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Summary

A historical prospective mortality study of 82 workers exposed to PCB's in their manufacture from 1945-1966 at Monsanto's W. G. Krummrich plant failed to reveal any causes of death, including malignant neoplasms, which were significant. Observed deaths were compared with expected deaths from the U.S. standard population and the St. Clair County population. The observations were based on somewhat small numbers, but the study does not support the carcinogenicity of PCB's in the liver, lung, pancreas, or skin.

A HISTORICAL PROSPECTIVE MORTALITY STUDY OF WORKERS EXPOSED TO POLYCHLORINATED BIPHENYLS

Background

The term "polychlorinated biphenyls" (PCB's) describes a group of theoretically two hundred nine different chlorinated biphenyls which, in mixtures, vary in consistency from oils to sticky resins in direct relation to the degree of chlorination of the phenyl rings. PCB's are manufactured by the chlorination of biphenyl with anhydrous chlorine in the presence of a ferric chloride or iron filing catalyst.

Mixtures of PCB's have been in use since 1929 in transformers, capacitors, lubricants, "carbonless" duplicating paper, fireproof sealants, plastics, adhesives, and many other products. Their resistance to biodegradation, photodegradation, oxidation, acids, bases, and other chemical agents made PCB's invaluable in scores of industrial uses.

However, these properties also make PCB's more stable as residual pollutants when released into the environment. Current interest in PCB's began in the mid-1960's, when technological developments in gas chromatography and mass spectrometry made environmental detection of low PCB levels possible. The first report of PCB's in the environment came from Sweden, where Jensen identified residues of PCB's in fish from various Swedish waters.[1] Risebrough et al found PCB's and DOT in marine ecosystems of the Pacific Ocean.[2] Detectable levels of PCB's were also found in 8 out of 39 human milk samples in rural Colorado.[3]

The first report of possible PCB effects on humans occurred in 1968, when over 1,200 Japanese were involved in an epidemic of Yusho, an acnelike skin disease which was later traced to the consumption of a rice-oil contaminated with PCB's from a leaking heat-exchange unit. However, it was later shown that the rice oil also contained a high level of polychlorinated dibenzoferrans (PCDF's), possibly due to the high temperature of the heat exchange unit. PCDF's were shown to be relatively more concentrated in the liver than PCB's, and these findings clearly indicated the necessity to pay greater attention to PCDF's for clarification of the nature of Yusho.[4]

While acute effects from relatively high PCB exposure levels are known and can be avoided by appropriate control measures, attention has more recently been focused on the chronic effects resulting from long-term low levels of exposure to PCB's. The Environmental Protection Agency considers PCB's to be suspect carcinogens, but animal tests have not given any definitive answer to their suspicions. In extensive two-year chronic oral toxicity tests of Aroclor 1242, 1254, and 1260 (42, 54, and 60 chlorinated Monsanto PCB products) conducted by Industrial Biotests for the Monsanto Company, no carcinogenic effects were observed in the rats and beagles tested. Hyperplasia, hypertrophy, and several benign tumors were observed in the livers of the rats, but there was no evidence of malignancy in any of the test animals.

Other investigators have shown liver tissue effects ranging from hyperplasia to well-differentiated hepatocellular carcinomas in rats or mice fed with various PCB-containing diets. For example, Kimbrough et al

fed rats with Aroclor 1254 and 1260, and observed hypertrophy, lipid accumulation, and adenofibrosis, but no malignancies, in the livers of the test animals.[5] In a later experiment the same investigator fed Sherman rats 100 ppm of Aroclor 1260 for 21 months and reported the induction of hepatocellular carcinomas and neoplastic nodules in the test animals' livers, whereas control animals showed little or no effects.[6]

The recent National Cancer Institute report of its carcinogenicity tests on Aroclor 1254 concluded that the substance was not carcinogenic in Fischer 344 rats under the conditions of the bioassay. However, their study was not definitive, since they alluded to the non-significant occurrence of gastrointestinal tract carcinomas and hepatocellular proliferative lesions in their test animals as possibly being related to the PCB-containing diet.[7]

There have been very few epidemiological studies of human populations exposed to low levels of PCB's over a long period of time. The Mobil Oil Company released a study in 1976 conducted by Dr. Anita Bahn in which a significant number of melanomas and pancreastic cancers were found in PCB-exposed chemical workers and research personnel. However, the study has been severely critized due to deficiencies in the identification of the study cohort, failure to identify other potentially carcinogenic chemical exposures, and other problems which left the results of the Mobil study highly in doubt.[8]

A preliminary study of PCB-exposed workers was begun at the Monsanto Company shortly after the Mobil study in response to the need for a valid epidemiological study of the chronic effects of PCB exposure on humans. The study focused on workers at the W. G. Krummrich plant in Sauget, Illinois, where PCB's were manufactured from 1936 until production ceased in 1977. This preliminary study failed to support the Mobil study results. No melanomas or pancreatic cancers were found, but an excess occurrence of lung cancer deaths was found in the study cohort. However, due to the preliminary nature of the study, no follow-up was done on over 30% of the study cohort who had left the company, and further definition of the exposed population was needed.

The study being reported here is an attempt to complete the epidemiological evaluation of the worker population at Monsanto's W. G. Krummrich plant, and evaluate the chronic effects of PCB-exposure on humans. The mortality experience of workers exposed to PCB's in their manufacture has been followed and evaluated.

Study Population

The Monsanto plants involved in United States manufacture of PCB's were the W. G. Krummrich plant in Sauget, Illinois, and the Anniston, Alabama plant. Since the preliminary study, upon which this study is based, involved the Krummrich plant alone, the present study deals solely with the Krummrich worker population.

The study population from the Krummrich plant consists of all male, waged employees who worked at least six months in department 246 - where PCB's were manufactured between January 1, 1945 and December 31,1965. This population includes active, retired, and terminated employees. Through interviewing plant personnel, it was determined that exposure levels of workers involved in PCB manufacture did not vary considerably; therefore, all male, waged workers in department 246 are considered to have a common exposure level.

Methodology

Work histories for all past and present Krummrich employees were obtained from the plant and screened for department 246 work. In order to verify the completeness of this search, two other sources were researched. Interviews were conducted with supervisory personnel from department 246 and any names which they recalled were recorded. After this, a plant developed computer listing of all department 246 workers was obtained, and the results of the work history search and plant interviews were crosschecked with the computer listing in order to insure completeness of the cohort. It should be noted that some workers, e.g., maintenance and salary, may have had significant exposures to PCB's, but were not included in this study due to exposure verification difficulties.

By using these methods of identification, 82 male, waged workers (57 white, 25 non-white) were identified as meeting the criteria for inclusion in the study cohort. For each worker, the following information has been obtained from company records: employee name, clock number, social security number, race, sex, date of birth, date of hire, date of termination (if applicable), and as detailed a work history as was available. The employment and vital status information on the 82 workers is shown in Table 1.

Vital status information was obtained by use of standard follow-up techniques such as worker interviews, Veteran's Administration files, Polk City Directories, and local telephone directories. All active employees and retirees currently receiving pension checks as of December 31, 1977, were assumed to be alive, and all persons known to have died on or after January 1, 1978, were assumed to be alive for the purposes of this study. For the 28 workers known to have died, a state death certificate has been obtained and coded by an experienced, trained nosologist for the underlying cause of death according to the International Classification of Diseases, Seventh Revision.

Results

Person-years of observation contributed by each worker was determined over five-year age and time intervals and summed for the total cohort. The mortality experience of the PCB-exposed study group was compared to the age, sex, race, and time-specific death rates of the standard United States population using the method of indirect standardization. The expected cancer deaths generated by this method were also adjusted to reflect the cancer mortality experience of St. Clair County (in which most of the Krummrich workers reside) by use of data found in U.S. Cancer Mortality by County:1950-69.

A standard mortality ratio (SMR) was calculated by the following formula:

$$SMR = \frac{\text{Observed Deaths (By Cause)}}{\text{Expected Deaths (By Cause)}} \times 100$$

Statistical significance of the SMR's was measured by the Mantel-Haensycl chi-square statistic:

$$\frac{(\left|\sum \text{Observed} - \sum \text{Expected}\right| - 0.5)^2}{\sum \text{Expected}}$$

The Poisson assumption is made in computing this statistic - the variance and mean of the expected are assumed to be equal.

The observed deaths by cause and the SMR's associated with each disease category are shown in Table 2. Twenty-eight deaths were observed among the 82 members of the study cohort. The average exposure to PCB's in department 246 for the 28 deceased workers was 33.6 months (vs. 34.8 months for the 54 living). The average age at death was 57.0 years, and the average time between first exposure to PCB's and death was 17.5 years. SMR values for the causes of death listed are not significant at the .05 level. The only category approaching significance was "all malignant neoplasms" in the comparison of observed deaths vs. expected (U.S.) deaths. However, St. Clair County's expected deaths are higher than U.S. experience, so that the county-adjusted SMR is decreased from 206.5 to 190.3.

Tables 3 and 4 summarize the mortality experience of white and nonwhite males, respectively. Seventeen deaths were observed among the 57 white male workers. The average age at death was 59.2 years. These workers were exposed an average of 36.0 months (vs. 37.2 months for the 40 living whites), and lived an average of 20.8 years after their first exposure to PCB's in department 246. As in the case of all males (Table 2), no cause of death category showed significance at the .05 level. The high SMR's in the "all other cancers" category resulted from an observed-expected distribution of 2-0.398 (U.S.) and 2-0.378 (St. Clair). The two observed cancers in this category were a generalized carcinomatosis (ICD 199) and a malignant neoplasm of the lung specified as secondary (ICD 165) with no primary site listed. The high SMR's for this category are not significant at the .05 level, and the numbers involved are too few to draw any definitive conclusions.

Table 4 outlines the mortality experience of the nonwhite male subset of the study cohort. There were 11 deaths among the 25 nonwhite study members. The average age at death was 53.5 years, with an average of 12.3 years between first PCB-exposure and death. The 11 deceased workers were exposed an average of 30.0 months (vs. 28.8 months for the 14 living). One category, lymphatic and hematopoietic system cancers, showed significance at the .05 level, and this category only showed 1 observed death. The category of "all malignant neoplasms" had an excess number of deaths which was not significant at the .05 level. As in most of the causes of death in Table 4, the numbers involved are too small to draw conclusions about health effects of PCB's from the SMR values of this table.

Discussion

The workers involved in this study are unique in that they represent the largest cohort available in the United States who were exposed to PCB in its manufacture. However, these workers were also exposed to other chemicals in the process of manufacturing PCB, such as hydrochloric acid fumes, trichlorobenzene, tetrachlorcbenzene, biphenyl, and small amounts of chlorine gas. Furthermore, all of the workers were exposed to other chemicals during their employment at the plant, such as oil additives, dyes, rubber additives, benzene, toluene, aniline, etc. The smoking, drinking, and prior work histories of the study cohort is also unknown. Therefore, in evaluating the effects of PCB's among

workers exposed to these compounds, the investigator must consider not only PCB exposure, but also a host of other potentially harmful agents.

Another factor to consider is the route of entry into the body. The workers' main exposure to PCB's was through skin absorption, since PCB's have relatively low vapor pressures. However, most of the chronic animal testing involved low dose ingestion studies, and environmental contaminants which enter the food chain would ultimately be ingested by man. It is unknown whether long-term, low dose PCB ingestion and long-term, low dose PCB skin absorption in humans can be considered as equivalent phenomena in terms of the potential health effects.

With these factors in mind, results from the analysis of the mortality experience of the PCB-exposed workers indicate no statistically significant excess in either total mortality or deaths due to almost all of the other categories - including malignant neoplasms. The results of this study do not support the Mobil study in which melanomas and pancreatic cancers were associated with PCB exposure, nor do the results uphold translating to man the outcome of animal tests, in which hepatomas have been associated with long-term PCB exposure. In the study cohort, the only digestive system cancer which occurred was a cancer of the colon which was diagnosed in a nonwhite study member.

The significant excess of lung cancer observed in the preliminary Monsanto study is not supported by this study. While 3 respiratory cancer deaths were observed and 1.3 to 1.6 were expected, the difference is not statistically significant, and other factors, such as cigarette smoking, would have to be taken into account.

It is important, however, to note that the small size of the study cohort could have prevented the detection of infrequent conditions which had increased in probability of occurrence due to the PCB exposure. A larger sample size would have increased the likelihood of identifying such a condition. However, since this worker population is probably one of the largest occupationally-exposed groups which has been identified and completely followed-up on, the ongoing concern regarding PCB's as possible human carcinogens warrants the continued follow-up of this group's mortality experience. The results of this study, while not conclusive in denying PCB as a health hazard, do fail to support other studies which had internal design problems, and put PCB's in a better perspective in terms of their effects on human health.

TABLE 1

Follow-up Status of Workers Exposed to PCB's

1.	Still Employed	22
2.	No Longer Employed	60
	a. Alive, Employed Elsewhere	10
	b. Alive, Retired	22
	c. Deceased	28

TABLE 2

SMR's Among All Males (n = 82) for Selected Causes of Death

Cause	ICD Code 7th Revision	Observed	SMR	County-Adjusted SMR
All Deaths		28	134.0	
All Malignant Neoplasms	140-205	8	206.5	190.3
Buccal Cavity and Pharynx	140-148	0	-	-
Digestive Organs and Peritoneum	150-159	1	88.8	81.0
Respiratory System	160-164	3	231.5	189.8
Genito-Urinary Tract	177-181	1	236.4	250.0
Lymphatic and Hematopoietic Tissue	200-205	1	326.8	341.3
All Other Cancers		2	346.0	367.0
Vascular Lesions of CNS Circulatory System Diseases	330-334 400-468	14	136.9	
Respiratory System Diseases	470-527	0	-	
Digestive System Diseases	530-587	2	178.9	
All External Causes	800-998	1	233.0	
Other+		3	133.0	

+"Other" ICD codes are all those not listed above.

TABLE 3

SMR's Among White Males (n = 57) for Selected Causes of Death

Cause	ICD Code 7th Revision	Observed	SMR	County-Adjusted SMR
All Deaths		17	134.8	
All Malignant Neoplasms	140-205	4	165.5	146.4
Buccal Cavity and Pharynx	140-148	0	-	-
Digestive Organs and Peritoneum	150-159	0	-	-
Respiratory System	160-164	2	241.1	184.2
Genito-Urinary Tract	177-181	0	-	-
Lymphatic and Hematopoietic Tissue	200-205	0	-	-
All Other Cancers		2	502.8	529.1
Vascular Lesions of CNS Circulatory System Diseases	330-334 400-468	10	158.1	
Respiratory System Diseases	470-527	0	-	
Digestive System Diseases	530-587	1	137.2	
All External Causes	800-998	0	-	
Other[+]		2	187.7	

[+]"Other" ICD codes are all those not listed above.

TABLE 4

SMR's Among Non White Males (n = 25) for Selected Causes of Death

Cause	ICD Code 7th Revision	Observed	SMR	County-Adjusted SMR
All Deaths		11	132.9	
All Malignant Neoplasms	140-205	4	274.5	271.7
Buccal Cavity and Pharynx	140-148	0	-	-
Digestive Organs and Peritoneum	150-159	1	209.1	191.9
Respiratory System	160-164	1	214.1	202.0
Genito-Urinary Tract	177-181	1	539.3	619.4
Lymphatic and Hematopoietic Tissue	200-205	1	1098.9	1234.6*
All Other Cancers		0	-	-
Vascular Lesions of CNS Circulatory System Diseases	330-334 400-468	4	102.6	
Respiratory System Diseases	470-527	0	-	
Digestive System Diseases	530-587	1	256.8	
All External Causes	800-998	1	113.7	
Other+		1	84.0	

+"Other" ICD codes are all those not listed above.

* $p < 0.05$

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A Brief Mortality Study of
Workers Exposed to Polychlorinated Biphenyls

Background

The term "polychlorinated biphenyls" (PCB's) describes a group of mixed chlorinated biphenyls which vary in consistency from oils to sticky resins in direct relation to the degree of chlorination of the phenyl rings. Mixtures of PCB's have been in use since 1929 for various period in transformers, capacitors, lubricants, "carbonless" duplicating paper, fireproof sealants, plastics, adhesives, and other products. Their electrical, chemical, and biological stability contributed significantly to their value for many industrial uses. These properties also made PCB residuals more persistent in the environment, as technical developments in gas chromatography and mass spectrometry for detection of trace quantities began to demonstrate in the mid-1960's [1,2,3].

While acute biological effects from relatively high PCB exposure levels are known and can be avoided by appropriate control measures, attention has been focused on the chronic effects resulting from long-term low levels of exposure to PCB's. In extensive two-year animal chronic oral toxicity tests of AROCLOR 1242, 1254, and 1260 (42, 54, and 60% chlorinated PCB products) conducted for the Monsanto Company, no carcinogenic effects were observed in the rats and beagles tested. Hyperplasia, hypertrophy, and several benign tumors were observed in the livers of the rats, but there was no evidence of malignancy in any of the test animals.

Other investigators have reported liver tissue effects ranging from hyperplasia to well-differentiated hepatocellular carcinomas in rats or mice fed with various PCB-containing diets. For example, Kimbrough, et al fed rats with AROCLOR 1254 and 1260, and observed hypertrophy, lipid accumulation, and adenofibrosus, but no malignancies, in the livers of the test animals.[4] In a later experiment, the same investigator fed Sherman rats 100 ppm of AROCLOR 1260 for 21 months and reported the induction of hepatocellular carcinomas and neoplastic nodules in the test animals' livers whereas, control animals showed little or no effects.[5]

A 1978 National Cancer Institute report of carcinogenicity tests on AROCLOR 1254 concluded that the substance was not carcinogenic in Fischer 344 rats under the conditions of the bioassay. Although the incidences of hepatocellular tumors and gastrointestinal carcinomas were not statistically significant, an excess incidence of hepatocellular proliferative lesions (hyperplastic nodules) appeared to be related to administration of the chemical.[6]

The first report of possible PCB effects on humans occurred in 1968, when over 1200 Japanese were involved in an epidemic of Yusho, an acne-like skin disease which was later traced to the consumption of a rice-oil contaminated with PCB's from a leaking heat-exchange unit. However, it was later shown that the rice oil also contained a high

level of polychlorinated dibenzofurans (PCDF's), possibly due to the high temperature of the heat exchange unit. The highly toxic PCDF's were shown to be relatively more concentrated in the liver than PCB's, and these findings clearly indicated the necessity to pay greater attention to PCDF's for clarification of the nature of Yusho.[7]

There have been very few epidemiological studies of human populations exposed to low levels of PCB's over a long period of time. The Mobil Oil Company released a study in 1976 conducted by Bahn[8] in which a significant number of melanomas and pancreatic cancers were found in PCB-exposed plant workers and research personnel. However, the study has been severely criticized due to deficiencies in the identification of the study cohort, failure to identify other potentially carcinogenic chemical exposures, and other problems which left the results of the Mobil study highly in doubt.[9]

Shortly after the Mobil study, a preliminary study of PCB-exposed workers was begun at the Monsanto Company, focused on workers at the W.G. Krummrich plant in Sauget, Illinois, where PCB's were manufactured from 1936 until production ceased in 1977. This preliminary study failed to support the Mobil study results. No melanomas or pancreatic cancers were found but an apparent excess occurrence of lung-cancer deaths was found in the incomplete study cohort. However, due to the preliminary nature of the study, no minimum time of exposure criteria was applied for the workers and no follow-up was done on over 30% of the study cohort who had left the company. Further definition of the exposed population was needed.

The study reported here is an attempt to complete the epidemiological evaluation of the worker population of Monsanto's W.G. Krummrich plant, and evaluate the chronic effects of PCB-exposure on humans. Thus, the mortality experience of workers exposed to PCB's in their manufacture has been followed and evaluated under accepted epidemiology criteria for follow-up of all active, retired and terminated employees with exposures to PCB's for at least 6 months.

PROPOSAL FOR A HISTORICAL PROSPECTIVE MORTALITY STUDY OF POLYCHLORINATED BIPHENYL EXPOSED WORKERS

BACKGROUND

The polychlorinated biphenyls (PCB's) have attracted much attention since the late 1960's when technological developments in gas chromatography and mass spectrometry made the detection of PCB's at low levels in the environment possible. PCB's have been in use since 1929 in transformers, lubricants, "carbonless" duplicating paper, fireproof sealants, plastics, adhesives, and many other products. Their resistance to biodegradation, photodegradation, and oxidation made them invaluable in scores of uses but also made them more stable as residual pollutants when released into the environment.

PCB's are highly lipid soluble compounds. Lipid solubility enables a proportion of food chain PCB residues to be stored in the fat depots of the body. The first reports of PCB's in the environment came from Sweden, where Jensen (1966)[1] identified residues of PCB's in fish from various Swedish waters. Risebrough et al (1968)[2] found PCB and DDT in marine ecosystems of the Pacific Ocean. Early reports of wildlife effects included egg shell thinning and baby seal effects, but subsequent studies have failed to conclusively show PCB's as the causative agent.

The first report of possible PCB effects on humans occurred in 1968, when over 1,000 Japanese were involved in an epidemic of Yusho, an acnelike skin disease which was traced to rice oil contaminated with PCB's. However, it was later shown that the rice oil also contained a high level of polychlorinated dibenzofurans (PCDF's), possibly due to use of the contaminating PCB as a high temperature heat transfer medium. It was shown that PCDF's are relatively more concentrated in the liver,

and the investigators' findings clearly indicated the necessity to pay greater attention to PCDF's for clarification of the nature of Yusho.[3] While acute effects from relatively high PCB exposure levels are known and can be avoided by appropriate control measures, attention has more recently been focused on the chronic effects resulting from long-term low levels of exposure to PCB's.

Animal tests have proved to be equivocable. The Environmental Protection Agency considers PCB's to be suspect carcinogens based on its own animal tests. Monsanto's extensive two-year chronic oral toxicity tests of Arochlor 1242, 1254, and 1260 in both rats and beagles at dose levels of 1, 10, and 100 ppm concluded that PCB's were non-carcinogenic. Hyperplasia, hypertrophy, and several benign tumors were observed in the livers of the rats, but there was no evidence of malignancy in any of the test animals.[4]

Other investigators have shown liver tissue effects ranging from hyperplasia to well-differentiated hepatocellular carcinomas in rats or mice fed with various PCB-containing diets. For example, Kimbrough et al (1972)[5] fed rats with Arochlor 1254 and 1260, and found hypertrophy, lipid accumulation, and adenofibrosis in liver tissue, but found no malignancy. The same investigator fed Arochlor 1254 to mice for 11 months and reported the induction of malignant hepatomas in the test animals.[6]

The recent National Cancer Institute report[7] of its carcinogenicity tests on Arochlor 1254 concluded that the substance was not carcinogenic in Fischer 344 rats under the conditions of the bioassay. However, they allude to the non-significant occurrence of gastrointestinal tract carcinomas and hepatocellular proliferative lesions in their test animals as possibly being related to the Arochlor diet.

There have been very few epidemiological studies of human populations

exposed to low levels of PCB's over a long period. The Mobil Oil Company released a study in 1976 conducted by Dr. Anita Bahn[8] in which a significant number of melanomas and pancreatic cancers were found in exposed chemical workers. While these results received publication, the study was severely criticized[9] due to deficiencies in the identification of the study cohort, failure to identify other potentially carcinogenic chemicals to which the workers and research personnel were exposed, and other problems which left the results of the Mobil study highly in doubt.

A preliminary study of PCB-exposed workers was begun at Monsanto shortly after the Mobil study in response to the need for a valid epidemiological study of the effect of PCB's on humans. The study focused on workers at the Krummrich Plant, where PCB's were manufactured from 1936 until production ceased in 1977. No melanomas or pancreatic cancers were found, but an excess incidence of lung cancer deaths was seen. However, due to the preliminary nature of the study, several necessary steps to complete the epidemiology study remained unfinished, such as following up on the mortality experience of over 30% of the study cohort who were lost-to-follow-up. In addition, no minimum limits on exposure time were used in the preliminary study. Thus, no attempt was made to distinguish between the workers exposed for years and the worker exposed for a few days.

The investigators involved in the preliminary Monsanto PCB study realized these deficiencies and advised that the study population should be further defined and evaluated so that a valid, comprehensive report could result. Therefore, due to the preliminary nature of the epidemiological data available and the inconclusive toxicological data, it is necessary to pursue further epidemiologic study in order to evaluate the chronic effects of PCB-exposure to man with more complete vital information on a verified, exposed worker cohort.

PURPOSE OF THE STUDY

This epidemiological study will investigate the mortality experience of workers exposed to polychlorinated biphenyls in their manufacture. Through studying this cohort we intend to (1) identify groups of workers that have PCB exposure of a sufficient latency to demonstrate any chronic health effects, and (2) analize the mortality experience of these workers with attention given to malignant neoplasms especially of the lung, liver, skin, and pancreas.

STUDY POPULATION

The Monsanto plants involved in the U.S. manufacture of PCB's are the W.G. Krummrich plant in Sauget, Illinois, and the Anniston, Alabama plant. Since the preliminary study, upon which the proposed study is based, involved the Krummrich plant alone, the proposed study will deal solely with the Krummrich workman population.

The study population from the Krummrich plant consists of all male waged employees who have worked at least six months in a job involving exposure to PCB after December 31, 1944, and prior to December 31, 1965. This population includes active, retired, and terminated employees. Through interviewing plant personnel, it was determined that exposure levels of workers involved in the manufacture of PCB's did not vary considerably; therefore, all waged workers involved in the manufacture of PCB's will be considered to have a common exposure level.

Work histories for all past and present Krummrich employees have been obtained and screened for PCB-department work by the Department of Medicine and Environmental Health (DMEH). A plant-developed computer listing of all PCB department workers has also been supplied to the DMEH, and the computer listing has been cross-checked with the hand work history search in order to insure completeness. It should be noted that some workers, e.g., maintenance, may have had significant exposures to PCB's, but are not included in the study due to exposure verification difficulties.

For each worker the following information has been obtained: name, social security number, employee number, race, sex, date of birth, date of hire, date of termination (if applicable), and as detailed a work history as is available. For those known to have died, the date and place of death, and a copy of the death certificate are being obtained.

MORTALITY FOLLOW-UP

1. All active employees, and retirees who are currently receiving pension checks will be assumed to be alive as of December 31, 1977.

2. All persons known to have died on or after January 1, 1978, will be assumed to be alive for the purposes of this study.

3. Personnel folders and pension files will be searched for death certificates or for pertinent information about the decedent if no death certificate is present.

4. The names of persons for which there is no information on vital status will be reviewed with plant personnel for any information which they can provide.

5. Other follow-up procedures, such as Veteran's Administration files, Polk Directories searches, telephone directories searches, and state driver's license files will be used, if necessary, to determine the vital status of lost-to-follow-ups.
6. A state death certificate will be obtained for every person known to have died.
7. An experienced, trained nosologist will review and code all death certificates for the underlying cause of death to the International Classification of Diseases, Seventh Revision.

ANALYSIS

The data will be analyzed using the modified life-table method. In this method of analysis,the age, race, cause, time-specific mortality rates in a standard population are applied to person-years classified by age, race, and time-specific subgroups of the worker population at risk (i.e. exposed) over the years of observation intervals. A standard mortality ratio will be calculated as the ratio of the sum of the observed deaths to the sum of the expected deaths x100.

The person-years of observation will be calculated by year of observation and age at observation as shown in Appendix A. Person-years of observation will be accumulated from date of first exposure to PCB's to the earliest of the following events: 1) date of death, 2) December 31, 1977, the cut-off ascertainment date, or 3) date at which the study member was lost-to-follow-up.

The expected number of deaths will be calculated using United States annual mortality rates, or county rates, if available, for every year from 1945-1977. If annual county mortality data is unavailable, the 1950-69 expected numbers of cancer deaths based on U.S. rates will be adjusted by cause for the local county death rates according to the ratio of the local county rate to the U.S. rate using U.S. Cancer Mortality by County: 1950-69. A standard mortality ratio will be calculated for certain selected causes of death (Appendix B).

David C. Musch

David C. Musch

APPENDIX A

PERSON-YEARS OF OBSERVATION BY YEAR OF OBSERVATION AND AGE

AGE	1945-49	1950-54	1955-59	1960-64	1965-69	1970-74
15-24						
25-34						
35-44						
45-54						
55-64						
65-74						
75-84						
85 +						

APPENDIX B

Krummrich PCB Study

Cause of Death with I.C.D. Number (Seventh Revision)	Observed	Expected	P.M.R.
Malignant neoplasms (140-205)			
Buccal Cavity and Pharynx (140-148)			
Digestive Organs and Peritoneum (150-156A, 157-159)			
Biliary Passages and Liver (155-156A)			
Other Parts of Digestive System (Residual)			
Respiratory System (160-164)			
Bronchus, Lung, and Trachea (162-163)			
Other Parts of Respiratory System (Residual)			
Genito-Urinary System (177-181)			
Leukemia and Aleukemia (204)			
Lymphosarcoma and Other Neoplasms of Lymphatic and Hematopoietic Tissues (200-203, 205)			
All Other Neoplasms (Residual)			
Diseases of the Cardiovascular System (330-334, 400-468)			
Diseases of the Respiratory System (470-527)			
Diseases of the Digestive System (530-587)			
All Other Diseases (Residual)			
All External Causes (E800-E998)			

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A Mortality Study of Workers Exposed to Polychlorinated Biphenyls

Judith A. Zack

David C. Musch

Summary

A historical prospective mortality study was conducted on workers exposed to polychlorinated biphenyls at Monsanto's W.G. Krummrich plant in Sauget, Illinois. Eighty-nine workers who were exposed to PCBs for a minimum of six months from 1945-1965 were followed for their mortality experience. Observed deaths were not significantly different from the expected number of deaths for any of the seventeen cause-of-death categories examined, including overall cancer and any of the site-specific cancers.

These observations were based on thirty deaths among eighty-nine workers who had been exposed to relatively high levels of PCBs for an average duration of almost three years during the period of study.

Background

The term "polychlorinated biphenyls" (PCBs) describes a group of mixed chlorinated biphenyls which vary in consistency from oils to sticky resins depending on the degree of chlorination. PCBs have been in commercial use since 1929. They have been used particularly in the insulation of electric cables and wires and in the production of electric capacitors and transformers.

Reports of adverse health effects in man and carcinogenic effects in certain animal species prompted the National Institute for Occupational Safety and Health (NIOSH) to request that epidemiological studies to be carried out on PCB-exposed worker populations. In a preliminary study of workers exposed to PCBs at the Mobil Oil Company's Paulsboro, New Jersey plant, Bahn reported an excess of deaths from malignant melanoma and pancreatic cancer among research and production employees.[1] At this same time, Roush reported the findings of a preliminary mortality study of PCB workers at Monsanto Company's Sauget, Illinois plant (G. Roush, written communication, September 1976). No cases of malignant melanoma or pancreatic cancer were found in this study.

The accidental poisonings with PCBs in Yusho, Japan provide information on the acute toxic effects of PCBs for man. PCB poisoning occurred following the ingestion of Kanemi rice oil contaminated with PCBs. The general symptoms of Yusho disease include neuroendocrine disturbances, abnormal lipid metabolism, disturbances of the respiratory system, acneform eruption, pigmentation, and ocular changes.[2] Yusho disease, however, has also been attributed to the ingestion of polychlorinated dibenzofurans (PCDFs) which was also present in the rice oil as a PCB contaminant. The presence of PCDFs makes interpretation of the relationship of PCBs to the clinical picture of Yusho disease difficult.

In 1976, the Monroe County Board of Health conducted biochemical tests among Bloomington, Indiana residents exposed to PCBs. Serum levels of gamma glutamyl transpeptidase and plasma triglyceride levels were found to increase significantly with increases in serum PCB levels.[3]

In a recent study, Miller reported a reduction in forced vital capacity, independent of obstructive changes, with virtually no radiographic change in fourteen percent of the PCB workers examined.[4]

Extensive studies of PCB toxicity in animals have been carried out. In a two-year animal chronic oral toxicity test of PCB, no carcinogenic effects were observed in the rats and beagles tested. Hyperplasia, hypertrophy, extensive fibrosis, and several benign tumors were observed in the livers of the rats, but there was no evidence of malignancy in any of the test animals.[5]

Other investigators have reported liver tissue effects ranging from hyperplasia to well-differentiated hepatocellular carcinomas in rats or mice fed with various PCB-containing diets. Kimbrough fed rats PCBs and observed lipid accumulation, hypertrophy, and adenofibromas, but no malignancies in the livers of the test animals.[6] In a later experiment, the same researcher reported the induction of hepatocellular carcinomas and neoplastic nodules in the test animals' livers.[7] PCB toxicity for animals has been thoroughly reviewed.[8]

The literature on PCB toxicity points to several organ sites in man that could potentially incur chronic toxic effects of exposure to PCBs. The study reported here, a continuation of the previously reported Monsanto study, will examine the mortality experience of PCB workers, with particular attention given to overall cancer, liver and pancreatic cancer, and malignant melanoma.

Population and Methods

This is a study of polychlorinated biphenyl workers from Monsanto's W.G. Krummrich plant in Sauget, Illinois. PCBs were manufactured at this plant from 1937 to 1977. All male employees from the hourly roll who worked in the PCB department for at least six months between January 1, 1945, and December 31, 1965, have been selected for study.

The PCB worker cohort was identified from the plant's computerized work history system. Eighty-nine male hourly employees met the criteria for inclusion in the study. The vital status of each member was determined as of December 31, 1977 , using standard followup techniques. A death certificate was obtained for each person found to be deceased. The underlying cause of death was coded to the Seventh Revision of the International Classification of Disease[9] by an experienced trained nosologist.

The data were analyzed by the modified life table method.[10] Standard mortality ratios were calculated for seventeen selected cause-of-death categories. Mortality comparisons were made with the general U.S. population. Confidence intervals were calculated for the standardized mortality ratios and statistical significance was determined at the five percent level.[11]

No industrial hygiene data were available to quantify the PCB exposure levels for the period of study. The exposure levels in the PCB department were quite uniform and fairly high. The smell of PCBs was omnipresent in the department; and the clothing and exposed skin areas of some of the workers were coated at times to some degree with the sticky substance. For the purpose of this analysis, it was asumed that all of the workers had the same level of PCB exposure. Other exposures in the department included hydrochloric acid, trichlorobenzene, tetrachlorobenzene, biphenyl, and chlorine gas.

Results

The results of the vital status tracing are shown in Table 1. Ninety-seven percent of the study cohort was traced. Of the 89 members in the study cohort, vital status was determined for all but 3. Fifty-six were verified living and thirty were verified deceased by death certificate.

Tables 2-4 show observed and expected deaths and standardized mortality ratios for selected caused of death, for all males and for white males and non-white males, separately.

None of the differences between observed and expected deaths were statistically significant for any of the comparisons made, as none of the standardized mortality ratios differed significantly from 100. In particular there was not statistically significant excess seen in deaths from overall cancer, liver or pancreatic cancer, or malignant melanoma.

The overall mortality of this group (SMR = 130) was elevated from what one would expect in an industrial population. Standardized mortality ratios for lung cancer and cardiovascular disease were also elevated.

The observed and expected deaths for all malignant neoplasms and neoplasms of the respiratory tract by latency are given in Table 5.

Table 6 lists the eight cancer deaths shown in Tables 2-4 for the interested reader.

PROCEEDINGS OF THE CONFERENCE
"PCBs IMPACTS ON HEALTH"
September 12, 1979
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SARDINAS: I'd like to welcome you today. My name is Anthony Sardinas. I'm the Division Director for Preventable Diseases at the Connecticut State Department of Health Services. Today, the Department is co-sponsoring this meeting on polychlorinated byphenyls and the health effects of these substances. We're particularly interested in the public health implications of PCBs, polychlorinated byphenyls. We're co-sponsoring this meeting with Toby Moffett's office today. It was coordinated at the request of the Connecticut Citizens' Watchdog Committee. Our goal is to inform the public of the current state of knowledge in respect to the health hazards imposed by PCB's and the general public. We're particularly interested, and this subject, of course, is timely, with regard to the PCBs that have been found in fish in our rivers. We hope that this conference will help the public to make an informed decision as to whether or not they want to risk eating contaminated fish or they want to risk drinking water with PCBs and that sort of thing. It's also hoped that this meeting will provide a better understanding of Connecticut's PCB program. Now, we have with us today two panels actually which are somewhat intermingled. We have a national panel of experts and we also have a local panel of experts. Let me first introduce to you our expert panel of speakers. We have with us Dr. Albert C. Kolbye. Dr. Kolbye is the Associate Director of Science, Bureau of Foods, for the Food and Drug Administration. We also

SARDINAS: (Continued) have Dr. Elizabeth Weisburger. Dr. Weisburger is the Chief of the Laboratory of Carcinogen Metabolism, the Division of Cancer Cause and Prevention, with the National Cancer Institute in Washington. Also with us today is Dr. James Douglas. Dr. Douglas is with the Yale School of Epidemiology of Public Health, he's also a member of the Pierce Foundation in New Haven, and he's on the Toxic Substances Advisory Board for the Environmental Protection Agency. We have Dr. John F. Brown, Jr. Dr. Brown is the Manager of Life Sciences Branch for General Electric in New York. I'll introduce the local panel to you after we've had an opportunity to hear from the expert panel, and, and give the local panel an option to ask some questions. So, let's begin in alphabetical order with the National panel first, and I'll call on Dr. Brown, again, to begin, to try to limit your comments as much as possible to about 10 minutes. Dr. Brown.

BROWN: (READS THE FOLLOWING)

THE PERILS OF PCB: MYTH AND REALITY

Remarks presented at public panel discussion:
"Public Health Implications of PCB's"
Hartford, Connecticut, Sept. 12, 1979

by John F. Brown, Jr., PhD
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At the outset, let me say I am not a Company officer, and my remarks do not represent Corporate policy statements. I am the head of a Life Sciences R&D Branch, and my opinions are those of chemical, medical, and biological research scientists who have been concerned with PCB's.

I have been asked to focus my present remarks upon PCB health hazards. However, I should point out that our studies have also addressed several other PCB issues that I would be glad to discuss if questioned. These include chemical composition, analytical methods, disposal technology, stability and fate in the natural environment, microbial degradation and biological effects.

With respect to present scientific knowledge about the health effects of PCB's, I'd like to make five main points.

First, there is a large body of scientific literature out there, over 500 original papers on PCB bioeffects. This means that many questions regarding persistence, toxicity, and carcinogenicity can be answered on the basis of observations already reported, if you're just willing to dig in, search, and correlate.

Second, the basic patterns of effects induced in warm-blooded animals by the toxic types of PCB's are identical to those produced by polychlorinated dibenzodioxins and polychlorinated dibenzofurans. Such patterns vary somewhat with the animal species. In chickens, the characteristic result is edema disease; in mink, it is reproductive failure. In rat and mice, there is progressive damage to the liver, culminating in cancer. That result, however, has never been seen in guinea pigs,

monkeys, or man. Instead, the characteristic pattern in humans features acne-like skin eruptions, called "chloracne," along with changes in skin pigmentation, peripheral numbness, digestive upsets, headaches, and fatigue.

Third, if one compares the reported observations, whether on chickens, rats, guinea pigs, mink, monkeys, or man, one finds an enormous variability in the ability of different PCB specimens to produce toxic effects. In many cases, the original investigators themselves recognized this variability, recognized that they were dealing with an impurity-dependent toxicity, and clearly reported it as such. Within the past year, these variabilities in effect have led both the International Agency for Research on Cancer, and our own FDA to declare the evidence for the carcinogenicity of PCB's to be inconclusive.

But there's nothing new about this. The very first American report on PCB-related chloracne, back in 1936, recognized that toxicity in PCB's as an unusual phenomenon that was associated with unidentified impurities in a single bad batch of early PCB.

Fourth, since 1970 the toxic impurity has been repeatedly identified as a polychlorinated dibenzofuran, or PCDF. PCDF's have apparently been virtually absent from industrial PCB's as made in this country for at least the last 25 years, but they have been present in European and Japanese production at levels of 5-30 parts per million, and in a number of the laboratory specimens used in biological testing. More significantly, these highly toxic PCDF's can be formed by scorching PCB's at temperatures above 500°F. The high temperature heat exchanger fluid that caused the Yusho illness episode in Japan is now known to have been a PCB that had been more than half decomposed to polychlorinated quaterphenyls and PCDF's.

Fifth, there is abundant evidence that human exposure to ordinary, unscorched PCB is without obvious health effects. PCB's were in widespread industrial use in all developed countries for nearly fifty years. Despite this, there have been only a handful of definite reports of

chloracne syndrome - all associated with baking, soldering, or heat-transfer applications.

The lack of toxic effects in the vast majority of exposed workers cannot be related to lack of PCB uptake, exposure time, or medical observation. Repeated studies of exposed electrical workers in both the US and Japan have shown them to be carrying in their bodies anywhere between 10 and 1000 times as much PCB as was found in the Japanese suffering from Yusho illness or roughly 100 times as much as the FDA figures you would get by eating fish controlled by their new 2 ppm tolerance limit. Many of these people had accumulated up to 30 years exposure before PCB use was stopped in 1977. Despite this, their health seems statistically indistinguishable from that of their unexposed cohorts.

In short, whether on grounds of toxicity or carcinogenicity, the scientific record provides very little basis for concern over low level exposure to ordinary, electrical grade PCB such as that presumably present in the Housatonic.

We all know, however, that this is not the popular perception of the case. One reads again and again the dread phrases, "acutely toxic," "linked to cancer," and "deadly." One sees pictures of policemen dressed like plutonium workers in order to clean up a contaminated grease spot, or farmers of the upper Hudson readying both shotguns and injunctions to stop PCB dredging, or New Jersey citizens mounting opposition to the use of an EPA-approved PCB incinerator. And all this over a widely used chemical that has produced no clear case of human illness in this country in the last 25 years.

This gulf between popular perception and scientific reality seems to have begun with good intentions. About 10 years ago it became apparent that PCB's were flowing into the environment faster than they were being degraded. This led to the prudent decisions, first, to sharply restrict PCB use and then to ban it completely. In order to

help promote the drive for a ban, the idea was advanced that perhaps any toxic effect exhibited by any type of PCB mixture in any animal should be considered a potential hazard of all PCB's in all creatures. This made an interesting as well as useful story, and it grew larger and larger with each retelling.

I believe that the PCB supertoxicity myth has now outlived its social value. The economic use and disposal of PCB is no longer an open issue. All PCB's were legally banned in the US in 1976. Their manufacture, import, and all major uses stopped in 1977. Elaborate procedures to limit the flow of scrap PCB into the biosphere were instituted by EPA in 1979. However, none of this can alter the fact that a hundred thousand tons have already passed into the biosphere. It is present, at varying levels, in the oceans, rainfall, soil, rivers, and fish, and there is no presently known human action that can radically change these environmental levels in the short term. There will be detectable levels of PCB's in fish from the Housatonic for decades, lower levels to be sure, but nevertheless detectable.

The real challenge we face today is learning to live with these realities. We must decide, for example, whether we'd rather give up fishing or readjust our perceptions of the perils of PCB's.

In my opinion, the FDA ruling of June 29, 1979, which proposed setting the Federal tolerance limit for PCB's in fish at 2 parts per million, makes sense only as a temporary measure. Basically, it is designed to provide protection to someone eating fish from waters contaminated with PCB's that are in turn contaminated with 1% of PCDF's, which was the extreme situation that caused the Yusho illness in Japan. The probability of this actually being the case is pretty low. However, the agency is forced to regulate on the basis of PCB's present rather than PCDF's feared because of the problem of chemical analysis. At present, chemists can reliably analyse fish for PCB's at parts-per-million levels, but not for PCDF's in the parts-per-billion range.

Fortunately, analytical methodologies are evolving very rapidly, and we think that valid high sensitivity techniques for PCDF's in fish should be available in a year or two. In due course, I would then hope to see the present Federal tolerance limit of 2 parts per million PCB replaced by a 20 parts per billion PCDF standard. This regulatory reform would probably permit the resumption of commercial fishing in several closed areas.

Meanwhile, I would hope that responsible State agencies could make diligent efforts to examine their PCB pollution problems on a region-by-region basis, and adopt regional fishing regulations that reflect the toxic hazard posed by the kind of PCB actually present locally, not just the worst possible kind as presumed by the Federal standard.

Obviously, any attempt to promulgate regional tolerance standards less rigorous than the Federal one will invite challenge. To develop and defend such standards will require hard work, citizen support, serious scholarly effort directed at the original scientific literature rather than agency summaries, and intellectual courage. However, it will not represent the first time that public health authorities have had to make hard choices between scientific reality and popular mythology. I would urge you to address this challenge.

SARDINAS: Thank you, Dr. Brown. Our next speaker is Dr. James Douglas, again from the Yale School of Medicine, Department of Epidemiology and Public Health, and the Pierce Foundation. Dr. Douglas.

DOUGLAS: Thank you, Mr. Chairman. First let me say that I am here as a toxicologist, and not with any special knowledge of the PCBs themselves. I have done no work in the area. And as far as we can ascertain there is little or no work being done on PCBs at Yale or in the Pierce Foundation. I have therefore spent some time reading the literature, and my knowledge is based on the material which is published. I think that there are a number of basic questions which come to my mind as a result of reading the literature. And I'm just going to briefly state what they are and not make any other formal presentation, but try to help in any questions that might come along. First of all, the fact that we can detect materials does not necessarily mean that they are toxic. Analytical methods become more and more sensitive all the time, and we can detect smaller and smaller quantities of materials. That does not necessarily mean that they exert toxic effects. And one of the things that we have to think about is the fact that PCBs are detectable does not mean that they are necessarily toxic. The methods of detection and analysis are particularly important. Toxicity is related to a particular substance. The PCBs are a group of substances which as, has been

DOUGLAS: (Continued) just mentioned, are, in some instances, contaminated with very small amounts of benzofurans. Certainly the toxicity of benzofurans seems to suggest that they are a good deal more potent than the PCBs. One wonders, therefore, whether many of the effects described to PCBs may not be due to contamination of that particular material. Toxicologists face a very difficult problem in that many materials are handled by animals in quite different ways. This is quite clear in the area of the PCBs where really there are fairly few animals which are truly representative of man, and I think that its fair to say that probably the primates give the closest types of responses to PCBs as compared to man, and there is, for various reasons relatively little work being done with the species. Having surveyed the evidence that is available, one of the concerns which I have with regard to the PCBs is the fact that the higher, more toxic species are very poorly metabolized, and are accumulated rather easily in various species. I think that that is an important consideration. It reminds me very much of, of DDT, for example, although DDT is a substance which could very easily be metabolized eventually. On the basis of the available information, I think that I would have to conclude that there's no conclusive evidence that the PCBs are carcinogenic. I think that considerable amount of data is equivocal. But I think that some of the more recent data would suggest that there are some effects in man, for example, Dr. Fishbein

DOUGLAS: (Continued) of Mount Sinai Hospital in New York, has reported some effects on pulmonary function in workers exposed to PCBs. But again, some of these studies are difficult to evaluate, since they do not have proper control groups. Thank you.

SARINAS: Thank you. Dr. Albert Kolbye, again, from the Food and Drug Administration. Dr. Kolbye.

KOLBYE: Thank you, Mr. Chairman. Ladies and gentlemen. I'll be speaking on behalf of the Food and Drug Administration, and explaining some of the viewpoints both legally and scientifically. My background is in medicine, epidemiology, toxicology and law. The Food and Drug Administration primarily has authority over interstate commerce with respect to food. And so the action levels that are set by Food and Drug refer to food that is in interstate commerce. At this meeting, if we are discussing sport fishing or intrastate commerce, I am here in an advisory capacity to share what knowledge and insight we in FDA have. To be a little bit more specific about the law, and not to get too legalistic, Section 406 of the Food and Drug Act is the one that applies to a PCB and fish situation. It's an Act that covers environmental contaminants in foods. And the law essentially says that FDA has the authority to set standards or action levels in fish, for example, to the extent necessary to protect public health. Let's

KOLBYE: (Continued) talk for a moment about human exposure and keep in mind that an action level is only one parameter. That's the level, so to speak, of permitted residues in a food commodity. A very important parameter that influences your exposure is how much food you eat at that level, and another important parameter is the frequency with which you are exposed to food contaminated at that level. Said in slightly different terms, if one has a systematic exposure, if one is eating day to day highly contaminated fish, one is getting a total exposure that is far different, and far stronger, if you will, than somebody who only occasionally consumes a particular food commodity that contains some residues of PCBs. So when we look at the overall health situation, the primary human experience has been referred to by other speakers, and that dealt with the disease suffered by the Japanese people, called Yusho. Back in the early 1970's, when FDA first got involved in regulating PCBs, we reviewed the evidence and available data from the Japanese populations and attributed all of the illness experienced by the Japanese to PCBs alone. Subsequently, we have determined that about half the organic chlorinated material in the contaminated rice oil was a quaterphenyl and that the level of polychlorinated dibenzofurans that were present in that rice oil approximated 500 parts per million. It has been mentioned that here in the United States the, the PCBs produced have been much cleaner with respect to

KOLBYE: (Continued) the presence of dibenzofurans. Here in the United States, to the best of my knowledge, the highest level of dibenzofurans that has been determined to exist approximate maybe about 10 parts per million in the PCBs. And so the American products have been much cleaner than the products manufactured in Europe or in Japan. One does have a problem though, as mentioned by an earlier speaker, that when PCBs have been exposed to heat formation of more of the dibenzofurans occurs. Now, the feeding studies in animals that have been conducted to attempt to assist the carcinogenic and chronic toxicity of PCBs also involve exposing the animal, since they're exposed to commercial preparations of PCBs, to whatever contaminants are present in that PCB product. And this then includes the likelihood that test animals were exposed to approximately 10 part per million level dibenzofurans in the amount of PCBs they received in their diet. So it's unclear to some scientists and to myself personally, what the exact role of PCBs is in terms of influencing the expression of cancer. And I'll be interested in Dr. Weisburger's comments in a few minutes. But basically the thing that one has to remember when considering PCBs, we're considering a spectrum of chemicals where the degree of chlorination and the positions chlorinated on the carbon rings are important determinants of the toxicity and the metabolic activity of these compounds. For dibenzofurans, there is about a thousandfold range of toxicity depending on the degree

KOLBYE: (Continued) of chlorination and the position of chlorination. And the same holds true for the dioxins. A 2378 tetrochlorodibenzodioxin is very, very toxic. But other tetroforms of the dioxins, if they're not chlorinated in those particular positions, have different toxicity. If you have higher chlorinated ones depending on position, they can be far less toxic. Thank you.

SARDINAS: Thank you, Dr. Kolbye. Dr. Elizabeth Weisburger is our next speaker, and again, she is from the National Cancer Institute. Dr. Weisburger.

WEISBURGER: (READS THE FOLLOWING

[illegible] Connecticut State Department of Health

on Seminar

"What Is the Present Understanding of Health Hazards of PCB's"

Elizabeth K. Weisburger, Ph.D.
National Cancer Institute
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Summary

A bioassay of Aroclor™ 1254 for possible carcinogenicity was conducted by administering the test chemical in feed to Fischer 344 rats.

Groups of 24 rats of each sex were administered Aroclor™ 1254 at one of three doses, either 25, 50 or 100 ppm, for 104-105 weeks. Matched controls consisted of groups of 24 untreated rats of each sex. All surviving rats were killed at 104-105 weeks.

Mean body weights of males and females receiving mid and high doses and females receiving low doses of the chemial were consistently below those of the corresponding controls, beginning at about week 10 of the study. The decrease in survival among males, but not among females, showed a significant dose-related trend. Adequate numbers of animals of both sexes survived for meaningful statistical analyses of the incidences of tumors.

The combined incidences of lymphomas and leukemias showed a significant dose-related trend in males (controls 3/24, low-dose 2/24, mid-dose 5/24, high-dose 9/24, P = 0.008). However, the direct comparisons of [illegible] dosed groups with those of the matched controls were not statistically significant, and the tumors cannot clearly be related to administration of Aroclor™ 1254.

Hepatocellular adenomas and carcinomas were found in the dosed groups, but not in the controls (males: mid-dose 1/24, high-dose 3/24; females: mid-dose 1/24, high-dose 2/24). Additionally, a high incidence of non-neoplastic hyperplastic nodules was noted in the dosed animals (males: controls 0/24, low-dose 5/24, mid-dose 3/24, high-dose 12/24; females: controls 0/23, low-dose 6/24, mid-dose 9/22, high-dose 17/24). Although the incidences of tumors were not significant, the occurrence of the hyperplastic nodules appeared to be related to administration of the chemical.

In the stomach, jejunum, or cecum, adenocarcinomas were observed in two dosed males and in two dosed females as well as a carcinoma in one dosed male. None of these lesions was found in control animals in this study. Historical incidences of these tumors at this laboratory (6/600 males [1%], 2/600 females [0.3%]) suggest that the lesions -- although not statistically significant -- may be related to the administration of Aroclor® 1254.

It is concluded that under the conditions of this bioassay, Aroclor® 1254 was not carcinogenic in Fischer 344 rats; however, a high incidence of hepatocellular proliferative lesions in both male and female rats was related to administration of the chemical. In addition, the carcinomas of the gastrointestinal tract may be associated with administration of Aroclor® 1254 in both males and females.

Aroclor™ 1254 (CAS 27323-18-8; NCI C02664) is the registered trademark of the Monsanto Chemical Company for their polychlorinated biphenyls (PCBs). PCBs were developed in 1929 primarily for use as heat transfer fluids and dielectrics (insulators). Aroclor™ 1254, a biphenyl containing approximately 54% chlorine, is a nonflammable heat transfer agent which functions in the range of 250-360°C (Hubbard, 1964; Poffenberger and Hubbard, 1965).

This bioassay of Aroclor™ 1254 was conducted as part of a larger study designed to assess the combined effects of a group of known or suspected carcinogens. Only the results of the study of the administration of Aroclor™ 1254 are reported here.

Aroclor™ 1254 was obtained in a single batch (Lot No. KB01-504) from the Monsanto Chemical Company, St. Louis, Missouri. The identity and relative purity of the test chemical were confirmed at Stanford Research Institute. Elemental analyses (C, H, Cl) indicated 54.6% chlorine. Gas-liquid chromatography and mass spectroscopy showed that the Aroclor™ 1254 contained at least 18 isomers of polychlorinated biphenyls ranging from 4 to 7 chlorine atoms per molecule. Identity was confirmed by nuclear magnetic resonance, infrared, and ultraviolet spectra, which were in agreement with the structure. No attempt was made to identify or quantitate impurities.

The chemical was stored at room temperature in amber glass jars.

Male and female Fischer 344 rats, obtained through contracts of the Division of Cancer Treatment, National Cancer Institute, were used in these bioassays. The rats were obtained from Simonsen Laboratory,

Gilroy, California. On arrival at the laboratory, all animals were quarantined for 2 weeks as an acclimation period. Following this period, all males gaining less than 25 grams, all females gaining less than 15 grams, and all unhealthy animals were culled. The remaining animals were assigned to cages, one per cage, until each cage contained three animals. Cages were then numbered and assigned to control and treated groups using a computer-generated randomization table. Rats were ear-clipped for individual identification.

All animals were housed in temperature- and humidity-controlled rooms. The temperature was maintained at 22°C with a range of 21-24°C, and the relative humidity was maintained at approximately 45%. The room air was changed 10 times per hour and was maintained under positive pressure to the access halls. Fluorescent lighting provided illumination 12 hours per day. Food and water were available ad libitum. Drinking water was softened, filtered, sterilized with ultraviolet light, and supplied by means of an automatic watering system.

Subchronic feeding studies were conducted with male and female Fischer 344 rats to estimate the maximum tolerated dose of Aroclor® 1254, on the basis of which low, mid, and high concentrations (hereinafter referred to as "low doses," "mid-doses," and "high doses") were determined for administration in the chronic studies. In the subchronic studies, Aroclor 1254 was added to feed in concentrations of 0, 50, 100, 200, or 400 ppm. Treated and control groups each consisted of 15 male and 15 female rats. The chemical was provided in feed to the treated groups for 3 weeks.

The animals receiving 400 ppm were inactive, had occasional diarrhea and tremors, and failed to gain weight. At this dose 4/15 males and 1/15 females died. Enlarged livers were observed on gross examination, and histologically atypical hyperplasia was observed. At 200 ppm, body weights for both males and females were approximately 70% of those of the controls, and mild hepatocellular pleomorphism was seen histologically in the livers. Rats treated with 25 ppm Aroclor 1254 had enlarged livers, but no evidence of histologic abnormalities. Weight gain in all animals treated at doses lower than 200 ppm was comparable to that in controls, and there was no mortality below 400 ppm. The low, mid and high doses for the chronic studies were set at 25, 50, and 100 ppm.

All animals were observed daily for signs of toxicity and palpated for masses at each weighing. Animals were weighed individually every other week for 52 weeks, and once every fourth week for the remainder of the study. Animals that were moribund at the time of clinical examination were killed and necropsied.

The pathologic evaluation consisted of gross examination of major organs and tissues from killed animals and from animals found dead. The following tissues were routinely examined microscopically from both treated and control animals: lungs and bronchi, spleen, liver, testes, pituitary, kidney, and brain. In addition, sections of stomach, urinary bladder, thyroid, uterus, and ovary were examined in a majority of the controls. These tissues were taken from treated rats only if a lesion was found at necropsy. Occasionally, additional tissues were examined

microscopically. The different tissues were preserved in 10% buffered formalin, embedded in paraffin, sectioned, and stained with hematoxylin and eosin. Special staining techniques were utilized when indicated for more definitive diagnosis.

Beginning at about week 10 for the high-dose groups and about week 20 for the mid-dose groups, mean body weights of both male and female rats fed Aroclor® 1254 at the doses used in this bioassay were lower than those of the controls. Mean body weights of low-dose males appeared comparable to those of controls throughout the study, while mean body weights of low-dose females were lower during the second year of the study. At week 30, an intercurrent respiratory infection in the colony caused weight loss, but no deaths; animals recovered within 30 days without treatment for the infection.

Clinical signs associated with administration of Aroclor® 1254 included alopecia, amber-colored urine, facial edema, exophthalmos, and cyanosis. These signs were apparent among the high-dose groups beginning at week 72 and among the mid-dose groups at week 104 of the study.

A variety of neoplastic processes were observed in both the control and treated rats, and, with the exception of the liver, the incidences of these neoplasms were comparable in the control and treated groups. Interstitial-cell tumors of the testes were present in the majority of control and treated males. The next most frequently observed neoplasm was leukemia of either the granulocytic or lymphocytic type, and it involved multiple organs. The incidence of this neoplastic process was

comparable in the control and treated groups. The following neoplasms were also present in some control and treated rats but without compound association: squamous-cell carcinomas of the skin, alveolar/bronchiolar adenomas of the lung, and uterine endometrial stromal polyps.

In male rats, the results of the Cochran-Armitage test for positive dose-related trend in the incidences of leukemia and of combined leukemia and lymphoma are significant ($P = 0.022$ and $P = 0.009$, respectively). The corresponding results of the Fisher exact test, however, are not significant in any treated group when compared with the controls. There is no other incidence of tumors at any specific site in either sex which is statistically significant. A significant Cochran-Armitage trend in the negative direction is observed in the incidence of interstitial-cell tumor of the testis, where the incidence in the controls exceeds those in the mid- and high-dose groups.

At the doses used in this bioassay, Aroclor™ 1254 was toxic to both male and female Fischer 344 rats, as shown by the dose-related depression of mean body weights and the clinical signs which occurred during the second year. Mean body weights of mid- and high-dose males and of all treated females were consistently lower than those of the corresponding controls after the initial growth phase. An intercurrent respiratory infection at week 30 resulted in temporary weight loss, but no deaths, in all groups including the controls; the animals later recovered without treatment. Clinical signs including alopecia, amber-colored urine, facial edema, exophthalmos, and cyanosis occurred in the high-dose groups beginning at week 72 and in the mid-dose groups at

week 104. Survival among males, but not among females, showed a significant dose-related trend. Adequate numbers of animals of both sexes survived for meaningful statistical analyses of the incidences of tumors.

The combined incidences of lymphoma and leukemia in males were significant (controls 3/24, low-dose 2/24, mid-dose 5/24, high-dose 9/24, P = 0.009) using the Cochran-Armitage test for positive dose-related trend, but not in females (controls 4/24, low-dose 6/24, mid-dose 6/24, high-dose 6/24). Since the results of the Fisher exact test for increased incidence were not significant for any of these groups, the occurrence of these lesions cannot clearly be related to the administration of Aroclor® 1254.

Hepatocellular changes including hyperplastic nodules, adenomas, and carcinomas were found in treated animals, but none of these lesions were found in controls animals in this study. Hepatocellular carcinomas were observed in one mid-dose and two high-dose males, and hepatocellular adenomas were observed in one high-dose male, one mid-dose female, and two high-dose females. Nodular hyperplasia was diagnosed with a dose-related frequency in the low-, mid- and high-dose male and female rats. Although the incidences of the tumors were not significant, the occurrence of these proliferative lesions appeared to be related to treatment.

In the stomach, jejunum, or cecum, adenocarcinomas were observed in two treated males and in two treated females as well as a carcinoma in one treated male. None of these lesions was found in control

animals in this study, suggesting that the lesions -- although not statistically significant -- may be related to the administration of Aroclor™ 1254.

SARDINAS: Thank you, Dr. Weisburger. We'll now move on to the State panelists. The first panelist is Dr. Kenneth Dixon. Dr. Dixon is the Scientific Advisor from the American Chemical Society to Representative Toby Moffett's office. He is a member of the PCB Citizen Watchdog Committee. And he's from Southbury, Connecticut. Dr. Dixon.

DIXON: Thank you. I'd like to say first of all that any remarks I make should not be attributed to the American Chemical Society, nor are they the opinions of the Watchdog Committee. Question one is, reports indicate that different PCBs have different toxicities. Also, PCDF, which is present in PCBs is reported to be more toxic than PCBs. That's incidently is what Dr. Brown said. My question is, would it be more desirable to establish the nature of PCBs and the PCDF content of the PCBs in the fish which we collect before issuing any health warnings?

SARDINAS: Dr. Kolbye, would you like to start off with that?

KOLBYE: One brief comment. Most residue patterns in fish approximate Aroclor 1254 to 1260. That means that you're dealing with the more highly chlorinated isomers. And those are the ones that have the longer biological half-lives, the ones that are

KOLBYE: (Continued) not necessarily metabolized to its greater degree. The recent reports of the chlorinated dibenzofurans in fish reported by Dr. Stalling and his associates from Columbia, Missouri and the other cooperating centers, concern whole fish. Now, one of the things that we have perceived, from some studies in humans and in laboratory animals is that the dibenzofurans have a different solubility pattern than do the PCBs, or at least there are differences. The dibenzofurans appear to want to concentrate in liver. And since Dr. Stalling did his studies on the whole fish, one of the questions that I discussed with him yesterday is whether or not he would run some fish livers to see what the concentration was of the dibenzofurans. And then compare that with the filet portion of the fish which is what humans ingest. I think certainly if I had responsibility for giving specific advice to a specific locality, it would be helpful to know in general whether the dibenzofurans are concentrating in fish liver and whether or not they are present to a significant degree in the edible filet. Also, I think that in any public health provision one makes, one has to talk about educating people primarily not to consume contaminated fish or you're going to have to close your streams if that is the ultimate judgment that you make. There are always going to be people who fish whether the stream is closed or not; and one has to be mindful of educating the people as to what the situation is, and to speak primarily to those sport

KOLBYE: (Continued) fishing people who will go back to the same portion of the river.

SARDINAS: Anybody else on the panel like to comment on that? Dr. Dixon?

DIXON: May I answer that? I've asked Randy Most of the Connecticut Department of Health Services and the people associated with her, to perform the same analysis on the fish which she collects. If she doesn't do that, will she have the whole story? I'm asking that the State Health Department have the same kind of analysis made for PCB and PCDF that Dr. Stalling has. And before that analysis is made, should our State Health Department issue any directives or comments on the entire situation?

SARDINAS: Okay, that's been noted and we will at the State Health Department discuss that suggestion further with our laboratory people. Did you have a further question, Dr. Dixon?

DIXON: And now the second question is, some experts have calculated that PCB toxicity and carcinogenicity would represent a health hazard if one were to consume one half a pound of fish containing 5 parts per million everyday for 8 to 21 months. This is a shortened statement of what Dr. Lewis has said in a publication.

DIXON: (Continued) Now I'm saying, isn't this an unlikely exposure? Wouldn't the hazard be greatly reduced if the intake were cut in half for those eating that much fish?

SARDINAS: I think perhaps for the sake of the national panelists who probably haven't seen that publication, I should just briefly mention that these data were based on some extrapolations from data that was existing on PCBs where we tried to some extent to give a perspective on the relative risk of eating a quantity, having an extended exposure based on levels that were found in fish flesh and in fish skin. We basically produced a linear model that would extrapolate foward something about the levels of risk. And I guess what you're basically asking though, Dr. Dixon, is two things. First of all whether or not half a pound a day ingestion of fish is a reasonable expectation for the population over a long period of time and secondly, whether or not if half that quantity were consumed this would sign ficantly decrease the risk of our projected morbidity. I don't, know if any of the panelists would like to speak to that issue. Perhaps Dr. Lewis, would you like to make a brief statement.

LEWIS: Two things, first of all. the use of those particular estimates was totally arbitrary. We were trying to get in the range of at least the kind of quantities somebody might eat in

LEWIS: (Continued) a day. We were extrapolating it to the entire state population and counting it over a long period. Now, we were also making assumptions, possibly not warranted, about extrapolating this to people that eat less. But at least it gave us a standard of comparison. It is interesting, however, that this summer, as we have been going around getting blood samples and interviewing people that eat fish from the Housatonic River, that we found of the people that eat fish about a quarter of them are eating in the range of 3 to 6 pounds per month. So we're not all that far off.

DIXON: May I? My third question is very simple, and indicates my attitude towards this problem. Three, why not say that the intake of fish may be, "Hazardous to the Health." We recognize that the level of consumption would then be left to the consumer. That little notice along the Housatonic River should read "Hazardous to the Health" to eat these fish.

SARDINAS: We have duly noted those comments. Okay, our next panelist is Mr. Edward Kluck; he's the President of the Housatonic Fly Fishermen's Association, and a member of the PCB Citizen Watchdog Committee. Mr. Kluck?

KLUCK: Thank you. I suspect my role up here is partly to

KLUCK: (Continued) represent not only our own group of trout fishermen, but also the sport fishermen who use the entire watershed. And I had a two part question primarily relating to the proposed, and now postponed for a period of time, 2 part per million threshold. I'm wondering, and it's been answered to a degree, wondering what the rationale was for achieving this 2 part per million as opposed to the existing 5 part per million?

SARDINAS: Dr. Kolbye?

KOLBYE: On a broad scale, we've had approximately a decade, nationwide, of exposure to PCBs and probably longer than that. Look at the types of incidents that have occurred, such as recycling paper that has then become contaminated with PCBs and PCBs that found its way into animal feed. Some of it can cause migration of residues from paper board to human food. We've controlled that situation. We've controlled the situation of using heat exchangers, PCB heat exchange fluid. PCBs were used as silo sealants in many parts of the country for a while, and residues got into milk, into the sileage and into dairy cattle. That situation is under reasonable control. So we come full circle. The only problem exposure, so to speak, is fish from certain geographic areas where there is a propensity for PCB residues. There's one other aspect that's been involved. We've been monitoring, and

KOLBYE: (Continued) so has EPA, the residues of PCBs in human breast milk. There has been some research with which I'm not completely comfortable that would seem to indicate the expected, that fetus and weening animals that are being nursed, have an exquisite sensitivity or may have a more exquisite sensitivity to PCBs than anything else therein. And so, what one ends up doing is drawing a bright line in a spectrum of grays and making a value judgment as to whether there is enough protection for the coming decade from the 5 part per million level versus bringing it down. The decision was to try to bring it down and 2 as the bright line was drawn. Now it's impossible to give you lucid explanations why it isn't 1½, why it isn't 3, it's ultimately a value judgment.

KLUCK: My question was not relative to the number chosen but to the tests and results which have related to that number at this point. The other half of my question deals with the assumption that at one point in the ball game 2 ppm will be the minimum. In the past of the various fresh water species that have been tested in the Housatonic watershed, pretty much every species has shown itself at or above the 2 ppm. Striped bass that have been previously tested have just been marginally below 2 ppm. I want to know what effect this 2 ppm will have on health activities, fisheries management, further investigatory activities,

KLUCK: (Continued) public education, etc., along the entire Housatonic watershed and the Sound.

SARDINAS: As Dr. Kolbye mentioned earlier, the Food and Drug Administration is primarily concerned with interstate transport of these materials and I guess what you're really asking is for an intrastate consideration of these materials.

LEWIS: I think so far we've been fairly consistent with the old standard of 5 parts per million and I don't anticipate any change just because the standard changes to 2 parts per million. Dr. Kolbye pointed out correctly that the FDA is looking primarily at interstate. They're also looking primarily at commercial operations. In the Housatonic River we're talking about sports fishing and private collection and consumption of fish. FDA certainly isn't going to regulate this. We don't have any regulatory powers. It's not really a question of imposing any standard. I think the promulgation of a standard is irrelevant to our policy and what we tell the public, with the possible exception that it does at least give a rough ballpark figure upon which to hang our hat. What we're anticipating doing with the 2 parts per million standard is simply considering the areas of the river that we post. We also are considering warning about salt water fish consumption such as striped bass, which may fall into this 2 parts per million

LEWIS: (Continued) standard. This is in no way a prohibition. The only thing we're doing and it's not effected by the standard, is trying to inform the public to the best of our knowledge, what risk they're taking. We're not in any way restricting them, or forcing any prohibition on fishing. Our main goal is to put whatever risk may be involved in context with other risks we're exposed to. Now, there's one other area that you sort of touched on and it's really within DEP's responsibility rather than ours, and that is the question of whether it's going to be state policy to stock the Housatonic River with trout. That's quite a different question. I don't see how our health policy has any effect on that whatever since presumably the stocking of trout has nothing to do with treating the river as a food source. It has to do with sports fishing. And again, I think the question of sports fishing versus eating fish is not necessarily related, since sports fishermen presumably are fishing for the pleasure of catching fish, not necessarily for the pleasure of eating fish. I think they're not necessarily related.

SARDINAS: Our next panelist is Dr. Armond Oppenheimer. Dr. Oppenheimer is the Conservation Chairman of the Housatonic Audubon Society, is a Professor at Columbia University, and a Fellow of the American Association for the Advancement of Science. Dr. Oppenheimer is also a member of our PCB Citizens Watchdog

SARDINAS: (Continued) Committee. And he's from Lakeville, Connecticut. Dr. Oppenheimer.

OPPENHEIMER: In view of the fact that the PCBs are found all over this planet in the polar regions and every lake and every stream in our country and in, certainly in the northern hemisphere, and since the question of the carcinogenic, mutagenic, reproductive damage and other toxic effects of PCBs with their contaminant, dibenzofural, are paramount to a national health policy program. And since the additive affects of PCBs together with other environmental toxins are of paramount importance in consideration of the PCB problem, and finally, since PCBs enter the environment through groundwater, through evaporative processes, into the environment, into the air, they're deposited on the soil, and perhaps they contaminate our vegetable, fruit products, I'd like to address a question to Dr. Weisburger. Namely, since Aroclor 1254 is only one of a number of PCB compounds, and since the additive effects of PCBs and many other environmental toxins are not taken into account in this research, how conclusive is this experiment, and can we take any comfort in the negative findings?

WEISBURGER: I would say that we cannot take any comfort in the negative findings because we know from many animal experiments that there's a great difference in the strain response to known

WEISBURGER: (Continued) carcinogens. There can be variation with some very potent carcinogens from 0 to 100% tumor incidence. So I would agree that we cannot take comfort from this negative study. We don't know, in fact there is one other study in the Sherman strain rat with Aroclor 1260 where it was reported that there were tumors were obtained.

OPPENHEIMER: The only other aspect of it was the question of the accumulation of PCBs over a lifetime, and their interaction with other environmental toxins, as a very important consideration in assessing the pathological threat to human health.

WEISBURGER: Unfortunately, there has not been enough laboratory experiments to make any statements. It takes a great deal of time and effort to do a single study. And to do this properly one must have to test a PCB with many other environmental chemicals and that just has not been done.

SARDINAS: Dr. Kolbye, I think you wanted to make a statement.

KOLBYE: Well, perhaps just a brief comment. One of the main effects of the PCBs depending upon degree and position of chlorination, seems to be related to inducing or inhibiting various enzymes like the mixed function oxidase enzymes. It's of interest

KOLBYE: (Continued) though, that there are many naturally occurring substances in our diet that have similar properties. When we review the PCB toxicity and evaluate the various data in terms of arriving at some decision with respect to a recommended action level, we try to take into account not only the direct evidence, but anything that we know or suspect would be interacting. But there is a limit to how far one goes in that. And I suppose I should also say that while it is fashionable and political to say that there is no such thing as a safe exposure to any carcinogen, I think it is fair to say that the greater the exposure to a carcinogen, the greater the risk, and the lower the exposure, the lower the risk. And from the viewpoint of societal decision making, one has to draw a line someplace.

SARDINAS: Thank you, Dr. Kolbye.

SARDINAS: Dr. Brown.

BROWN: Yes. There has been a little work reported in the literature on the supplemental effects of PCBs with some environmental carcinogens. And the results are rather peculiar. In the case of, is worked on by the Japanese, in the case of polycyclic aromatic hydrocarbons it has been found that simultaneous administration of PCB decreased the incidence of tumors produced by the other

BROWN: (Continued) carcinogen. There is one of the chlorinated pesticides in which this effect was not observed. I don't remember which one I think it was heptachlos.

SARDINAS: So you're suggesting that in the literature, at least, there is a protective effect of PCBs?

BROWN: Yes, this would be as expected from Dr. Kolbye's remarks. That its primary effect is as an enzyme enducer. And in high doses it's going to simply change the metabolism of everything in your body.

SARDINAS: Sure. Thank you, Dr. Brown.

OPPENHEIMER: Would Dr. Brown suggest that we take a small capsule of PCBs with our vitamins? In as much as PCB contamination poses a national health problem, and since scientific and professional groups in many areas are engaged in research and technology aimed at finding solutions to the many problems related to PCBs, would it not be a great saving in time and money, and avoid duplication if the EPA set up a central office to collect, digest, evaluate, and promptly distribute information to the proper departments of the several states. As I say, this is not a debatable question, it is offered more as a suggestion.

SARDINAS: Thank you, Dr. Oppenheimer. Did you want to comment?

BROWN: Yes, that's a very interesting question and suggestion. Historically in studying any question of environmental pollution the three R's of environmental science are rates, routes and reservoirs. Better trace the flow of the pollutant. EPA as a whole has been very uninterested in these questions. The people who have studied PCB transport around the environment, and have done the most impressive jobs have been other state and regional groups, particularly in Michigan, Wisconsin, southern California, Chesapeake Bay area. Ian Nesbit of the Massachusetts Audubon Society has been very much concerned with the global flow. This is because in most cases when you get down to the problem of what do you do with a specific pond, river or lake, it is a local problem.

SARDINAS: Thank you, Dr. Brown. We have with us substituting for Mr. Melvin Schneidermeyer, Tom Turick, of the Department of Environmental Protection here at the State of Connecticut. Tom?

TURICK: Thank you, Mr. Moderator. My questions are of a general nature and they fall into three specific areas, and that is the health effects of PCBs through, number one, occupational exposure, number two, the consumption of contaminated fish; and

TURICK: (Continued) number three, possible health effects of PCBs in drinking water. My questions are addressed at no specific individual but rather at the panel in general. Dr. Brown, if I heard him correctly, today stated that the, the risks from occupational exposure to PCB could be as much as 100 times greater than the risk from consuming fish that have low levels of PCB in their tissues. I'm wondering what the panel's thoughts are on occupational risks as related to fish consumption risks. And would it be true then that, if there is to be a break through as far as cancer risks from PCB, would it not come about through research into occupational exposures versus recreational fishermen research?

BROWN: We think so. And there are some good model systems available in several populations of capacitor workers, both in the United States and Japan. These people were very heavily exposed for periods up to 30 to 40 years before the PCB use was terminated in 1977. And there are a number of studies of such populations going on. Some results have been reported already, and some are continuing.

SARDINAS: Dr. Weisburger?

WEISBURGER: It's usually thought that a period of 20 to 30 years of human exposure is equivalent to the type of experiment

WEISBURGER: (Continued) we do in rats, and therefore, if no human cancers have shown up after heavy exposure over such a long period, its deemed that the chemical probably does not have an effect on humans.

SARDINAS: Did you want to comment on that Dr. Douglas?

DOUGLAS: Yes, just to say that Dr. Fishbein and the group in New York have done some fairly nice work in looking at people occupationally exposed for periods of longer than 15 years. And as I recall in one of their papers they state that there are remarkably few findings in these individuals. I think that that's rather significant.

SARDINAS: Tom?

TURICK: My next question, I'm wondering do we know enough about low level exposure through consumption of fish to move towards, as far as our fish warnings on the Housatonic, a warning system, that for instance, Canada has employed. Canada's warning system is a very specific one, which recommends against eating certain size fish, and type of fish in certain areas of the river. Their system contains such parameters as the portion of fish per week that could be consumed. And also, I believe, it brings in the

TURICK: (Continued) population as a parameter. It warns specifically to certain segments of the population, such as pregnant women, and children. I'm wondering do we know enough about low level exposure through fish consumption that Connecticut could be moving towards this kind of warning?

SARDINAS: Dr. Kolbye?

KOLBYE: Well, I think one could set some priorities on the message that one conveys to the populace. Other states have faced this problem and have recommendations that in some instances appear right on the fishing license. I would recommend that this approach be considered by the State of Connecticut. It's really a matter for your own review and recommendations as to which warnings you think are most appropriate, or which cautions or recommendations. Just as an example, I think some of the authorities in the United States, state authorities have said not more than one meal of fish per week and from certain sources, not to be consumed by women in the child bearing years.

SARDINAS: Tom?

TURICK: My third question, at this time the state has no reason to suspect that we have any type of problem with PCBs in

TURICK: (Continued) drinking water in the Housatonic River basin. However, in New York, if my information is correct, communities do utilize the water from the Hudson River. They have been finding I believe up to 3 parts per billion in the drinking water supply. They will spend millions of dollars for treatment plants to try to reduce that level to 1.5 parts per billion. I'm wondering what is known about the health effects of drinking water contaminated with PCB in the range of 1 to say, 5 parts per billion?

KOLBYE: I don't think there are any data at that low level. And one only can make projections.

SARDINAS: Thank you. is Dr. John N. Lewis who's our next panelist, is the Chief of the Bureau of Health Promotion and Disease Prevention for the Connecticut State Department of Health Services. He is also our state epidemiologist. And I'll ask Dr. Lewis for his questions at this time.

LEWIS: Thank you, Tony. I basically have more comments than questions, and they're mainly directed at Dr. Brown's talk. First of all it's been the State Department of Health's policy as regards PCB exposure in Connecticut to, in agreement with Dr. Brown's comments about the relatively low toxicity and the

LEWIS: (Continued) relatively low risk to the general population, to deemphasize the toxicity of PCBs. In fact, in Connecticut, I think in terms of overall risks to humans, in comparing it to many other things it is a very low order of magnitude. In fact, we are only concerned in considering toxicity of PCBs, primarily with people who fish in the Housatonic River and eat the fish. And that's a fairly small part of the population. But as regards that group we have considered it important to put whatever risk they may have in context. Some comments related to extrapolating the animal data to human data, and in fact, Dr. Brown said there was no evidence of cancer in monkeys or man, related to PCBs. I think that statement is somewhat deceptive. First of all, humans are not experimental animals. And the kind of data that we have collected on rats is simply not available on humans. Second, monkeys which would be a good species to use theoretically, are not available for the type of experiments that were described by Dr. Weisburger, because they're very expensive and you can't do experiments on large numbers in the way you can with rats. So we have to rely on the rat experiments. However, in addition to that, I believe there is some data in man, albeit not laboratory data, but rather epidemiologic data, that does suggest cancer and liver damage in humans. And this includes, first of all, extensive data of elevation of liver enzymes in people exposed both in this country and in Japan to PCBs. And second, some

LEWIS: (Continued) evidence, fairly weak, of an excess of cancer among some Mobil Oil Company workers who had worked specifically with PCBs. Now this is inconclusive evidence, and it's certainly true that we don't have any final conclusions on this. On the other hand, I'm not aware of any very solid human epidemological data in the literature that suggests that it's not cancer causing in humans, so it's really, I think, just left in the unanswered category. And that's exactly the reason that we feel it's important to warn people about it. We have published, or at least given the press and the PCB Watchdog Committee, our estimates of just what order of risk we're talking about. And we did use figures like people in Connecticut, everyone in Connecticut eating a half a pound a day for a year of trout from the Housatonic, obviously not a situation that's likely to occur. But at least it gave us a standard of comparison, and one of the comparisons we came up with is that people eating that much fish in Connecticut would produce in our estimate, granted a crude estimate, an occurrence of excess cancer deaths in Connecticut that would be comparable to the excess deaths due to drowning in Connecticut. Now, that's a very small part of the deaths in Connecticut, drowning. We would estimate further that if people eat less fish the risks would be less than that of drowning. We're going to be making more estimates like this in the future to put the various substances that are not known to cause cancer in context. This, for example,

LEWIS: (Continued) is a miniscule risk compared to the risk of smoking cigarettes. It's a very low risk compared to the risk of working with asbestos, or working with radiation. Or a variety of other things, or the risk of not wearing your seatbelt, or the risk of eating certain fats that have a high fat content. So that, to put it in context, it is a very small risk. It is a real risk, however, and we feel that the, the standards that are being used by FDA give us a good cutoff point to inform the public that they are taking a risk when they eat fish from the Housatonic River. Some comments were made about fishing, and if you listened at what everybody says about PCBs, you would want to give up fishing. I don't believe that follows, because most fishermen I think get their rewards not out of eating the fish, but rather out of the sport of catching fish. We certainly have no warnings at all about catching fish and throwing them back. Some things have been said about standards. It's my understanding as regards standards, that standards are based primarily on toxicity other than cancer. I think we haven't heard any disagreement with the concept that with a cancer causing substance, even a very small exposure might confer a small risk. And it's for this reason that we are warning about all fish that have PCB in them, without real regard for the standard, because we think there is some risk at any level of PCB consumption. Until we know for a fact that PCBs don't cause cancer, I think we have to make that

LEWIS: (Continued) kind of warning. My comments are mainly directed as criticisms of Dr. Brown's speech, and perhaps you'd like to comment.

BROWN: Yes. On this first point, I don't think we are in as much a disagreement as it might sound. I said that in rats or mice the primary target of attack by the toxic forms of PCBs and the dibenzofurans and dioxins, appears to be the liver. And the characteristic syndrome produced by all of these agents is a progression, as Dr. Weisburger has indicated, starting out with enzyme induction, hypertrophy, adenofibrosis, and eventually hepatocellular carcinoma. This entire progression, culminating in liver cancer does not occur in guinea pigs, monkeys or man. As regards other types of cancer, the report that Dr. Lewis cited is of two refinery workers who were exposed to a large number of agents at Atlantic-Richfield, and eventually developed melanomas. The identification of the agent I think is still ambiguous, and certainly melanomas have not been associated with PCB exposures in any other case. With respect to the industrial workers who have had heavy PCB exposures for many years, the existing studies I might say, would probably be best described as superficial. The local medical people have looked at those groups, have eyeballed the data, and have said, yes, there are no gross effects, but the high quality matched cohort pair of study required to find out whether there

BROWN: (Continued) is a small incidence has not yet been done. However, I would still like to emphasize one point that you have made. These studies have all involved electrical workers who worked with highly purified PCBs. The PCB in the Hudson is not all high purity electrical grade. It has apparently come from a variety of sources. I certainly would have no idea what the toxicological quality of that particular PCB is. I think any health authority would have to act in a conservative manner until that determination had been made.

SARDINAS: Dr. Weisburger?

WEISBURGER: I'd just like to ask Dr. Lewis about these melanomas in the refinery workers, if he could tell me, did these people work in a southern location?

LEWIS: I'm afraid I don't know any more about that study. A warning came out of the National Institute of Occupational Safety and Health about three years ago. I never saw any follow up material on it.

WEISBURGER: Because melanoma is also associated with excessive exposure to sunlight. And if they worked in a southern location, and were outside all day, this would also be a factor to be considered.

LEWIS: Yes, I'm not even sure we're talking about the same study because my memory of this rough study was that it was Mobil rather than Atlantic-Richfield...

BROWN: Excuse me, you're right, I'll withdraw my comment.

LEWIS: My further memory of it was that it involved more than just melanoma, namely leukemia. But again, it was a very crude study and I'm just trying to point out that the really elegant studies that could demonstrate this epidemiologically just haven't been done. Nobody's going to hang their hat solidly on a slight excess cancer in some refinery workers who obviously are exposed to other substances, but, as you say, you have to act conservatively when you don't have enough information. And I think our responsibility is to err on the side of warning the public as opposed to not saying anything about it.

SARDINAS: Dr. Douglas, you had a comment?

DOUGLAS: Yes, I'd like to clarify one thing, with regard to the liver damage and the number of comments about the induction of liver enzymes. I just want to make it clear that it is a rather general phenomenon, and not something specifically associated

DOUGLAS: (Continued) with PCBs. Many agents which we use medicinally induce liver enzymes, so that in itself, whether it's bad or good, nobody really knows. It doesn't seem to bother people or animals in any way and is quite a reversible process. The concern about the induction of liver enzymes is that because these enzymes are more active, they may then convert other materials which we ingest, for example, nitrates, into carcinogenic agents in a more vigorous way than if we had not been exposed to PCBs and increased liver enzymes. There is evidence in the literature to suggest that exposure of humans to PCBs does produce liver enzymes. I'm not sure that there is any evidence in the literature to suggest that there is additional evidence of liver damage as is seen in the rat model.

SARDINAS: Thank you, Dr. Douglas. Dr. Kolbye, you had a comment earlier.

KOLBYE: I believe that it might be helpful to phrase estimates of risk as maximum theoretical risks from linear extrapolation. In other words, it's a very conservative approach, and probably, I should think, over estimating risk.

SARDINAS: Okay, thank you. John?

LEWIS: Just one other very brief question. The point has been made several times about the contamination of PCBs with dibenzofurans, and how that may in fact be the more important toxic principle. We've been assuming that consumption of pure PCBs would not produce exposure to dibenzofurans. On the other hand, there's the possibility that the PCBs, pure PCBs may be metabolized as dibenzofurans. I wonder if Dr. Weisburger could comment on whether humans may actually metabolize to the other substances, or whether other species such as fish, might do that?

WEISBURGER: I do not know of any studies where this has been proven.

SARDINAS: Dr. Kolbye?

KOLBYE: The information available to me, if I'm recalling it correctly, is that while with certain isomers you may get an apoxide formation of a PCB which may have electrophilic properties, and may be associated with a possible carcinogenicity. That the human metabolism of a PCB to a dibenzofuran would be rather unlikely, although theoretically possible, it would be unlikely.

SARDINAS: Well, at this point then, let me open up for questions from the audience.

MALISH: My name is Steven Malish. I'm section chief of the Toxic Hazardous Section of the State Department of Health Services. The question I have is directed to Dr. Weisburger. I've heard epidemiological evidence and toxicological evidence, but I'm still not quite sure what the effect of PCBs are on man. From animal studies it would appear that an impure grade or a grade of PCB of unknown purity, was used. Moreover, the toxicological test laboratories have recently come under fire because of shody testing procedures. Therefore, do we have any conclusive proof that pure PCBs or at least PCBs that impurities have been characterized do cause cancer in animals? Obviously we do not have any epidemiology data to this effect right now.

SARDINAS: Dr. Weisburger?

WEISBURGER: We have not done any tests on a pure PCB, containing only PCB and none of the impurities, or a PCB which has been definitively characterized. I would like to comment, however, on the remark you made about the quality of the work and the toxicology and the pathology and so forth. All the tests which were done were performed under NCI contracts. If a report is published it's a sign that the pathology has been reviewed by both NCI and outside pathologists. The statistics such as for the animal handling

WEISBURGER: (Continued) and all that, have been reviewed and we have fairly good assurance that the work is of good quality. In other words, once a report appears it's very definitive.

MALISH: I certainly hope this is true, because we don't have definitive toxicological information, and people are basing their risk estimates on faulty data. (INAUDIBLE)

SARDINAS: Thank you, Dr. Malish.

HORNBECKER: My name is Joyce Hornbecker, I'm chairman of the Conference of Lake Authorities, vice chairman of the Lake Zoar Authority. I'm from Southbury, Connecticut. I would like to make a comment. I'm actually very aware of the people who are eating the fish. First of all the majority of the people in my area don't throw the fish back. I'm talking about ethnic groups that live in Southbury and in the area. People eat the fish for two reasons; it's a free meal, and for the ethnic groups in particular, fish is a very large portion of the diet. I'm very concerned about these people who are eating high concentrations of fish. When a black man from Waterbury, for instance, catches a fish, he doesn't know whether the concentration is 2 parts or 20 parts per million. The testing that the Lake Zoar Authority did initially indicated that some of our fish were 20, 22 parts

HORNBECKER: (Continued) per million. So we're talking about a variable. Also, the people who come to Lake Zoar and Lake Lillinonah to fish are people from Waterbury, from New Haven. A lot of them are black people. The only reason I'm making a point of this is that they eat the bottom feeders, such as bullheads. These people have the higher concentrations of PCB. I would like to see emphasis put on ways to cook fish that might reduce the toxic effects. Is it true that it tends to settle in the skin? If they remove the skin would they be less apt to become contaminated or not contaminated as highly? Is PCB in the head and in the liver? Should we say don't make fish chowders using the head and so forth? If they remove the skin, if they remove the head, if they remove the intestines and make a filet, is there less contamination? I would like to request that this kind of information be made available to these people. Thank you.

SARDINAS: Dr. Kolbye?

KOLBYE: I'd just like to mention that if, if one filets a fish, takes off the skin and broils it in such a way so that the drippings move away from the flesh of the fish, you can reduce your PCB intake considerably.

SARDINAS: Thank you, Dr. Kolbye. Next.

BANDOLIN: My name is Larry Bandolin, I'm a fisheries biologist at the State of Connecticut, Department of Environmental Protection. I have a statement and a question. Tom Turick mentioned that Canada has been quite specific as to their warnings about eating fish caught in Canada. New York State has taken the opposite tact. In their fishing syllabus which is a listing of the laws of the New York State which every fisherman gets when he gets a license, they have stated, and I am paraphrasing as I do not have that brochure with me, that you should not eat more than one-half pound of fish from any waters of the State of New York. My question is, an extensive effort was undertaken this year to collect fish from the Housatonic River in Connecticut, both from the Massachusetts border right down to the lower sections of the river. These fish have not been analyzed yet for PCBs. Would it be wise to analyze these fish for both PCBs and dibenzofurens?

SARDINAS: Dr. Kolbye?

KOLBYE: Just simply to mention that dibenzofuran analysis is tricky. And the analytical sensitivity is not what it should be. And it's a tough method as I'm sure you may well be aware. Earlier I mentioned that I would be interested in somebody looking at fish liver, because I suspected it may be concentrated there.

KOLBYE: (Continued) I think it would be worth doing.

BANDOLIN: The fish have been cleaned and are now fillets, some with skin on, some with skin off, depending on how the fishermen would be eating that particular fish. They would not have their livers any longer.

KOLBYE: Well, it might be of interest to take a couple fflets where you know they came from a high PCB fish, and try it on one or two and see what you find.

BANDOLIN: Thank you.

SARDINAS: Are there any other questions from the audience?

COLVIN: My name is Frank Colvin, I represent the Bristol Fish and Game Club. We have approximately 325 members. I'm a member of the PCB Watchdog Committee, and also a member and a commissioner of the Bristol Water Department. My question is a question that has been asked me many times from some of our members who fish the Housatonic exclusively: How long does it take a stocked fish, say, in April, before the season starts, to consume PCBs from the water? Can a person catch a fish within a week and feel free that he's not eating a fish with PCB content?

KLUCK: New York State a year or two ago ran a test and showed within two or three weeks they were approaching their maximums, if I'm not mistaken.

BROWN: Yes, I'd emphasize that fish pick up PCBs mainly through the gills, partly through feeding, in studies that have been done in the past, they reach an equilibrium level within about 30 days. However, the total PCB content will vary with the fat content of the fish. And as the fish gets older and the fat content gets higher, the total PCB will be higher.

COLVIN: Thank you very much.

SARDINAS: Are there any other questions from the audience? back and forth.

FOSTER: My name is Joanne Foster, and I'm a lay person with the Southington Citizens Action Group. Recently we have discovered that we had had contaminated public water supply. This is my first exposure with the PCB incidence. I'm a little confused as to the purpose of the meeting here today. Is it to clarify if there is a potential danger with the consumption of PCBs? Or, is there not enough evidence to warrant that kind of a warning?

FOSTER: (Continued) I'm getting the impression that it's almost a choose your poison attitude. But if that's the case. I would like to be informed and to have the right to choose my poison, whether it be cigarettes, my water, or what it is. Is that the basic issue here today?

SARDINAS: The purpose of today's meeting was to discuss the public health issues, and the health effects of PCBs and to help the State of Connecticut make determinations regarding, informing the public and any continued action that we may take in the future. We're looking really to get as much informed, scientific information from national experts regarding PCBs and their health effects as possible.

FOSTER: So, the purpose eventually will be to make an informed decision?

SARDINAS: Absolutely, well, of course, we've made a decision already, and we have been trying to educate the public with regard to the information and data that we have currently. The purpose of today's meeting is to get some national opinions from experts regarding PCBs as a potential health problem so that we can make a better informed choice as time goes on with regard to informing the public.

FOSTER: Okay, thank you.

SARDINAS: John?

LEWIS: I'd like to just add to that a comment a small note about the study already going on in Connecticut, because I don't think it was mentioned specifically today. In addition to keeping an eye on what's happening nationally and in the world, from the point of view of opinions and data on PCB, we're doing a very specific study in Connecticut comparing people who are eating fish from the Housatonic River with the control groups who are not eating fish from the Housatonic River. We are evaluating what levels of PCB they may have in their bodies, and whether there's any evidence of specific physiological effects, or even disease effects from this exposure. So, although that's not apt to show anything very dramatic, because of the relatively low exposures in Connecticut, at least it may have some specific value to people in Connecticut.

DIXON: I hope that most of you have seen this bulletin, "PCBs and the Housatonic River," prepared by the Department of Environmental Protection, with some assistance from the Watchdog Committee. There are two statements I think should be read with

DIXON: (continued) caution -- that PCBs are known to cause cancer in laboratory animals. As I hear Dr. Weisburger, I don't think she said that. The next statement, should I eat fish from the Housatonic? No. The State Department of Health Services recommends that fish from the Housatonic not be eaten. I hope they aren't saying that.

SARDINAS: This is Randy Most. Randy is an epidemiologist with the Connecticut State Health Services, and has been very much involved with the study that Dr. Lewis mentioned earlier to look at some of the health effects of folks eating fish from the Housatonic.

MOST: I just would like to point out although Dr. Weisburger's study that she was discussing did not seem to show that cancer was formed in the animals, there have been a large number of studies done by other groups, both federal, private, in Japan, using various types of PCBs on rats, guinea pigs, mice, and a number of other studies that have been done that have definitely showed that this chemical produces cancer in animals. Now, I'm not stating which studies are good or bad, or making any value judgments, but the comment that Dr. Dixon just made about that statement is based on other studies that have been done and not

MOST: (Continued) Dr. Weisburger.

SARDINAS: Okay. State your name, please, who you represent.

SALCIUS: John Salcius I'm a sanitarian from the Manchester Health Department. My question is is there a reversible process in the body once you eat the i.e., PCBs, does the body rid of it? Or is it a culminative thing where you eat a little bit and it just keeps accumulating?

SARDINAS: Dr. Kolbye?

KOLBYE: It has a long biological half-life. And the biological half-life increases with the increasing degree of chlorination. You're talking about years. There is some depletion. There is some metabolism. What will happen is that some of the isomers will dechlorinate, and you'll get lower chlorinated isomers emerging and the lower the chlorination, the more quick the excretion from the mammalian body. But I wouldn't want to leave you with the impression that it's quick. You're talking about a long biological half-life generally speaking.

SALCIUS: Alright, say you ate a great deal of it, you had five, six pounds of fish, and you got PCB in your body. Would

SALCIUS: (Continued) the effect be the same thing as eating the small amount over a long period of time? I guess it would.

KOLBYE: Well, there are several implications to the statement that you just made. In terms of the residue level that you experience and the distribution in your body, they're likely to be different, a pulse exposure as compared to a low level exposure. They're not mathematically equivalent in terms of the absorption and the distribution and the compartments of the body which will have the residues; toxicity-wise the implications would be different. I hope that answers your question.

BROWN: I'd like to comment on that, because in the older literature, where people were exposed to contaminated PCBs there is data on what happened to them. For these people who got relatively low level exposures, going on chronically, generally after some months the chloracne syndrome came on. They developed facial acne and they felt awful, just felt sick and tired and headachey. When the exposure was removed, the symptoms generally disappeared over a period of months. I would anticipate that if you were able conceivably to eat that much PCB you would see the same symptoms.

SARDINAS: Dr. Kolbye?

KOLBYE: I'd just like to emphasize for the record, I believe Dr. Brown is referring to the Yusho patients in Japan.

BROWN: No, I am referring primarily to the American cases reported of industrial workers exposed in the 1930's. 40's.

KOLBYE: I see. I thought you were using the term in terms of ingested PCBs, that's why, I'm unaware of any human sickness in the United States that is related to the ingestion of PCBs.

SARDINAS: Dr. Douglas, you've done rather extensive research and have reviewed the literature, would you like to comment on that?

DOUGLAS: I'll just say that PCBs stay around for a very long time, and I think if you look at the people who had the Yusho exposures there are a number of years after their exposure where the symptoms and conditions still remain. So there is a concern that once these manifestations show themselves that they may well be around for a long time. But I am also unaware of any information in regard to U.S. exposures in that regard.

SARDINAS: Thank you.

SALCIUS: My final question. Is it through eating that you, you become exposed to PCB or can you contract it through breathing and contact?

SARDINAS: Dr. Kolbye?

KOLBYE: You can be exposed to it in a variety of ways theoretically. But the main human exposure in the United States comes from ingestion of food, primarily fish.

SALCIUS: Okay.

BLACK: I'm J. Stanley Black, I'm from New Haven. I'm an environmental sociologist with Yale University. I'm specifically referring to a number of comments both by the National panel and the State panel related to the quality of the various studies that have been done, both laboratory and epidemiological studies. There seems to be a fair agreement that truly elegant studies have in general not been done. There have been few or no primate studies and sophisticated epidemiological studies have not in general been done. Apparently some of the laboratory studies have not been of the kind of quality and size to be really definitive. I'm not certain whether anyone made the point as to whether or not there have been studies of metabolism of PCB in humans. But

BLACK: (Continued) in general, I'd like to ask whether, we can expect a continuation of the basing of public policy on research which apparently there is some agreement, is lacking in definitive results.

SARDINAS: Want to start, Dr. Kolbye?

KOLBYE: Yes, I don't think I would accept in my own mind a characterization that the available scientific evidence is tainted or grossly inadequate. If one has in mind one particular commercial laboratory, there were some studies conducted in days earlier, connected with PCBs where the reliability of that particular laboratory has been questioned. That's one issue. But in terms of the other data available from a variety of laboratories, I would say that the data that are available are reliable and are untainted. Then the question evolves, what additional tests should be done. One can evaluate whether or not to conduct more lifetime feeding studies in animals. If such are conducted, one should have a starting knowledge of what contaminants are also present, like what level dibenzofurans. From the epidemiological viewpoint, there is a study in part financed by FDA of sport fishing people in the state of Michigan. The study is attempting to get some idea of what their exposure is and to monitor to a degree that population over a longer period of time. Now the Michigan situation got further

KOLBYE: (Continued) clouded because of the polybrominatedbyfenyl incident. Anybody who would like further information on the Michigan study could contact the Michigan state health department.

WEISBURGER: I would like to make a comment too. The bioassay program of the National Cancer Institute is set up largely to test materials that people are exposed to. And that doesn't mean then, since people are not exposed to pure PCBs except in special cases, that's why we tested a commerical available aroclor with the resultant impurities. But the results show there's something there and it does give an indication that perhaps further stucies should be done.

SARDINAS: Dr. Douglas and then Dr. Lewis.

BLACK: Excuse me, I'd like to respond to that. I was not by any means complaining that a commercial preparation had been used as the test subject. It just seems to me that that's the only logical thing to do, since that's what humans will be exposed to.

SARDINAS: Dr. Douglas?

DOUGLAS: Unfortunately that's not often the logical thing

DOUGLAS: (Continued) to do as a scientist. As a scientist, we try to control as many of the variables as possible. And that necessarily means that our results do not always conform to the environmental types of exposure. I think that is the reason we express reservations about the scientific results, not because of the conduct of the experiments themselves, but because we are not sure how to interpret those experiments in the real world. That is a difficulty which we, as toxicologists, always face. We never are able to do the right experiment. It's for this reason that the standards which we set and we arrive at, are largely intuitive. They are not handed out in black and white as a result of experiments. They are the result of weighing a variety of situations. I do want to say also that one of the areas where one can get considerable information about toxicology in man is occupational exposures. Dr. Fishbein and his group, Dr. Selikoff and others in New York have done a number of excellent epidemiological studies of people who were exposed in Michigan, for example, in some capacitor factories. I reiterate again their comment was that the findings were remarkably few. And these are people who are exposed for long periods of time to quite high levels of PCBs. I think that those results are very significant.

BLACK: Just one question with regard to those sorts of studies. Dr. Brown suggested earlier that these studies relate to exposure

BLACK: (Continued) to the very pure PCBs as might have been the exposures in occupational cases. What I was given to understand from his earlier comment was that the, the actual environmental contaminants in say, the Hudson River, for example, were much, were likely to be much less pure PCB contaminant.

SARDINAS: I'm going to let Dr. Lewis respond first.

LEWIS: Yes, your original question related to public policy, and implied that public policy decisions should await more definitive answers. In this sense I would think that here at the State Health Department at least, we don't get into public policy at all because we really function more as a conduit of information then we do of setting policy. At least in this kind of area. I think in almost all of the areas where we're talking about carcinogens or suspected carcinogens in the environment, and where people are exposed to them, we're dealing with incomplete information. Our role is not to forbid people or place harsh restrictions on what happers when they're exposured to these substances, but rather to inform them, and to certainly err on the side of informing them about the risks as opposed to trying to make things look safer then they may prove to be.

BROWN: I would like to comment on the quality of the scientific

BROWN: (Continued) data available. As I said, this is an area in which there is an enormous amount of information available. There are really hundreds of papers out there. Obviously they run the complete spectrum of quality from outstanding to pretty dubious. It's also true that the questions that the investigators had in mind when they did the study are not necessarily the same as a public health authority might wish that he had in mind when he reads it. This is why I think it's quite important to go back to the original literature to find out what it said, and to compare observations from different sources. The importance of purity effects, of course, becomes evident when you make quantitative comparisons of the results of different investigators. In the case of PCB effects on monkeys, for example, successive reports out of the same group showed levels of toxicity varied by a factor of 100. This, of course, leads you to be a little bit concerned as to what they are looking for, but this is the type of thing that I think any review of the literature has to focus on.

MALISH: Steven Malish, Department of Health Services. What is the half-life of PCB in man? And if in fact it has a long half-life, wouldn't this mean that any additional exposure would build up the body burden of this substance in the body?

KOLBYE: Well, I don't know that there's a good precise answer

KOLBYE: (Continued) time-wise to your question, because one would have to in order to be accurate, specify what degree of chlorination you're talking about. Depending upon the rate of entry and the rate of excretion, you will hit a level where you should be in a degree of equilibrium. But there's no direct good answer to your question except to say that the more you're exposed to the higher the likelihood that you will be accumulating some of the residues in your body fat. The less that you're exposed to, the less likely. Whatever you are exposed to, and you do accumulate in your body fat, you will likely have there for a period of years.

MALISH: Thank you.

BROWN: Could I add to that comment? This is a question that has been on several people's minds as they review the human data. In the case of capacitor workers, it looks as though the half-life, of the lower, less highly chlorinated PCBs is probably of the order of two to four months. The data's very fuzzy still, but the half life is certainly longer than it is in rats. The higher PCBs, as Dr. Kolbye indicated, are quite persistent. This is not true for the people who have so-called Yusho disease, where they get PCB plus PCDF. Those people clean out their PCBs very rapidly, and the studies on Yusho victims show low levels of PCBs,

BROWN: (Continued) presumably due to the induction of mixed function aromatic hydrorylates enzymes.

SARDINAS: Dr. Kolybe?

KOLBYE: I'd like to ask if researchers have also taken a look at the persistence of the residues of quaterphenyls, over time, because I bet you those things really hang in there, in the Japanese people, and are complicating the entire picture to a degree.

BROWN: As far as I know, the only data on quaterphenyls come out of your laboratory.

SARDINAS: Next question, please.

GOLAS: My name is Kathleen Golas, I'm a National Science Foundation, Public Service Science Resident, working on hazardous waste management for the League of Women Voters of Connecticut. My question concerns the waste management of PCBs. One thing that I did learn this morning, definitely, is that we may be more concerned with the contaminant PCDFs, and not so much PCBs. I would expect that waste substances would be contaminated more highly than the substance that comes out of the factory, since

GOLAS: (Continued) I think I heard this morning that it's heat induced. I believe that the use of the PCBs is as an insulator, and therefore, subject to heat. I wonder if studies on disposal technologies, concur with the EPA in their estimation that PCB waste should undergo high incineration as a disposal mechanism.

BROWN: The procedure recommended by EPA for PCB disposal is high temperature incineration. This is at much higher temperatures than we're talking about, say, 2200 Fahrenheit, which is intended to guarantee absolute removal. This is currently recommended for PCB mixtures containing more than 50 parts per million of PCBs. EPA is currently recommending disposal in secure landfills for wastes containing lower levels. The EPA in its disposal practices is tending to treat all PCBs as if they were heavily contaminated with dibenzofurans and very toxic to deal with.

FLEMING: John Fleming, Watchdog Committee. I have a question to particularly Dr. Douglas, Dr. Kolbye and Dr. Weisburger. You're all acquainted with the literature that's available on the subject of PCBs relative to public health. I'm sure that you have some acquaintance with our work in the Health Department on blood sampling and fish sampling at PCB levels found in the Housatonic River. Each of you three have expressed a desire that maybe there's something we ought to know beyond what we do know. Dr. Douglas even pointed

FLEMING: (Continued) cut one of the fallicies, really, of the scientific approach of trying to control things too carefully. Maybe somehow or other we ought to learn to work with more variables. Anyhow, my question is this, what areas of research do you think might be fruitful areas to explore toward the end of having a better understanding of the effects of PCB on public health and nature at levels found in the Housatonic River?

WEISBURGER: Well, we could start with the simple experiment and feed animals low levels of PCBs. You could feed animals PCBs at 5 parts per million, see what effects there are compared with controls. That would be at least the foundation of, or at least part of the answer to the question.

SARDINAS: Dr. Douglas?

DOUGLAS: In one sense the approach you request is somewhat alien to me. You are asking me to go on a fishing expedition and again, as a scientist, one often sees a problem and then starts to ask questions about it, from a health point of view, for example. If I had to choose any particular area in which work, should be done, which would provide more information about the toxicity of PCBs to man, I think my interests would still be in the occupational environment, where there are high levels

DOUGLAS: (Continued) of exposure for long periods of time. If there's going to be any evidence of reactions to PCBs, I believe that it's in that type of situation that we're going to see it. In terms of examining it's effects on the environment, that's a very complicated problem, because one, as the EPA has to face in its toxic substances control act, we don't have to only worry about health effects, we have to worry about its effects on birds and plants and so on. There is some information on that in regard to PCBs. Its effects in food chains may be a rather interesting area to examine.

SARDINAS: Dr. Kolbye.

KOLBYE: From the health viewpoint there is a fair amount of ongoing research in a variety of centers. And while the data may not have been published, I think there's new knowledge coming down the road which will be helpful to us. All the evidence that I've seen, if we're talking about PCBs per se, is pretty consistent with a conclusion that we ought to try to minimize human exposure. Howscever, it is not a highly toxic compound, you know, as compounds go. That doesn't mean it's a compound that I'd like, or compound that I'd recommend to you. With respect to the dibenzofurans, we're up several orders of magnitude now, of increased toxicity if we're talking about certain isomers. And those are ones that

KOLBYE: (Continued) I think some additional research is needed on, with respect to animal studies. For example, I'm aware of a ongoing or at least a recent study, that deals with monkeys being exposed to dibenzofurans. Interestingly enough although I've not reviewed the data carefully yet, there is a suggestion that some of the effects of the dibenzofurans may be reversible as compared to the dibenzodioxin effects which were of a much more permanent nature. I'd like to close with a statement that one hopefully will not get the impression that because an action level is at 5 or 2 parts per million that a human is getting exposed to the same dosage that a rat would get exposed to if that rat were eating 2 parts per million in its total diet. The rat would be getting a far higher, more intensive exposure. The human exposure anticipated either at 5 or at 2 parts per million in fish is a far less of an exposure.

FLEMING: Thank you very much. That's been very helpful to me.

SARDINAS: Well, seeing no further questions, I'd like to conclude this by, first of all thanking representative Moffett's office for participating with the State Health Department in conducting this information seminar. Secondly, by thanking the panel and particularly the National experts, Dr. Kolybe, Dr. Douglas, Dr. Weisburger,

SARDINAS: (Continued) and Dr. Brown, for giving of their time, and a portion of their rather busy schedule. Finally, I thank also the audience who appeared today with concerns; I hope we all have been able to gleen some new information about PCBs. I thank all of you and this meeting is concluded.