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# News Release

Release

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## U.W. SEA GRANT P.C.B. BREAST MILK STUDY RELEASED

MADISON, Wis. -- The results of a three-year study involving 73 Sheboygan mothers on how PCBs, a widespread industrial contaminant, affect a baby exposed to PCBs while in the womb and later to PCBs in its mother's breast milk were released today by the University of Wisconsin Sea Grant Institute.

The major findings of the study included:

* Exposure to PCBs in the womb resulted in an increased number of infectious illnesses in the first four months of life. A mother's blood serum PCB level during pregnancy was positively associated with the number and type of infectious illnesses her infant suffered later, such as colds, earaches and the flu. But infant development and growth up to age four months was normal and unaffected by PCB levels.

* The benefits of breast-feeding outweigh the risks of PCBs in the milk. PCBs in breast milk did not seem to have any negative effects at the levels seen in this study. Breast milk contains natural immunoglobulins that apparently give an infant protection against infectious diseases and gastrointestinal illnesses despite the presence of PCBs. So infants who were exposed to PCBs in the womb may do better if breast-fed than if bottle-fed. But high levels of PCBs in breast milk may still be harmful.

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* The Sheboygan women's PCB levels were generally below national averages. Despite serious PCB contamination in the local environment, the average level of PCBs in the blood and breast milk of the Sheboygan women studied was below that of women studied elsewhere in the nation. The average PCB level in American women has been declining in recent years following the U.S. ban on most uses of PCBs.

* Fish and workplace exposure are minor factors in total PCB body burden. Eating PCB-contaminated fish appears to only slightly increase the amount of PCBs a mother carries in her blood serum and breast milk. Workplace PCB exposure also seemed to be a minor factor in blood and breast milk PCB levels.

The 73 women studied gave birth between September 1980 and September 1981. The women ranged in age from 18 to 36 years. Some of the infants were breast-fed, while others were bottle-fed.

Carried out in cooperation with the Sheboygan Public Health Department, the UW Sea Grant study was funded through special state legislative funds keyed to toxic substances research in Wisconsin.

The study was undertaken because the health effects of low levels of PCBs are largely unknown. Sheboygan was selected as the study site because of the large amount of PCBs in the local environment. Many of the area's large sport fish like salmon and lake trout and bottom-feeding fish like carp are contaminated with PCBs above the maximum five parts per million (ppm) level that the U.S. Food and Drug Administration considers safe for human consumption.

PCBs can enter the body from the air, drinking water and food. Like other chlorinated chemicals, PCBs (polychlorinated biphenyls) collect in body fat and are not readily expelled -- with the exception of nursing mothers. There, the chemicals are excreted in concentrated amounts in the fat of breast milk and are passed on to the nursing infant.

PCBs IN BREAST MILK - ADD TWO

"With respect to breast-feeding, the study is good news," said Jill Smith, who received a Ph.D. from the UW-Madison Department of Anthropology and a master's degree from the UW-Madison Department of Preventive Medicine for this study. "With respect to what happens to a developing infant exposed to PCBs in the womb, it's something we did not expect to find."

"The results should make people sit up and take note, because PCBs are not the only contaminants a mother is carrying in her blood serum that can cross the placental barrier," said Smith, who now lives in West Virginia.

Although the study only followed infants through the first four months of life, Smith projected the impact of PCB exposure through the first year of life.

"At the levels we found in our study -- which averaged 1.13 ppm in the breast milk -- we found that breast-fed infants, as compared to bottle-fed infants, should expect to have four fewer minor illnesses in their first year of life," said Smith.

The PCB study confirmed what the American Academy of Pediatrics has recommended for women concerned about possible health effects of PCBs in their breast milk: Don't worry unless you have a history of PCB exposure.

"If you suspect you have high levels of PCBs in your body from eating contaminated fish or from the workplace, you should go to your physician and have your blood tested," said Smith.

She recommends that if a woman's blood PCB level is above 11 parts per billion, then she might want to have her milk tested. If her milk fat PCB level is above 4 ppm, then she might want to discuss with her pediatrician the risks of breast-feeding.

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"I think this study should put some minds to rest considering the possible health effects of PCB exposure," said Soloman Belinky, director of the Sheboygan Public Health Department and area coordinator for the project. "PCBs are a problem, but if they are kept under control -- which is what the government is now doing -- and if people avoid PCB-contaminated fish, there is not much of a problem for developing children."

"In fact, this study may help state and local officials decide what action to take if there is a PCB problem nearby," Belinky added.

Based on their study, Belinky and Smith recommend that women who are pregnant or nursing or who plan to bear children in the future should avoid eating fish from known PCB-contaminated waters.

High levels of PCBs have long been known to cause health problems. In 1968, more than 1,000 Japanese became seriously ill after eating cooking oil accidentally contaminated with large amounts of PCBs. Afterward, the children born to the exposed Japanese women were underweight and had hyperpigmented skin. And in laboratory studies at UW-Madison, PCB levels on the order of 2 ppm in the diet of monkeys affected both their health and reproductive ability.

Since PCBs were first used in this country, hundreds of millions of pounds have been released into the environment. Though disposal and use of the compounds are strictly regulated today, PCBs already in the environment do not break down readily and are expected to remain a problem for some time. The compounds are most troublesome in the Great Lakes and Mississippi River, where they have built up to levels above 5 ppm million in the fat of many of the larger sport and bottom-feeding fish.

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# WHAT WE KNOW ABOUT HEALTH EFFECTS OF PCB'S

By John H. Craddock, PhD
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Presented Before
Summer National AIChE Meeting
August 30, 1982
Cleveland, Ohio
Symposium On
"Engineering Solutions to the PCB Problem"

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# WHAT WE KNOW ABOUT HEALTH EFFECTS OF PCB'S

POLYCHLORINATED BIPHENYLS, PCB'S, HAVE RECEIVED CONSIDERABLE ATTENTION OVER THE PAST DECADE BECAUSE OF INCREASING CONCERNS ABOUT THEIR POSSIBLE EFFECTS ON HUMAN HEALTH AND THE ENVIRONMENT.

AS A CLASS OF CHEMICALS PCB'S ARE ONE OF THE MOST MISUNDERSTOOD, MOST FEARED AND MALIGNED GROUPS OF CHEMICALS KNOWN TO MAN. THEY HAVE BEEN SINGLED OUT IN THE CONGRESS, LEGISLATURES AND NEWS MEDIA OF THIS COUNTRY AS POSING A GENERAL THREAT TO HUMAN HEALTH. CERTAIN ENVIRONMENTALISTS, REGULATORY OFFICERS, LAWMAKERS AND THE MEDIA HAVE DUBBED PCB'S AS "DEADLY TOXINS", "HUMAN AND ANIMAL CANCER-CAUSING AGENTS" AND "LIFE THREATENING CHEMICALS." THIS HAS RESULTED IN AN UNWARRANTED PUBLIC PERCEPTION THAT EVEN THE SLIGHTEST PRESENCE OF PCB'S REPRESENT A SIGNIFICANT HAZARD TO HEALTH AND THE ENVIRONMENT.

PCB'S ARE THE ONLY CHEMICAL SUBSTANCE WHICH CONGRESS SPECIFICALLY TARGETED FOR IMMEDIATE REGULATORY ACTION BY THE EPA ADMINISTRATOR. THE PCB BAN REGULATIONS ARE PREMISED ON EPA'S BELIEF THAT ANY EXPOSURE OF HUMANS TO PCB'S IS SIGNIFICANT AND MAY PRESENT AN UNREASONABLE RISK.

TODAY MANY SCIENTISTS BELIEVE THAT SUBSTANTIAL EVIDENCE DOES EXIST TO SUPPORT THE CONCLUSION THAT LOW-LEVEL EXPOSURES TO PCB'S DO NOT PRESENT A RISK TO HUMAN HEALTH OR THE ENVIRONMENT.

MUCH NEW INFORMATION HAS BEEN PUBLISHED ON THE HEALTH EFFECTS OF PCB'S SINCE EPA PROMULGATED ITS BAN REGULATIONS IN 1976. A RECENT SEARCH OF THE PUBLISHED LITERATURE SHOWS THAT OVER 5,000 SCIENTIFIC AND TECHNICAL PAPERS ON PCB'S HAVE BEEN PUBLISHED FROM 1976 TO SEPTEMBER, 1981. AT MOST, CONGRESS AND EPA HAD AVAILABLE LESS THAN 2,800 SCIENTIFIC ARTICLES WHICH WERE PUBLISHED DURING THE 10-YEAR PERIOD PRIOR TO 1976, INCLUDING ONLY ONE HUMAN EXPOSURE INCIDENT, UPON WHICH TO BASE THEIR FINDINGS OF ADVERSE HEALTH EFFECTS OF PCB'S.

ON THIS BASIS ALONE, OF SHEER NUMBERS OF PUBLICATIONS, THE EPA SHOULD EVALUATE THE NEW SCIENTIFIC INFORMATION AND REASSESS THE POSITION THAT ANY EXPOSURE TO PCB'S IS SIGNIFICANT.

OF PARTICULAR SIGNIFICANCE IN THE NEWLY PUBLISHED SCIENTIFIC REPORTS ARE THOSE RELATING TO HUMAN EXPOSURE (EPIDEMIOLOGY) STUDIES. WITHIN THE LAST 12-24 MONTHS A LARGE NUMBER OF HUMAN PCB EXPOSURE STUDIES HAVE BEEN PUBLISHED WHICH SHED SIGNIFICANT NEW LIGHT ON THE PCB HEALTH EFFECTS PROBLEM.

IN ADDITION, IN CONJUNCTION WITH THE NEW PCB RULEMAKINGS BEING CONDUCTED BY EPA UNDER MANDATE OF THE FEDERAL DC CIRCUIT COURT, SEVERAL INDEPENDENT GROUPS OF SCIENTISTS (ABOUT SIX AT LAST COUNT) HAVE RECENTLY RE-REVIEWED THE TOTAL BODY OF PCB HEALTH AND TOXICITY LITERATURE WITH PARTICULAR EMPHASIS ON THE HUMAN EXPOSURE STUDIES. THEIR INDEPENDENT CONCLUSIONS, WHICH ARE SUPPORTIVE AND CONSISTENT WITH EACH OTHER, ARE SUMMARIZED AS FOLLOWS:

1. PCB'S GENERALLY DO NOT POSE ANY SERIOUS RISK OF INJURY TO HUMAN HEALTH.
2. PCB'S ARE NOT HUMAN CARCINOGENS.
3. PCB'S HAVE NOT BEEN SHOWN TO ADVERSELY AFFECT HUMAN REPRODUCTION OR CAUSE BIRTH DEFECTS. PCB'S ARE NOT MUTAGENS OR TERATOGENS.
4. THE ONLY PROVEN ADVERSE HUMAN HEALTH EFFECTS RESULTING FROM PCB'S ARE TWO SKIN CONDITIONS: DERMATITIS AND CHLORACNE, WHICH ARE REVERSIBLE AFTER DISCONTINUANCE OF EXPOSURE.

I SHOULD EMPHASIZE THAT THESE CONCLUSIONS ARE NOT NEW OR STARTLING TO SCIENTISTS WHO HAVE BEEN INVOLVED IN PCB STUDIES OVER THE PAST DECADE. HOWEVER, THE WEIGHT OF THE NEW EVIDENCE UPON WHICH THEY'RE BASED SHOULD REINFORCE THE BELIEVABILITY AND, HOPEFULLY, RESOLVE THE ISSUE OF PCB HEALTH CONCERNS.

AS RECENTLY AS 1979, THE NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES REVIEWED THE SUBJECT OF PCB'S. IN THE REPORT PREPARED BY THE COMMITTEE ON THE ASSESSMENT OF POLYCHLORINATED BIPHENYLS IN THE ENVIRONMENT, THE NAS GROUP CONCLUDED WITH RESPECT TO ASSESSMENT OF PCB HAZARD:

> "AN ANALYSIS OF PCB DATA COMPILED FOLLOWING THE CRITERIA OF FIFRA AND TSCA PROPOSED GUIDELINES, LEADS TO THE CONCLUSION THAT PCB'S ARE PERSISTENT, AND ARE LIKELY TO ACCUMULATE. PCB'S DO NOT APPEAR PARTICULARLY TOXIC FOR SHORT-TERM EXPOSURE, BUT RESULTS ARE SUBJECT TO INTERPRETATION."

THE MOST RECENT 1981-1982 REVIEWS WERE CONDUCTED INDEPENDENTLY BY SEVERAL GROUPS OF SCIENTIFIC EXPERTS WHICH INCLUDED THE FIELDS OF CHEMISTRY, TOXICOLOGY, PATHOLOGY, EPIDEMIOLOGY, INDUSTRAL HYGIENE AND

MEDICINE, INCLUDING OCCUPATIONAL MEDICINE, TO NAME A FEW. THE DATA AND CONCLUSIONS FROM THESE STUDIES WERE RECENTLY SUBMITTED TO THE U.S. EPA FOR THEIR USE IN DEVELOPING NEW PCB REGULATIONS. IN ADDITION, EPA IN MAY OF 1982 SPONSORED A TWO-DAY SYMPOSIUM OF LEADING WORLD SCIENTISTS AT BETHESDA, MARYLAND, TO REVIEW AND DISCUSS "THE RECENT ADVANCES IN EXPOSURE, HEALTH AND ENVIRONMENTAL EFFECTS STUDIES OF PCB's." HOWEVER, THERE IS LITTLE PUBLIC AWARENESS OF THESE SIGNIFICANT STUDIES, THEIR REVIEWS AND THEIR IMPLICATIONS. IN ESSENCE, THESE CONCLUSIONS FROM ALL OF THE REVIEWS TO-DATE DEMONSTRATE AND STATE IN "LEGALESE" TERMS THAT:

1. PCB's PER SE DO NOT REPRESENT AN UNREASONABLE RISK TO HUMAN HEALTH AND THE ENVIRONMENT.
2. THAT ANY EXPOSURE TO PCB's IS NOT SIGNIFICANT.

I'D BRIEFLY LIKE TO DISCUSS IN MORE DETAIL WHAT WE DO KNOW ABOUT THE HEALTH ASPECTS OF PCB's FROM THE (1) LABORATORY STUDIES ON ANIMALS, (2) THE NOW AVAILABLE AND MORE MEANINGFUL RETROSPECTIVE STUDIES ON HUMAN EXPOSURE, I.E., EPIDEMIOLOGY STUDIES, AND (3) SOME ENVIRONMENTAL CONSIDERATIONS.

## LABORATORY STUDIES

THE PROBABILITY THAT A CHEMICAL WILL RESULT IN AN ADVERSE EFFECT IS A FUNCTION OF EXPOSURE TO THE COMPOUND AND ITS INHERENT TOXICITY. FORTUNATELY, ONE OF THE KEY PHYSICAL PROPERTIES OF PCB's WHICH MADE IT A VALUABLE INDUSTRIAL CHEMICAL, THE LOW VAPOR PRESSURE, ACTUALLY MINIMIZES THE POTENTIAL FOR EXPOSURE EVEN AT CONCENTRATIONS OF SEVERAL

THOUSAND PPM. ANIMAL TOXICITY LITERATURE DOCUMENTS THAT PCB'S ARE NOT A HIGHLY TOXIC COMPOUND. UTILIZATION OF STANDARDIZED CRITERIA FOR ACUTE TOXICITY CLASSIFIES PCB'S AS ONLY SLIGHTLY TOXIC TO NON-TOXIC (TABLE 1). THIS RANKING IS BASED IN PART ON THE FACT THAT THE DOSES REQUIRED TO PRODUCE SHORT-TERM TOXIC EFFECTS IN SOME TEST SPECIES ARE SO HIGH THAT THE DOSE NECESSARY TO CAUSE SIMILAR EFFECTS IN HUMANS WOULD EXCEED ONE QUART. A COMPARISON OF THE ACUTE TOXICITY OF PCB'S WITH OTHER COMMONLY KNOWN CHEMICALS IS SHOWN IN TABLE 2.

PCB COMPOUNDS HAVE BEEN EVALUATED FOR MUTAGENIC POTENTIAL IN SEVERAL SYSTEMS, RANGING FROM BACTERIAL TEST SYSTEMS TO INTACT ANIMAL STUDIES. THEY HAVE BEEN FOUND TO BE NEGATIVE IN THE AMES TEST WITH THE EXCEPTION OF A POSITIVE MUTAGENIC RESPONSE FOR ONLY ONE COMPOUND, THE 4-CHLOROBIPHENYL CONGENER. THIS EARLY STUDY HAS NOT BEEN CONFIRMED, DESPITE REPEATED ATTEMPTS TO DUPLICATE THE RESULTS. THIS LACK OF REPRODUCIBILITY IN THE EARLY FINDINGS CAN ONLY LEAD TO THE CONCLUSION THAT THE POSITIVE RESULT IS UNFOUNDED.

CHLORINATED BIPHENYLS ARE FOUND TO EXHIBIT NEGATIVE RESPONSES IN THE DOMINANT LETHAL TEST (A TEST FOR HERITABLE DAMAGE LEADING TO EMBRYO-TOXICITY) AND ARE NOT CLASTOGENIC (CAPABLE OF CAUSING GROSS OR MORPHOLOGICAL DAMAGE TO CHROMOSOMES OF BLOOD, SPERM CELLS OR RATS OR CULTURED HUMAN BLOOD CELLS). COLLECTIVELY, THE RESULTS OF THESE STUDIES INDICATE THAT LOW-LEVEL EXPOSURE TO CHLORINATED BIPHENYLS DO NOT PRESENT A MUTAGENIC RISK.

PCB'S HAVE PRODUCED EMBRYOTOXICITY AND SPONTANEOUS ABORTIONS IN LABORATORY ANIMALS, BUT ONLY AT DOSES WHICH ARE HIGH ENOUGH TO PRODUCE MATERNAL TOXICITY. PCB'S ARE NO MORE TOXIC TO THE FETUS THAN

Table 1

TOXICITY RATING CHART

| Rating | Animal $LD_{50}$ | Probable Oral Lethal Dose for Humans* |
|---|---|---|
| 1. Nontoxic | 15,000 mg/kg | |
| 2. Weakly Toxic | 5,000-15,000 mg/kg | 1 Pint-1 Quart |
| 3. Moderately Toxic | 500-5,000 mg/kg | 1 Ounce-1 Pint |
| 4. Toxic | 50-500 mg/kg | 1 Teaspoon-1 Ounce |
| 5. Extremely Toxic | 5-50 mg/kg | 7 Drops-1 Teaspoon |
| 6. Super Toxic | 5 mg/kg | Less Than 7 Drops |

* Average Adult of 70 kg

Adapted from Casarett and Doull's, Toxicology: The Basic Science of Poisons (2nd edition) Macmillan Publishing Co., Inc., New York (1980)

Table 2

ACTUAL TOXICITY AND THE TOXICITY RATING CHART

OF SOME SELECTED CHEMICALS

| Agents | Animal $LD_{50}$ (mg/kg) | Expected Human Dose* |
|---|---|---|
| PCBs | 14,000 | 1 Quart |
| Alcohol | 10,000 | 1 Pint-1 Quart |
| Table Salt | 4,000 | 1 Pint |
| Iron | 1,500 | 1 Ounce-1 Pint |
| DDT | 100 | 1 Teaspoon-1 Ounce |
| Strychnine | 2 | 4 Drops |
| Nicotine | 1 | 1 Drop |
| TCDD | 0.001 | Less Than 1 Drop |
| Botulinus toxi | 0.00001 | Less Than 1 Drop |

* Averege Adult 70 kg

Adapted from Casarett and Doull's, Toxicology: The Basic Science of Poisons (2nd edition) Macmillan Publishing Co., Inc., New York (1980)

MOST CHEMICALS WHEN GIVEN AT TOXIC DOSES TO THE MATERNAL ANIMALS.

THE CHEMICAL MANUFACTURERS ASSOCIATION (CMA) CONTRACTED WITH THE INDEPENDENT CONSULTING FIRM ECOLOGY AND ENVIRONMENT, INC. (E&E), TO PREPARE A REVIEW OF THE LATEST HEALTH EFFECTS INFORMATION ON PCB'S. IT IS E&E'S "INDEPENDENT PROFESSIONAL OPINION THAT 'ANY EXPOSURE TO PCB'S' DOES NOT POSE A SIGNIFICANT HEALTH RISK TO HUMANS." E&E CONCLUDED "THAT PCB'S DO NOT REPRESENT A CARCINOGENIC (GENOTOXIC/INITIATOR) RISK AND THAT, EVEN IF THEY POSSESS ONCOGENIC (EPIGENETIC/PROMOTING) ACTIVITY, THE RISK AT LOW EXPOSURES IS INSIGNIFICANT."

NUMEROUS STUDIES INVOLVING BOTH MICE AND RATS HAVE BEEN REPORTED, BUT TO-DATE, ONLY ONE STUDY EXISTS WHICH SUGGESTS THAT PCB'S MAY CAUSE AN INCREASE IN HEPATOCELLULAR CARCINOMA (LIVER CANCER). TWO OTHER CHRONIC TESTS IN RATS, AS WELL AS TESTS IN THE MOUSE, DID NOT REVEAL A STATISTICALLY SIGNIFICANT INCREASE IN LIVER CANCER OR ANY OTHER CANCER FROM EXPOSURE TO PCB'S. A RECENT BIOASSAY PERFORMED BY THE NATIONAL CANCER INSTITUTE DID NOT DEMONSTRATE THAT PCB'S PRODUCED CANCER IN THE RAT. COMPARING THE ONE POSITIVE STUDY WITH THE LARGE NUMBER OF NEGATIVE TESTS AND CONSIDERING OTHER IMPORTANT CONTRIBUTING FACTORS (SUCH AS THE SPONTANEOUS RATE OF LIVER INJURY AND LIVER REGENERATION WHICH CAN LEAD TO ABERRANT HEPATOCELLULAR GROWTH), SUPPORT THE CONCLUSION THAT PCB'S DO NOT REPRESENT A CANCER RISK TO HUMANS.

AT WORST, PCB'S AT HIGH OR ELEVATED DOSES IN LABORATORY ANIMALS MEET SOME OF THE CRITERIA FOR A CHEMICAL PROMOTER, I.E., THEY ENHANCE TUMOR GROWTH THROUGH EPIGENETIC MECHANISMS. PCB'S DO NOT INDUCE NEW TUMOR

GROWTHS. AT MOST, PCB'S HAVE BEEN SHOWN TO POSSESS ONLY A WEAK PROMOTING ACTIVITY. THEREFORE, THE THRESHOLDS BOTH PROPOSED IN THEORY AND OBSERVED IN ANIMAL STUDIES SUGGEST THAT THERE ARE SAFE EXPOSURE LEVELS FOR PCB'S.

IT SHOULD BE EMPHASIZED THAT TWO FACTORS CONFOUND ISSUES RELATING TO THE HEALTH EFFECTS OF PCB'S. FIRST OF ALL, THE EFFECTS OF PCB'S VARY GREATLY WITH THE DEGREE OF CHLORINATION OF THE BIPHENYL MOLECULE. SECONDLY, MOST OF THE TOXICITY STUDIES AVAILABLE HAVE UTILIZED COMMERCIAL PCB MIXTURES. THESE MIXTURES FREQUENTLY CONTAIN CONTAMINANTS WHICH MAY BE TOXIC THEMSELVES AT HIGH EXPOSURE LEVELS.

## EPIDEMIOLOGY

THE MOST MEANINGFUL INFORMATION FOR ASSESSING A CHEMICAL'S CHRONIC HEALTH EFFECTS CAN BE DERIVED USING HUMAN DATA FROM PROPERLY DESIGNED EPIDEMIOLOGY STUDIES. EPIDEMIOLOGICAL STUDIES ARE OFTEN POSSIBLE IN SITUATIONS WHERE PEOPLE HAVE BEEN EXPOSED FOR MANY YEARS.

A RECENT REVIEW OF TWENTY-ONE EPIDEMIOLOGY STUDIES FOUND THAT DURING OCCUPATIONAL EXPOSURE, PCB'S CAN CAUSE TEMPORARY SKIN PROBLEMS. YET, THERE ARE NO CLINICALLY OBSERVABLE LONG-TERM HUMAN HEALTH EFFECTS, INCLUDING THE OCCURRENCE OF CANCER. STUDIES OF NON-OCCUPATIONALLY EXPOSED POPULATIONS FOUND NEITHER DERMATITIS NOR OTHER CLINICAL EVIDENCE OF EXPOSURE-RELATED EFFECTS.

MANY OF THE RECENT EPIDEMIOLOGY STUDIES INCLUDE DATA ON LARGE NUMBERS OF INDUSTRIAL WORKERS WHO, OVER MANY YEARS, WERE OCCUPATIONALLY

EXPOSED TO PCB'S. THESE OCCUPATIONAL EXPOSURES, IN MOST CASES, INVOLVED CHRONIC PCB EXPOSURE LEVELS WHICH WERE ORDERS OF MAGNITUDE GREATER THAN ANY WHICH CAN REASONABLY BE FORESEEN UNDER EXISTING REGULATIONS. A COMPARATIVE REVIEW OF THESE OCCUPATIONAL-EXPOSURE STUDIES REVEALS THAT, LIKE OTHER CHEMICALS, PCB'S CAN CAUSE ADVERSE HEALTH EFFECTS, BUT IN MOST RESPECTS THESE EFFECTS HAVE BEEN MINIMAL. WHILE DERMATITIS AND CHLORACNE HAVE BEEN NOTED, THESE SKIN DISORDERS WERE REVERSIBLE AFTER DISCONTINUING THE EXPOSURE. IN SPITE OF OVER 50 YEARS OF USE, NO CAUSAL RELATIONSHIP HAS BEEN ESTABLISHED FOR ANY SPECIFIC TYPE OF CANCER, NOR HAS IT BEEN PROVEN THAT THE INCIDENCE OF CANCER MORTALITY HAS INCREASED FROM PCB EXPOSURE.

A RECENT STUDY BY THE NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH (NIOSH) FOCUSED ON 2,500 ELECTRICAL EQUIPMENT MANUFACTURING WORKERS. OVER HALF OF THE COHORT WAS OCCUPATIONALLY EXPOSED IN EXCESS OF 20 YEARS. SOME OF THE WORKERS WERE EXPOSED TO PCB'S FOR AS LONG AS 40 YEARS. THE STUDY FOUND NO EXCESS IN TOTAL MORTALITY, NOR IN MORTALITY DUE TO CANCER, CARDIOVASCULAR DISEASE OR NEUROLOGICAL DISORDERS. SINCE THIS STUDY FAILED TO DEMONSTRATE AN EXCESS CANCER RATE IN A HIGH-EXPOSURE POPULATION, IT PROVIDES SOME REASSURANCE THAT IT IS UNLIKELY THAT FUTURE STUDIES WILL SHOW ANY INCREASED RISK OF CANCER FROM PCB'S. AS ADDITIONAL DATA HAVE BEEN ACCUMULATED ON THE YUSHO INCIDENT, IT APPEARS THAT IT WAS NOT THE PCB'S WHICH WERE RESPONSIBLE FOR THE ADVERSE HEALTH EFFECTS OBSERVED BUT THE EXTRA-ORDINARILY HIGH LEVELS OF IMPURITIES IN THE JAPANESE COMMERCIALLY MANUFACTURED PCB MIXTURE.

THE CONCLUSIONS REACHED BY ALL OF THE EPIDEMIOLOGIC STUDIES ARE IN DISTINCT CONTRADICTION TO STATEMENTS APPEARING IN THE PRESENT COURT OF APPEALS DECISION THAT "PCB'S ARE EXTREMELY TOXIC TO HUMANS", AND THAT "EPIDEMIOLOGY DATA AND EXPERIMENTS ON LABORATORY ANIMALS INDICATED THAT PCB'S POSE CARCINOGENIC AND OTHER RISKS TO HUMANS."

## ENVIRONMENTAL CONSIDERATIONS

ALTHOUGH MOST RECENT SCIENTIFIC LITERATURE REVIEWS HAVE FOCUSED ON HUMAN HEALTH EFFECTS STUDIES, RECENT PUBLICATIONS ON THE EFFECT OF ENVIRONMENTAL CONTAMINATION BY PCB'S DO NOT SUPPORT THE CONCLUSIONS THAT PCB'S HAVE EXHIBITED A SIGNIFICANT IRREVERSIBLE EFFECT ON THE ECOSYSTEM. EARLY REPORTS DOCUMENTED THAT PCB'S ARE BOTH PERSISTENT IN THE ENVIRONMENT AND THAT THEY BIOACCUMULATE IN SOME SPECIES. SCIENTISTS AGREE GENERALLY THAT THE HEAVILY CHLORINATED PCB HOMOLOGS ARE PERSISTENT AND BIOACCUMULATE TO SOME DEGREE. HOWEVER, CURRENT AVAILABLE SCIENTIFIC EVIDENCE DOES NOT SUPPORT THE ALLEGED HEALTH AND ENVIRONMENTAL EFFECTS.

FEAR OF DIRE ECOLOGICAL CONSEQUENCES CAUSED THE ADMINISTRATOR OF EPA TO FIND "THAT ANY RELEASE OF PCB'S INTO THE ENVIRONMENT WILL EVENTUALLY RESULT IN WIDESPREAD EXPOSURE OF WILDLIFE, INCLUDING SOME OF MAN'S FOOD SOURCES AND HUMANS, AND THAT SUCH EXPOSURE MAY HAVE ADVERSE EFFECTS." IN 1976, EPA PRESENTED DATA ON PCB CONTAMINATED FOOD FOR THE YEARS 1973-1975 (TABLE 3). THESE DATA CLEARLY INDICATE A SIGNIFICANT DOWNWARD TREND IN PCB LEVELS, INCLUDING A DECLINE IN THE HIGH CONCENTRATIONS FOUND IN FISH. THESE DOWNWARD TRENDS IN CONCENTRATION LEVELS ARE THE RESULTS OF VOLUNTARY INDUSTRY ACTIONS

Table 3

PCBs IN FOOD

| Products | 1973 | 1974 | 1975 | Maximal Concentration (50ppm) |
|---|---|---|---|---|
| Fish | 60.4 | 44.0 | 17.8 | 123.0 |
| Milk | 2.2 | 2.6 | 0.7 | 2.3 |
| Eggs | 1.1 | 4.2 | 0.0 | 11.0 |
| Cheese | 0.9 | 2.6 | 0.0 | 2.8 |
| Feed Components | 12.7 | 0.0 | 0.3 | 9.0 |
| Animal Feed | 7.2 | 0.0 | 0.0 | 199.5 |
| Processed Fruit | 4.5 | 0.0 | 0.0 | 19.2 |
| Baby Food | 1.1 | 0.0 | 0.0 | trace |
| Meats, Poultry | 1.9 | 1.2 | 0.3 | 5 ppm |

Adapted from Jelinek, C. F. and Corneliussen, P. E., Levels of PCBs in the U.S. Food Supply, National Conference on Polychlorinated Biphenyls (EPS-560/6-75-004) pp. 147, (1976)

TAKEN IN 1971 TO REDUCE USAGE AND POSSIBLE EXPOSURE TO PCB'S. THESE RESPONSIBLE INDUSTRY ACTIONS WERE TAKEN PRIOR TO PROMULGATION OF TSCA IN 1976 AND CERTAINLY MUCH EARLIER THAN THE ACTUAL PCB REGULATIONS WHICH BECAME EFFECTIVE IN MID-1979.

VERY RECENT DATA ON CONTAMINATION OF FISH AND NATURAL BODIES OF WATER FROM COMMERCIAL PCB MIXTURES HAVE SHOWN THAT ENVIRONMENTAL LEVELS ARE STILL DECREASING AT A SIGNIFICANT RATE. LEVELS IN FISH IN THREE DIFFERENT AREAS OF THE UNITED STATES (GREAT LAKES, NEW YORK STATE AND ALABAMA-GEORGIA) WERE IN THE RANGE OF 1 TO 5 PPM IN 1980-81, AS CONTRASTED WITH THE DATA WHICH RANGE FROM 60 PPM IN 1973 TO 18 PPM IN 1975. IN ADDITION, AT LEAST TWO RECENT PUBLICATIONS DEMONSTRATE THAT THE EARLIER PREDICTION OF EXTREME PERSISTENCE OF THE HIGHER CHLORINATED PCB HOMOLOGS IN THE ENVIRONMENT IS NOT OF THE ORDER OF A HUNDRED YEARS BUT IS MEASURABLE AND IS, ON THE AVERAGE, IN THE RANGE OF 40-50 MONTHS. THESE DATA ARE BASED UPON HALF-LIFE VALUES OF PCB'S IN THE TISSUES OF FISH ENVIRONMENTALLY EXPOSED. IN ADDITION, RECENT DATA PUBLISHED BY THE NATIONAL RESEARCH COUNCIL (1979) HAVE SHOWN A SIGNIFICANT REDUCTION OF PCB CONCENTRATIONS IN AIR OVER THE NORTH ATLANTIC OCEAN. THESE DATA HAVE DEMONSTRATED AN ORDER OF MAGNITUDE DECREASE IN PCB CONCENTRATIONS IN AIR RANGING FROM $0.76 \pm 0.55$ NG/M$^3$ IN 1973 TO $0.074 \pm 0.099$ NG/M$^3$ IN 1977.

THUS, A THOROUGH EVALUATION OF THE TOXICOLOGICAL AND, TO A LESSER EXTENT, THE ENVIRONMENTAL LITERATURE SUBSTANTIATES THE CONCLUSION THAT UNDER MOST CONDITIONS OF EXPOSURE PCB'S HAVE NOT BEEN DEMONSTRATED TO BE HAZARDOUS TO THE PUBLIC AND THAT LOW EXPOSURES

WILL NOT LEAD TO HARMFUL CONSEQUENCES. HOPEFULLY, THE EPA AND GOVERNMENT SCIENTISTS WILL TOTALLY REVIEW THE RECENT DATA AND PUBLISHED LITERATURE AND REACH SIMILAR CONCLUSIONS TO THOSE OF THEIR OTHER SCIENTIST COLLEAGUES.

# RECENT EPIDEMIOLOGIC STUDIES OF PCBS

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Before the Yusho incident in 1968, published studies of the health effects of PCBs, with the exception of Meigs et al (1954), were essentially clinical studies of occasional accidental severe exposures. In the following decade ten epidemiologic studies were published (in addition to the many reports on the Yusho incident itself), all but one of which dealt with occupationally exposed populations, and only one of which studied the relationship between cancer and PCB exposure (Gaffey, 1982).

## DISCLAIMER

This document is a preliminary draft. It has not been released formally by the Office of Drinking Water, U.S. Environmental Protection Agency, and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical merit and policy implications.

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## 2 PCB EPIDEMIOLOGY

Since 1978 there have been ten epidemiologic studies of the health effects of PCBs. Seven of them are cross-sectional investigations of symptoms and biochemical parameters. Of these, five are occupational, one is a study of both occupational and non-occupational exposure, and one is non-occupational. The remaining three reports are cohort mortality studies of occupationally exposed groups. In addition, there has been a report on cancer mortality in the Yusho population.

This paper briefly summarizes the status of the epidemiologic evidence on health effects as of 1978, and reviews and evaluates the subsequent studies in detail.

### THE EVIDENCE AS OF 1978

The Yusho incident of 1968 at first appeared to be a classic example of the effects of a massive ingestion of PCBs. Over 1000 Japanese became ill after eating a cooking oil contaminated with Kanechlor 400, a PCB compound of Japanese manufacture. The most common acute symptoms observed were hyperpigmentation and acne-like lesions, central nervous system symptoms, discharge from the eyes, and vomiting and diarrhea. These symptoms were dose related, and some of them persisted for as long as six years. Laboratory tests showed disturbances of liver function and fat metabolism, and there were clinical reports suggestive of some abnormalities in the children of Yusho mothers (NIOSH, 1977).

As of the end of 1977, 51 deaths among Yusho patients had been identified, with an apparent excess of cancer deaths (Urabe et al, 1979). However, the data were not adjusted for age, and the completeness of ascertainment of the deaths is not known. The elapsed time from the original incident to the reported deaths (one decade) was short enough to cast doubt on whether the cancers could in fact have arisen from the Yusho exposure.

In any case, in the decade following the Yusho incident analytic techniques for identifying PCBs and allied compounds improved considerably, and the cooking oil was reanalyzed. The new analyses showed that the Yusho patients had in fact ingested about the same amount of polychlorinated dibenzofurans (PCDFs) as of PCBs, in addition to polychlorinated quater-phenyls (PCQs). Current determinations of blood and tissue levels of these other compounds in Yusho patients have shown total levels about equal to that of PCBs (Kimbrough, 1980). It therefore appears that the epidemiologic findings in the Yusho incident should properly be attributed to the more toxic PCDF rather than to PCBs.

There were nine other published cross-sectional studies of symptoms and biochemical parameters related to PCB exposure, one of which was non-occupational, and one occupational study of cancer morbidity and mortality.

In summary, the occupational studies found chloracne or other dermatitis, and mild liver function abnormalities

in the absence of clinical illness, to be associated with PCB exposure. Two studies of cholesterol levels gave contradictory results, and one study of triglyceride levels showed an increase. The non-occupational study showed no association between blood PCB levels and any of the Yusho symptoms, but did not examine liver function or fat metabolism.

The cancer study found an apparent excess of malignant melanoma based on three cases, but was later withdrawn because of concern about whether the exposed population had been correctly identified.

## RECENT STUDIES

The seven cross-sectional studies completed since 1978 address a broader range of health effects than did the pre-1978 studies, and in some cases used formal statistical techniques to take account of confounding variables such as age, sex and weight. Two of the studies, Fischbein et al (1979) and Smith et al (1982) evaluated their findings in relation to higher chlorinated and lower chlorinated PCBs separately. The studies' findings can be classified under five general headings; dermatologic effects, liver function, fat metabolism, other objective findings, and reported symptoms and illnesses. The cohort mortality studies, although they collected data on all causes of death, were concerned primarily with cancer.

Dermatologic Effects

Table 1 summarizes the results of the five studies that reported on dermatologic effects. The negative study of Baker et al (1980) examined 18 exposed workers, 19 members of their families, and 89 community residents with exposure to fertilizer containing PCBs. The rest were occupational studies, two of which found chloracne and all of which found dermatitis.

Fischbein et al (1979) reported that 50 percent of 326 capacitor manufacturing workers reported a history of dermatological symptoms, the most common being a rash. Those with symptoms had higher blood levels of high chlorinated PCBs. Maroni et al (1981 II) reported ten cases of dermatitis (five diagnosed as active or past chloracne) in 80 exposed workers, but provided no further data on the blood PCB levels of those with dermatitis vs. those without. Chase et al (1982) found increased dermatitis, and some chloracne, in the most exposed group out of 120 railroad maintenance workers, but within the group found no significant association with blood or fat PCB levels. Smith et al (1982), in a study of 92 employees of two utility companies, found no consistent association between dermatitis and either high or low chlorinated blood PCB levels.

Although the data are not consistent, they suggest that there may be a gross dose response relationship between dermatitis and blood levels of PCBs, possibly

complicated by variations in individual susceptibility and in work habits that may affect absorption of PCBs through the skin.

Liver Function

Table 2 shows the results of the six studies that investigated liver function. The two non-occupational studies showed no liver function anomalies associated with blood PCB levels. The first one did not adjust for confounding variables (Baker et al, 1980). The second, a study of 458 residents of a community with high environmental levels of PCBs, found an association which disappeared when age and alcohol consumption were taken into account (Kreiss et al, 1981).

Of the four occupational studies, three showed various liver function anomalies related to blood PCB levels. Chase et al (1982) adjusted the results for age. Smith et al (1982) adjusted the data for age and sex. The latter study showed a significant association of liver function anomalies with low chlorinated blood PCBs in one of the two plants studied but not in the other. Maroni et al (1981 II) found liver abnormalities associated with elevated blood PCB levels, but the liver abnormalities were defined as liver function anomalies or liver related symptoms or clinical findings of abnormality. They state that "only in a few cases was a well-defined liver failure (presence of symptoms, hepatomegaly, and abnormal liver findings) present."

Fischbein et al (1979) found no liver function anomalies associated with exposure, and in fact commented on the "paucity of abnormal results" in their biochemical studies.

With the exception of Maroni et al, the occupational studies agree in finding few or no liver function abnormalities, and no associated clinical illness.

Fat Metabolism

Table 3 summarizes the results of the five studies that examined fat metabolism. Fischbein et al (1979) found no association between cholesterol or triglycerides and blood PCBs. Kreiss et al (1981) found an increase in cholesterol with increasing blood PCB levels, but no relationship of triglycerides to blood PCBs when an adjustment was made for cholesterol level. Two other studies, Baker et al (1980) and Chase et al (1982) agree that cholesterol is not associated with blood PCBs but that triglycerides are.

Smith et al (1982) found cholesterol levels to be positively associated with low chlorinated PCBs in one of the two plants studied. Triglycerides were positively associated with high chlorinated PCBs in one plant and negatively associated in the other, where they were positively associated with low chlorinated PCBs.

The preponderance of evidence is that cholesterol is not associated with blood PCBs. There is no obvious

explanation for the association of cholesterol and blood PCBs found by Kreiss et al. However, their use of cholesterol as an adjustment factor for triglycerides implies that they view cholesterol as an independent variable that predicts triglycerides. The results of Baker et al and Chase et al do not support this view, since they show that the putative predictor, cholesterol, is not associated with blood PCB levels while triglyceride levels are. The association between triglycerides and blood PCB levels appears to be ambivalent at the least.

Other Objective Findings

Fischbein et al (1979), Baker et al (1980) and Maroni et al (1981 II) examined blood chemistry and found no association with blood PCB levels.

Kreiss et al (1981) found a statistically significant positive association between diastolic blood pressure and blood PCBs after adjusting for cholesterol, triglycerides, smoking and race. However, Smith et al (1982) reported no such association.

Warshaw et al (1979) reported decreased vital capacity in 243 capacitor manufacturing workers compared with published reference standards. However, most of the study population were current or former smokers, while the reference standard is based on a non-smoking population. The affects of smoking could be sufficient to explain the findings.

Reported Symptoms and Illnesses

Six of the studies investigated a range of symptoms and illnesses. Two of them reported positive findings in occupationally exposed populations. Fischbein et al (1979) reported a history of gastrointestinal symptoms in 18 percent of 326 capacitor manufacturing workers, a prevalence of from 3.0 to 15.2 percent of various musculoskeletal symptoms, and a prevalence of from 4.8 to 27.8 of various neurological symptoms. These were, however, unrelated to blood PCB level or duration of employment. Maroni et al (1981 II) reported eight cases of gastrointestinal complaints in 80 exposed workers with no indication of whether there was a relationship to blood PCB level or duration of employment. They also reported two bleeding haemangiomas and one case of chronic myelocytic leukemia.

The other four studies reported no PCB related findings. Specifically Baker et al (1980) found no relationship with any of the following; fever, weight loss, anorexia, fatigue, headache, eye irritation, cough, shortness of breath, nausea, vomiting, diarrhea, abdominal pain, arthralgia and persistent rash. Kreiss et al (1981) reported the same thing for prevalence of illness or weight loss in the previous year, use of medication, use of medical care, history of heart disease, and percentage of pregnancies ending in miscarriage, stillbirth or infant death.

Chase et al (1982) failed to find any evidence of organ toxicity in a review of the medical histories and physical findings in a group of exposed railroad maintenance workers, and Smith et al (1982) reported no consistent dose-dependent increase in either symptoms or past illnesses. Their inquiry covered digestive, respiratory, central and peripheral nervous system, dermatologic, and emotional symptoms.

The evidence shows no PCB related symptoms or illnesses, since the two reports out of six that mentioned symptoms failed to show an association with level or duration of exposure.

Carcinogenicity

Table 4 shows the major findings of cancer mortality in three cohort studies of PCB exposed workers. Brown et al (1981) studied a cohort of capacitor manufacturing workers in two plants who had been exposed at least three months between 1946 and 1975 inclusive in one plant or between 1940 and 1975 inclusive in the other. Follow-up was more than 97 percent complete as of the end of 1975, and expected mortality was calculated from U.S. population rates. Non-statistically significant excesses were found for rectal cancer, based on four deaths, and liver cancer, based on three deaths. The rectal cancers showed a slight increase with an increase in the latency period, but the liver cancers showed no consistent trend. There were no

increases in mortality from these causes associated with increasing lengths of exposure.

Bertazzi et al (1981) also studied a cohort of capacitor manufacturing workers in a plant near Milan. The cohort consisted of every person who had worked for at least six months between 1946 and 1970, inclusive, except for clerical workers. Follow-up was over 98 percent complete as of the end of 1978, and expected mortality was based on rates in the city where the plant was located. Data were analyzed separately for male (290) and female (1020) workers. A statistically significant excess mortality from all cancers, based on eight deaths, was found in male workers, and a statistically significant excess for all causes was found in female workers, based on 15 deaths. There were non-significant excesses of lymphatic and hematopoietic cancer in both sexes, based on four deaths, and of digestive cancer in males, based on three deaths. The sites involved in the digestive cancer deaths were stomach, pancreas and biliary tract. No analysis by duration or latency of exposure was attempted because of the small numbers involved. The authors note that the cohort was very young, and that their follow-up will be continued.

Zack et al studied all hourly male workers who had been employed in the manufacture of PCBs in a general chemical plant for at least six months between 1945 and 1965 inclusive. Follow-up was approximately 99 percent

complete (one person was lost) as of the end of 1977, and expected mortality was calculated from U.S. population rates. There were eight cancer deaths. The only noteworthy finding was a non-statistically significant excess in lung cancer based on four deaths. No liver cancer deaths were found.

## DISCUSSION

Doll (1981) has suggested criteria for establishing carcinogenicity from epidemiologic evidence. They are similar to those proposed by the International Agency for Research on Cancer (1980) and are essentially as follows; (1) there is an excess in exposed groups beyond what can be expected by chance, (2) there is an appropriate relationship with dose or duration of exposure, (3) there are no known biasing or confounding factors, (4) the association is observed repeatedly in different circumstances. The development of these criteria was stimulated by a concern to provide generally accepted guidelines for establishing carcinogenicity, but they apply equally well to other health outcomes.

Criteria for establishing the absence of a health effect are inherently more difficult. The cliché that it is impossible to prove a negative is true but misleading, in the sense that it is also impossible to prove a positive association by means of epidemiologic studies. A statistically significant positive finding allows us to conclude

that an association exists, with a known probability that the conclusion is wrong. Repeated positive studies reduce that probability in a manner that can be calculated, but there remains a chance that the finding is false. On the other hand, a negative study allows us to conclude that there is no association, with a probability of error that depends on how great an association really might exist. Repeated negative studies reduce this probability, but there is always a large probability that a very small effect might not be detected. Therefore both positive and negative studies carry a risk of error, although in both cases the strength of the evidence may be such as to make that chance negligibly small.

Cross-sectional Studies 16 studies both pre and post 1977

There is a reasonable consensus that dermatitis is associated with occupational exposure to PCBs, although the dose response relationship has not been established in all of the studies. Two non-occupational studies agree that there is no dermatitis associated with environmental, i.e., non-occupational exposure. The difference in the results of the occupational and non-occupational studies is consistent with the order-of-magnitude differences in the exposures of the two groups.

There is a similar preponderance of evidence that mild liver function anomalies are associated with occupational but not with non-occupational exposure. One occupational

study found associated clinical symptoms, but the remaining three studies found no detectable clinical illness. By Doll's criteria of consistency, it is very unlikely that clinical illness is associated with the anomalies found in occupationally exposed populations.

Findings concerning cholesterol levels again show a preponderance of evidence that cholesterol levels are not associated with blood PCB levels, even though one non-occupational study did report an association.

The situation with respect to triglyceride levels is slightly more ambiguous. Two out of five studies, including one non-occupational study, found a relationship with blood PCBs, so that the possibility that such a relationship really exists must be considered.

Studies of blood chemistry were uniformly negative. Two studies of diastolic blood pressure gave contradictory results. One study of pulmonary function suffered from a failure to account for smoking so that its findings cannot be attributed to PCB exposure. None of these areas of study appear to show any relationship to PCB exposure.

None of the six studies of reported illnesses and symptoms constitute evidence by Doll's criteria. Four studies showed no relationship of a wide range of symptoms to PCB exposure. Two occupational studies reported various symptoms, but did not show that they were related to blood PCB level or duration of employment.

Cohort Cancer Studies

The most noteworthy characteristic of the three mortality studies is that they do not agree with each other. Excess cancer of the liver, rectum, stomach, pancreas, biliary tract and lung are each found in one of the studies but in none of the others.

Although the power of the studies is limited (the most powerful one, Brown et al (1981) has a probability of about 0.33 of detecting a threefold excess in liver cancer mortality), the lack of a latency relationship in that study and the complete absence of liver cancer in the other two studies strengthens this power in a way that cannot be quantified precisely.

The average duration of follow-up in each of the three studies was 15.3 years (Brown et al), 15.7 years (Marconi et al) and 20.2 years (Zack et al). Further follow-up, especially of the first two studies, would provide the longer latency and greater number of deaths that would increase the power of the studies. Nevertheless, the data available at the present time do not provide the consistent, exposure related results that would justify concluding that PCBs are carcinogenic in human beings.

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Table 1

Studies of Chloracne and Other Dermatitis in

Relation to Blood PCB Levels*

| Study | Chloracne | Other Dermatitis | Dose Related | Adjusted for Other variables |
|---|---|---|---|---|
| Fischbein et al (1979) | N | Y | Y | N |
| Baker et al (1980) | N | N | | N |
| Maroni et al (1981 II) | Y | Y | ? | N |
| Chase et al (1982) | Y | Y | ? | N |
| Smith et al (1982) | N | Y | N | N |

* N = Not found
Y = Found
No entry = Not reported
? = Equivocal finding

Table 2

Studies of Liver Function in Relation to Blood PCB Levels*

| Study | Abnormalities | Dose Related | Adjusted for Covariables |
|---|---|---|---|
| Fischbein et al (1979) | N | | N |
| Baker et al (1980) | N | | N |
| Kreiss et al (1981) | N | | Y |
| Maroni et al (1981 II) | Y | Y | N |
| Chase et al (1982) | Y | Y | Y |
| Smith et al (1982) | Y | Y | Y |

* N = Not found
Y = Found
No entry = Not reported

Table 3

Studies of Fat Metabolism in Relation to Blood PCB Levels*

| Study | Total Cholesterol | Triglycerides | Adjusted for Covariables |
|---|---|---|---|
| Fischbein et al (1979) | N | N | N |
| Baker et al (1980) | N | Y | N |
| Kreiss et al (1981) | Y | N | Y |
| Chase et al (1982) | N | Y | Y |
| Smith et al (1982) | N | N | Y |

* N = Not found
Y = Found

Table 4

Inconsistencies in Mortality Studies of Cancer in PCB Exposed Populations

| Study | No. Studied | No. of Deaths | Principal Findings |
|---|---|---|---|
| Brown et al, (1981) | 2567 | 163 | Liver Rectum |
| Bertazzi et al, (1981) | 1310 | 27 | Digestive Lymphatic and hematopoietic |
| Zack et al, (in preparation) | 89 | 30 | Lung |