homes and randomly selected homes. Comparison of exposure measurements in each group for homes of the same age can adjust for the differences in sampling. Therefore, the 95% upper bound confidence limit from the Wisconsin random study of mobile homes is shown. Most of the exposure measurements in homes of complainants fall within the range expected from the random comparison group.

The formaldehyde exposure data from the mobile homes studied in the states of Minnesota and Washington, respectively, are shown in Figures 2 and 3. All measurements are from homes of complainants. No comparison group was used in either state. Thus, the results of the Wisconsin random sampling are the only comparison data available. For each figure, the 95% upper bound confidence limit from the Wisconsin random study of mobile homes is shown. The results are similar to the Wisconsin complaint homes data. Most of the exposure measurements from these states fall within the range expected from the comparison study; although there are some higher values among the complaint homes that stand out as being greater than those in the random homes.

Dose-Effect Relationship

If specific complaints of mobile home residents are the result of a dose-effect relationship for formaldehyde exposure documented in the home, one would expect (a) that the levels of formaldehyde would be greater in mobile homes where residents complained of irritative symptoms than in mobile homes where residents did not allege increased symptoms and (b) that, in homes where increased symptom occurrence was alleged, the frequency of specific symptom complaints would be greater in homes with higher measured levels of formaldehyde than in homes with lower levels present. Analyses of the data from studies conducted on behalf of various state governments do not yield the predicted findings.

The symptom data from the Minnesota and Washington studies were given for each mobile home examined along with the measured exposure level. Thus, these data could be analyzed to determine whether the complaint frequency for each symptom increased with increasing exposure level.

Symptom prevalence data by exposure level for the Minnesota and Washington studies are presented in Figure 4. There appears to be little evidence of a dose-effect relationship. Generally, the symptom prevalences for complainants with higher exposures appear to be no greater than those for the total reported complainant population. Eye complaints appear to increase with exposure level in the Minnesota data, but to decrease with exposure level in the

Washington data. That eye complaints was the most frequently reported symptom in both states may be of significance or may reflect a selection bias upon which complaints were accepted for inclusion within the study. Wisconsin has reported a positive dose-effect relationship only for eye symptoms (5).

Nasal symptoms appear to increase with exposure up to 1 ppm, and then decrease. Little can be made of these individual fluctuations, but the general pattern is that specific symptom prevalences do not appear to have increased with exposure levels over the range studied. There is, however, little data at the higher levels of exposure.

#### Conclusion

The data in the Wisconsin, Minnesota, and Washington studies have been analyzed to examine both the formaldehyde exposure levels of random mobile homes and those of complainants and the relationship of those formaldehyde exposures to the prevalence of a variety of symptoms. Analysis shows that the formaldehyde level reflects the age of the mobile home and is similar in similarly aged homes of complainants and homes randomly selected. Further, specific symptom prevalences among the complainants does not appear to be related to the specific formaldehyde levels measured. It appears unlikely that formaldehyde, as measured in these homes, is the cause of the symptoms reported. The possibility that some other factor in new mobile homes may induce increased symptom reporting by residents cannot be ruled out at this stage.

Similar symptom complaints made by occupants of modern energy-efficient buildings where formaldehyde levels are not elevated have been labeled "Tight Building Syndrome." It may be more appropriate to consider symptom complaints of mobile home residents as a special case of the "Tight Building Syndrome" rather than as a special case of a formaldehyde problem.

#### References

1. Breyse PA. Formaldehyde in Mobile and Conventional Homes. University of Washington Environmental Health & Safety News 1977; 26:1-6.
2. Geomet, Inc. and Technology & Economics, Inc. Mobile home research: An evaluation of formaldehyde problems in residential mobile homes. U.S. Department of Housing and Urban Development Contract H1505, April 1980.
3. Garry VF, Oatman L, Pleus R, Gray D. Formaldehyde in the home: Some environmental disease perspectives. Minnesota Medicine 1980; 63:107-111.
4. Dally KA, Hanrahan LP, Woodbury MS. Formaldehyde exposure in non-occupational environments. Arch Environ Health 1981; 36(6):277-284.
5. Anderson HA, Dally KA, Hanrahan LP, Eckmann AD, Kanarek MS, Rankin J. The epidemiology of mobile home formaldehyde vapor concentration and residents' health status. U.S. EPA Contract CS806856-01-3, February 1983.

### FORMALDEHYDE LEVELS IN WISCONSIN COMPLAINT & RANDOM MOBILE HOMES BY AGE OF MOBILE HOME

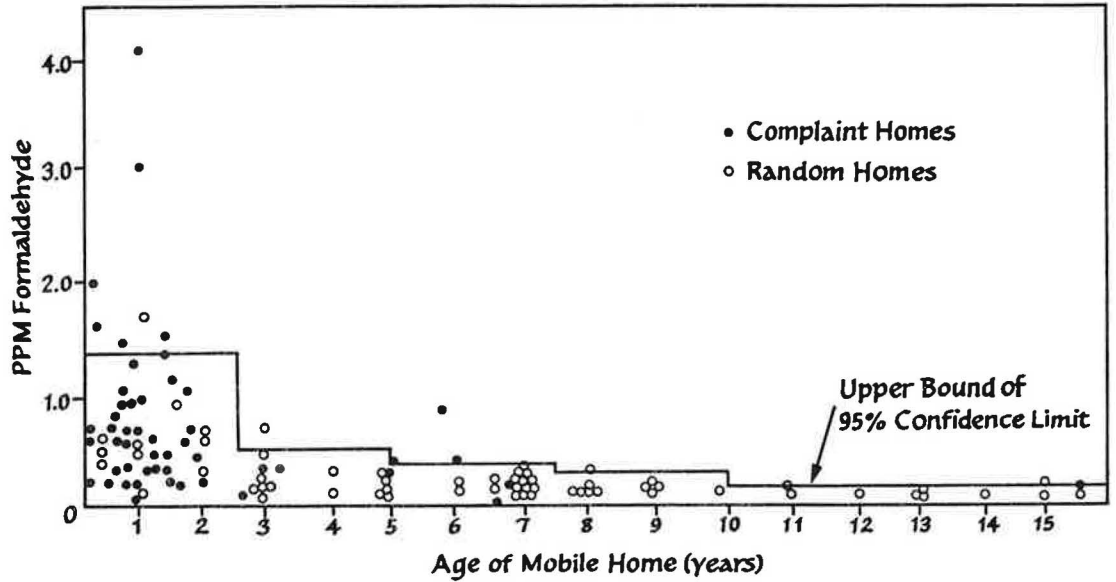
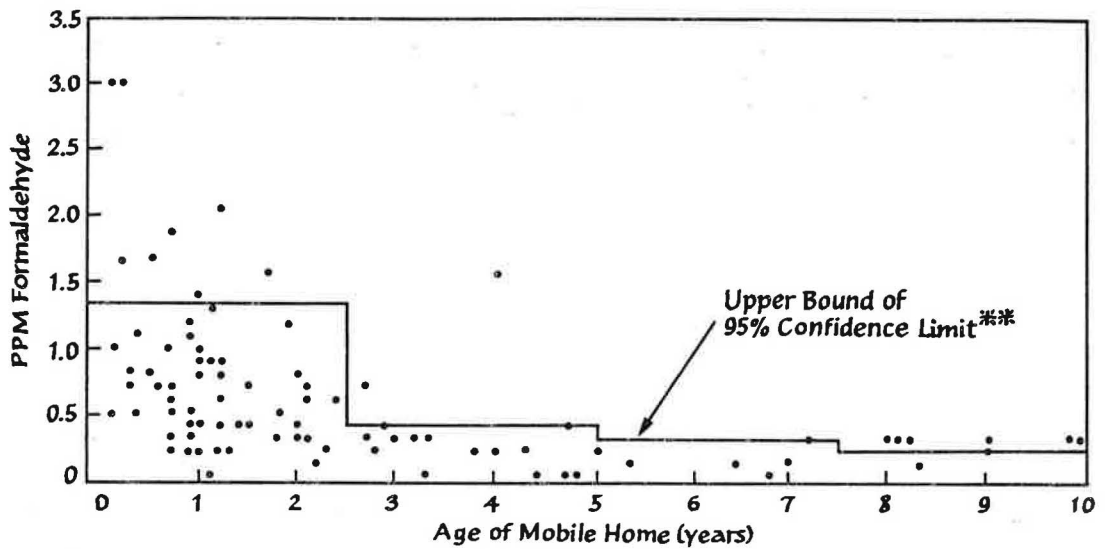


Figure 1

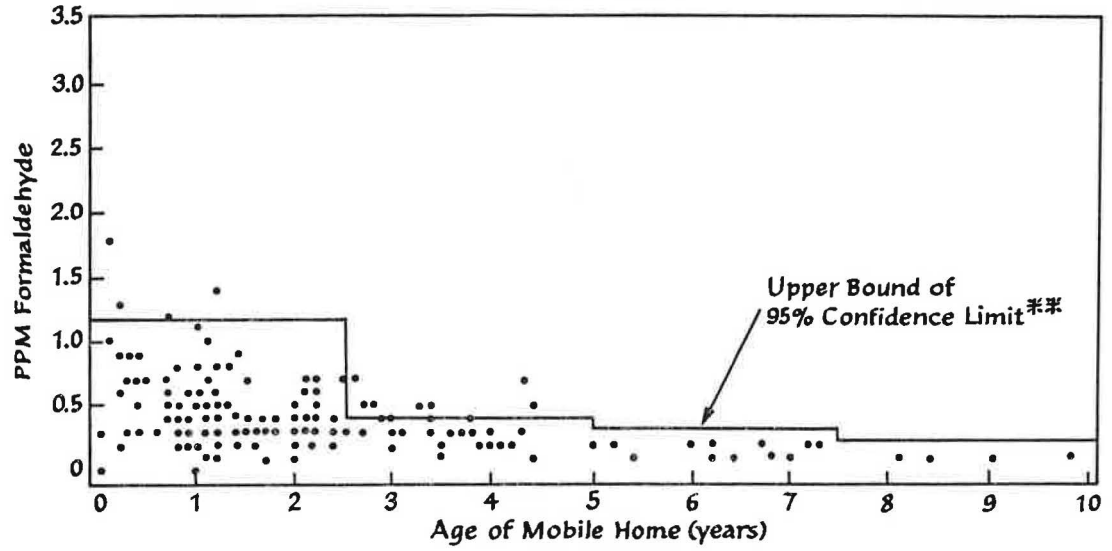
### FORMALDEHYDE LEVELS IN MINNESOTA COMPLAINT MOBILE HOMES BY AGE OF MOBILE HOME\*



\*After GEOMET (1980)  
\*\*Based on Wisconsin Random Mobile Homes

Figure 2

## FORMALDEHYDE LEVELS FROM WASHINGTON COMPLAINT MOBILE HOMES BY AGE OF MOBILE HOME\*

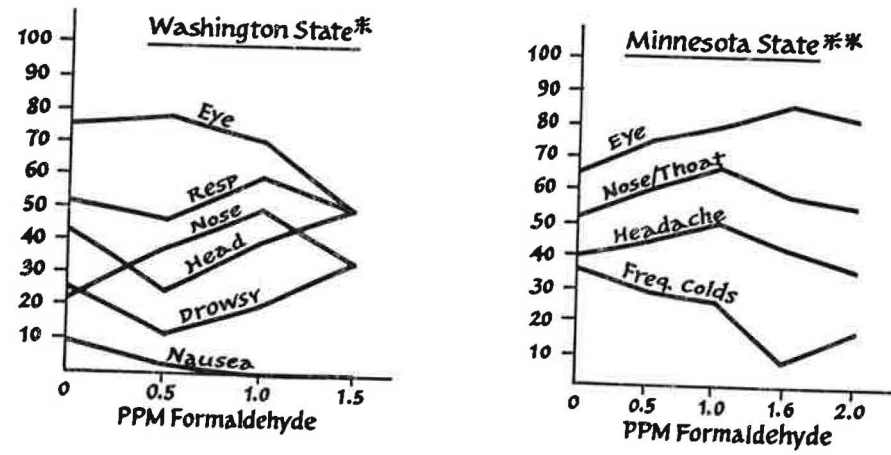


\*After GEOMET (1980)

\*\*Based on Wisconsin Random Mobile Homes

Figure 3

## SYMPTOM PREVALENCES FOR RESIDENTS OF COMPLAINT MOBILE HOMES WITH EXPOSURE REPORTED AT GREATER THAN GIVEN FORMALDEHYDE LEVEL



\* Modified from Breysse (1977)  
\*\* Calculated from data in GEOMET Report (1980)

Figure 4