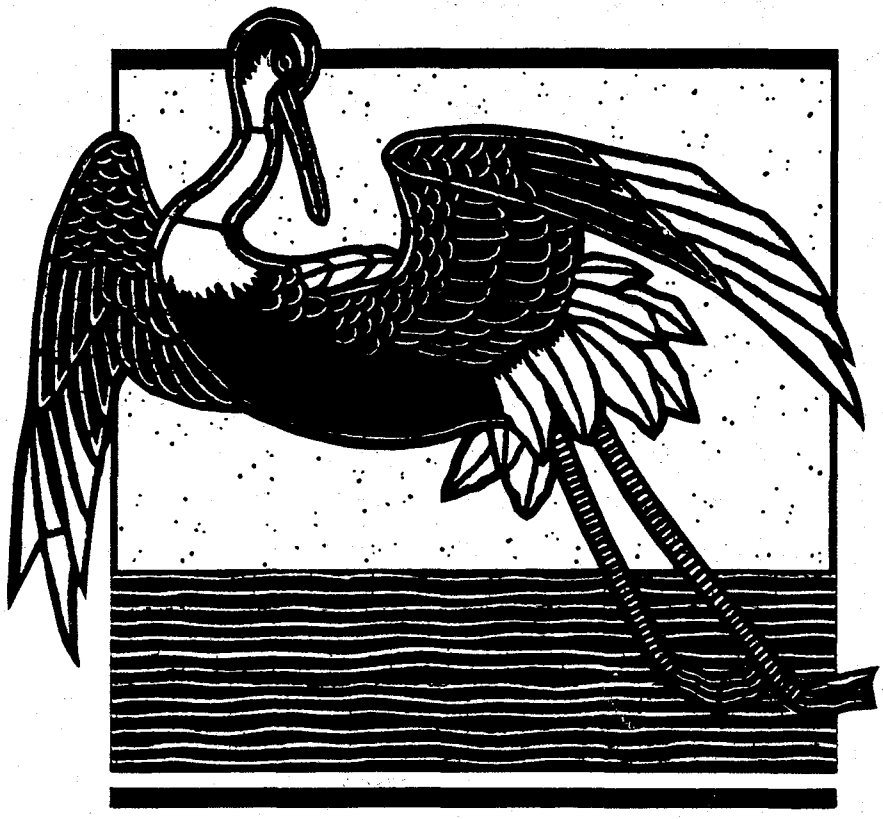


P.C.B. Levels in Human Fluids:

SHEBOYGAN CASE STUDY

By B. Jill Smith

UNIVERSITY OF WISCONSIN ■ SEA GRANT INSTITUTE

P.C.B. Levels in Human Fluids:

SHEBOYGAN CASE STUDY

P.C.B. Levels in Human Fluids:

SHEBOYGAN CASE STUDY

By B. Jill Smith

Published by the

UNIVERSITY OF WISCONSIN SEA GRANT INSTITUTE

Technical Report WIS-SG-83-240

WIS-SG-83-240

This study and report were funded by the University of Wisconsin Sea Grant Institute under grants from the National Sea Grant College Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and from the State of Wisconsin. Fed. Grant NA80AA-D-00086, projects R/MW-18, AS/A-2.

The study was requested by the Wisconsin Department of Natural Resources and the Wisconsin Department of Health and Social Services and conducted in cooperation with the Sheboygan City Public Health Department

This report was condensed from a thesis submitted by B. Jill Smith in partial fulfillment of the requirements for the degrees of Doctor of Philosophy (Anthropology) and Master of Science (Preventive Medicine) at the University of Wisconsin-Madison, 1983.

Editing · Stephen Wittman
Design · Christine Kohler
Cover · Adapted by Christine Kohler from a Japanese stencil design

This publication is available from:

Communications Office
Sea Grant Institute
University of Wisconsin
1800 University Avenue
Madison WI 53705

Phone (608) 263-3259

Cost: $4.00, including postage and handling.

Contents

CONTENTS (cont'd.)

List of Figure & Tables

Acknowledgements

Special thanks must go to the University of Wisconsin Sea Grant Institute for four years of support and for its leaders' unfaltering belief in the need for this study.

Also, this research would never have been possible without the cooperation and help of the Sheboygan City Public Health Department and its director, Solomon Belinky. Belinky and his staff were directly responsible for the collection of data and the field organization for this research. Without Mr. Belinky's efforts and those of Mrs. Fran Belinky and Mrs. Shirley Verhage, this study could not have been completed.

The faculty and staff of the University of Wisconsin-Madison Anthropology and Preventive Medicine departments have provided me with needed encouragement, counsel, typing, xeroxing, coffee and kindness at every opportunity, and for this I say "thank you."

I wish to extend my deepest appreciation to Drs. Richard Osborne, Robert Miller, Vernon Dodson, Donn D'Alessio and Louis Leavitt, all of whom truly define the role of "advisor." Without their help and persistence, this report would not have been possible. My thesis was dedicated in memory of Drs. John Rankin and Edward Kendrick, who initiated this research project.

Summary

This University of Wisconsin Sea Grant Institute study, done in Sheboygan, Wis., during 1980-81, was aimed at determining (1) if there were high levels of PCBs in mother's serum and breast milk in the vicinity of a PCB spill, (2) if these levels could be linked to the women's consumption of local fish and (3) if the infants born to the women in the study showed signs of impaired health, growth and/or development.

Seventy-three Sheboygan mothers who gave birth between September 1980 and September 1981 participated in the study. The women ranged in age from 18 to 36 years. Sixty-two of the infants were breast-fed, while 11 were bottle-fed. Serum PCB levels for the study population ranged from 1.29 to 14.90 parts per billion, with a mean of 5.76 ppb. The breast milk PCB levels for the women who were breast-feeding were .29 to 4.04 parts per million, with a mean of 1.13 ppm.

The major findings of the study were:

1. 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.

2. 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 the breast milk may still be harmful.

3. 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.

4. 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.

Other findings were that birth weight increased with increased *in utero* exposure to PCBs, and post partum weight gain in infant females decreased with increased alcohol consumption by the mothers. Additional research must be done to fully understand the implications of these results.

This report was condensed from a thesis submitted by B. Jill Smith in partial fulfillment of the requirements for the degrees of Doctor of Philosophy (Anthropology) and Master of Science (Preventive Medicine) at the University of Wisconsin-Madison, 1983, under the supervision of Drs. Robert J. Miller and Richard H. Osborne, UW-Madison College of Letters and Science.

Introduction

Polychlorinated biphenyls (PCBs) are among the most commonly found contaminants in all ecosystems, and they have been detected at various levels in a multitude of plant and animal species. But the PCB problem became a national concern in the U.S. when the PCB levels in the breast milk of some women were found to be higher than the maximum contamination level allowed by the federal government for any commercially sold food.

Research in Michigan in 1979 showed that PCBs were present in the milk of the majority of the nursing mothers sampled (Wickizer et al. 1981). The magnitude of PCB body burdens in the citizens of Wisconsin is unknown, nor is it known what factors play a part in the accumulation of PCBs in the body.

People may accumulate a PCB body burden from a variety of sources -- from the consumption of fish from contaminated waterways, from direct industrial expoure, from simply living in an industrial area, or from continuous low-level exposure through food.

The guiding purposes of this University of Wisconsin Sea Grant Institute study were to (1) determine PCB levels in the serum and breast milk of childbearing women in an industrial town in Wisconsin, (2) to determine whether the consumption of fish from a PCB-contaminated local river and Lake Michigan is associated with an increased PCB body burden and (3) to obtain preliminary information on the potential toxic effects of maternally transferred PCBs on infants.

Background

In 1978, routine testing for PCBs in fish along the Sheboygan River in Wisconsin revealed that the game fish had PCB levels far in excess of the 5 parts per million (ppm) standard set for fish by the U.S. Food and Drug Administration (USFDA). The PCB levels in the sampled fish from the river averaged 158 ppm; the highest level was 750 ppm. Later that year, during a more intensive sampling period, a fish with a PCB level of 970 ppm was discovered (Kleinert 1977).

In late March 1978, the source of the river's PCB contamination was traced to the Tecumseh Products Company, an aluminum die cast plant in Sheboygan Falls, about 26 miles upriver from Sheboygan. The company had been using a diked area of its property on the banks of the river as a dumping site for floor sweepings, including spilled hydraulic fluid containing PCBs. Soil samples from this diked area were tested by the Wisconsin Department of Natural Resources (WDNR) and found to have PCB levels as high as 12,000 ppm (Kleinert 1978).

Flooding in autumn 1977, spring 1978 and the normal leaching of surface elements from the soil into the river had contaminated the sediments of the

Sheboygan River from Sheboygan Falls down to the U.S. Coast Guard station at Sheboygan Harbor with PCBs at levels ranging up to 190 ppm. As a result, the Sheboygan River was closed to fishing from the Tecumseh Company downstream to Lake Michigan, and signs were posted along the river warning of the potential health hazard of eating fish from the river.

The warnings were later removed from some parts of this stretch of the river, but about 120 miles of the river and its tributaries were supposed to be still posted as containing contaminated fish in 1980. In summer 1980, however, no such signs were found along the Sheboygan River at popular fishing areas. One such area was less than 100 yards downstream from the Tecumseh dumping site.

Study Site

Sheboygan, Wis., is an industrial town located 60 miles north of Milwaukee (Figure 1). It has 126 manufacturing businesses, and most of its workforce (48 percent) is in the durable manufactured goods sector. Sheboygan has a relatively stable population: The town's population in the 1980 census was 48,121, only some 300 fewer people than in the 1970 census.

The city is located on the west shore of Lake Michigan and is almost evenly divided by the Sheboygan River. The town hopes to increase public use of Sheboygan Harbor by developing recreational facilities on its shores. It also wants to increase shipping and industrial use of the harbor by dredging it to accommodate deep-draft ships, which may stir up PCBs already buried in harbor sediments.

Polychlorinated Biphenyls (PCBs)

PCBs were discovered late in the 19th century, but their manufacture and extensive use in industry did not begin until 1929. PCBs are a mixture of chlorinated biphenyls with a variable chlorine content. Some 210 different isomers are possible, though only about 20 of these were commonly used at the height of their manufacture. Odorless, colorless, chemically very stable and nearly nonconductive of electricity, PCBs were widely used in adhesives, plastics, paints, carbonless carbon paper and electrical components.

Because of their toxic properties and exceedingly long environmental persistence, the federal Toxic Substances Control Act of 1976 restricted the use of PCBs to "closed" systems (e.g., electrical transformers and capacitors) and banned the manufacture of PCBs after Jan. 1, 1979. In the preceding 50 years, however, an estimated 1.4 billion pounds of PCBs were manufactured and marketed. Some 500 million pounds of PCBs have already ended up in the nation's dumps. More than 130 million pounds still in use have yet to be released to the environment (Gustafson 1970).

Sources of PCB Contamination

Human contamination from PCBs generally comes from three different pathways: accidental, direct acute poisoning (Kuratsune et al. 1969; Skinner 1980; Chen et al. 1980), industrial exposure (Baker et al. 1980; Hammer et al. 1972; Hara et al. 1974; Hasegawa et al. 1972; Yoshida et al. 1979, Warshaw et al. 1979)

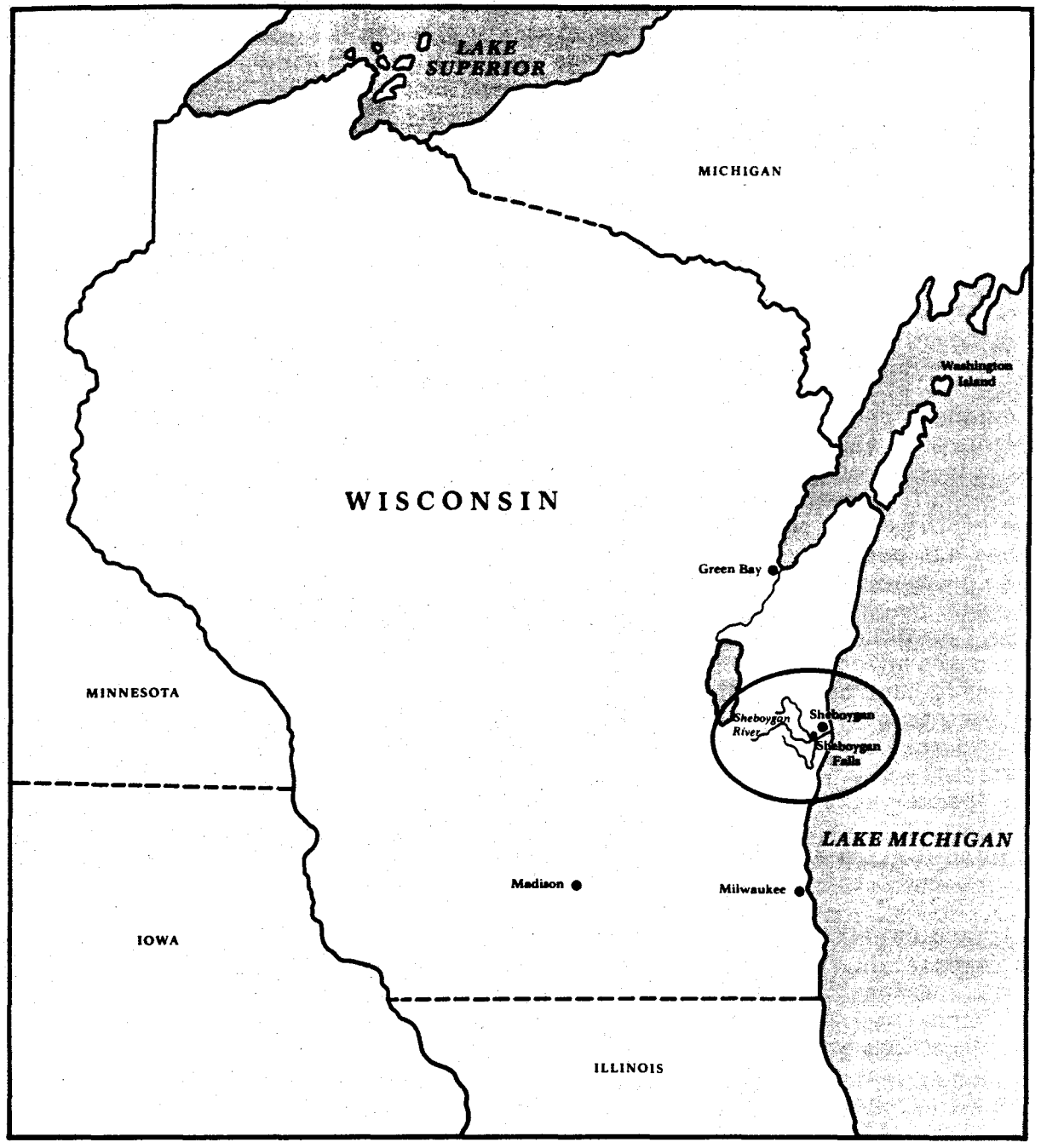


FIGURE 1
Site of Study: Sheyboygan, Wisconsin

and consistent low-level exposures via the public food supply (Jelinek and Corneliussen 1976; Kolbye 1972).

PCBs may be absorbed through the skin, the respiratory tract or the gastro-intestinal tract (Cook 1972), so subtler forms of contact with the chemical -- through air pollution (Treon et al. 1956), water pollution (Tucker et al. 1975a), food contamination and waste disposal (Hammer et al. 1972; Baker et al. 1980) -- increase the probability of PCB exposure.

Given the variety of routes for PCB absorption, the most common source -- and probably the most serious means of exposure for the U.S. population as a whole -- is the general food supply. Foods and packaging that would normally be suspected of containing PCBs have been monitored by the USFDA since the discovery of PCBs in fish in 1966 (Jelinek and Corneliussen 1976).

These food supply sources of PCBs are all fairly well controlled -- except the supply of fish for human consumption. The persistence of significant dietary PCB contamination has been demonstrated for fish from the Great Lakes, Upper Mississippi River and the Hudson River. Ingestion of fish from Lake Michigan has been positively correlated with increased serum PCB levels (Humphrey 1978).

Health Effects: General

Since the discovery of the extent of PCB pollution in the mid-1960s, practically every animal species has been studied for PCB contamination and the resulting effects on their biological systems.

Some of the most thorough and extensive research done on PCB exposure in humans has been done as the result of an accidental poisoning of rice oil in 1968 in Japan. The acute human toxic response following the ingestion of this rice oil resulted in extensive epidemiological research (Kuratsune et al. 1969; Kuratsune et al. 1972) to assess the scope and danger of this kind of environmental pollution. The disease symptoms resulting from this rice oil poisoning have been labeled as Yusho (rice oil) disease, and the 1,052 patients identified in this accident are called Yusho patients.

Practically every human tissue is a repository site for PCBs, except perhaps hair (Hammer et al. 1972). Blood, milk, bones, organs, muscles, brain, adipose, skin, etc., all contain varying amounts of PCBs (Abe et al. 1975; Goto and Higuchi 1969; Kuratsune et al. 1969; Kuratsune et al. 1971, 1972; Okumura and Katsuki 1969; Matthews and Anderson 1976; Watanabe et al. 1980).

Adult and stillborn autopsies and live biopsies reveal definite patterns of PCB deposition. Common sites for PCB accumulation in adult humans are adipose tissue and the liver (Watanabe et al. 1980). In a sample taken from a stillborn, full-term human infant (Kikuchi et al. 1969), the highest PCB concentrations were found in the liver and the brain.

In stillborn infant rhesus monkeys (Allen and Barsotti 1976), the highest PCB concentrations were in the lung and pancreas. In infant monkeys whose mothers had been fed a daily diet containing 2.5 ppm PCBs, the highest concentrations were in the thymus, testes, kidney and cerebrum. In seven infant rhesus monkeys whose mothers were fed diets containing up to 5 ppm PCBs, the highest levels were in the bone marrow and the pancreas.

Health Effects: Adults

The clinical symptoms of PCB toxicity are highly diverse and tend to effect several different anatomical systems. The most physically apparent indications of toxic PCB exposure are changes in the skin, gingiva and around the eyes. The skin undergoes hyperkeratinization, resulting in splotchy darkening of the gingiva and the epidermis, and acne-like skin eruptions.

For dermatological symptoms, the severity of clinical signs and PCB exposure have been divided into four levels:

> "Grade I: Increased cheese-like discharge from Meibom gland, pigmentation of nails. Grade II: Grade I plus comedones. Grade III: Grade II plus acne-form eruption, cyst formation of sebaceous glands in genitals and evidence of follicular openings in the site of neck and upper chest. Grade IV: Enlarged and elevated follicular openings all over the body and extending distribution of acne-form eruption. [sic]" (Goto and Higuchi 1969, p. 8.)

In the gastrointestinal tract, the clinical symptoms appear as extreme and lasting nausea and weight loss and a tendency toward organ edema in newborns (Chen et al. 1980; Kuratsune et al. 1971, 1972).

The nervous system responded to the toxic exposure with numbness in the extremities (Goto and Higuchi 1969) and reduced nerve conductivity (Kuroiwa et al. 1969). Other neurological symptoms included pain, hypoesthesia and areflexia. Kuroiwa concluded that "the sensory fiber is predominately involved in chlorobiphenyl polyneuropathy" (p. 60).

In the respiratory system, there appears to be a reduced vital capacity in individuals with a history of industrial exposure to PCB vapors (Warshaw et al. 1979) and an increase in the number of respiratory infections (Shigematsu et al. 1971, 1974).

In the reproductive system, men tended to show some impotence, at least in the Yusho accident (Goto and Higuchi 1969), while women had interrupted menses, delayed or prolonged menstrual cycles (Kuratsune et al. 1971; Kusuda 1971) and a tendency toward toxemia in pregnancy (Wasserman et al. 1980).

In lower primates, increased spontaneous abortions and stillbirths have been reported (Allen et al. 1973; Barsotti et al. 1976). PCBs have also been implicated in effecting steroid metabolism and estrogen production in females, increasing both the possibility of reduced fertility and the risk of defective oocyte production (Butcher and Page 1981; Chao et al. 1981).

Research into the circulatory system revealed a marked increase in triglyceride levels in humans and in cholesterol levels in rats and humans (Okumura et al. 1975; Uzawa et al. 1971) and an increased risk of hypertension (Kreiss et al. 1981). There are also documented decreases in hemoglobin and red blood cells and increases in leucocytes in patients with the most extreme exposures to PCBs (Kuratsune et al. 1972).

Health Effects: Newborns and Children

Almost all of the previously mentioned symptoms and clinical pathological findings have been documented in infants, with the addition of Small For Date (SFD) birth weight in humans and lower primates (Kuratsune et al. 1972; Allen and Barsotti 1976; Abe et al. 1975; Taki et al. 1969; Abrahamson and Allen 1973) and some behavioral abnormalities like learning impairment and hyperactivity in rhesus monkey infants (Bowman et al. 1978). Other findings in children were early teeth eruption and slightly retarded growth in adolescent males (Kuratsune et al. 1976).

Chang et al. (1981) investigated the effects of PCBs on the human immune system at the cellular level. They discovered that "PCBs caused decreased concentrations of IgA and IgM, but not of IgG" and "that the percentages of total T cells, active T cells and T_γ cells were decreased, while the percentages of β cells and T_μ cells were not affected" (p. 58). Other research indicated that immunologically, humans exposed to high levels of PCBs demonstrated decreased immunological response to infections (Shigematsu et al. 1971; Shigematsu et al. 1974; Saito et al. 1972).

In any number of animals like rats and dogs, PCBs have proven to be carcinogenic (Wasserman et al. 1979). There are few long-term studies on nonhuman primates indicating that PCBs are carcinogenic (Allen and Norback 1976; Hsu et al. 1975a). In a continuing study of Yusho patients, Urabe (1979) reports that 11 of 31 deaths (35.4 percent) in the nine years following their exposure to PCBs were caused by malignant neoplasms (cancers). This rate is substantially higher than the 21.1 percent of mortalities due to neoplasms in the same prefecture this year, but it would be premature to conclude that this high mortality is associated with PCB poisoning (Urabe 1979, p. 273).

Breast Milk and PCBs

Infants are known to be exposed to PCBs by two possible routes: through the mother's bloodstream (i.e., transplacentally), and via the mother's breast milk (Abe et al. 1975; Yoshida and Nakamura 1979; Yakushiji et al. 1978; Kuratsune et al. 1971, 1972; Mes and Davies 1979; Masuda et al. 1978; Wickizer et al. 1981; Savage et al. 1973). Which of these routes poses the most serious health hazard to the infant has never been investigated.

Serious controversy has been most actively focused on the level of contamination in the mother's breast milk, primarily because this is an area where some control may be placed on infant exposure. The controversy increases when one tries to determine a point at which a woman should cease to breast-feed her child because of PCB contamination of her milk. Given the physiological, immunological and psychological benefits from breast-feeding (Lawrence 1980), trying to decide when the benefits of breast-feeding are outweighed by the potential harm from contamination is extremely difficult. This question has been broached many times (Kendrick 1980; Wickizer and Brilliant 1981; Harrod 1980; Barr 1981), yet no conclusive consensus on "safe" levels of PCBs in breast milk have been determined.

Objectives of the Study

The primary objectives of this UW Sea Grant study were:

1. Establish the range of PCB contamination of breast milk and blood in women giving birth to children between Sept. 1, 1980, and Sept. 30, 1981, of a potentially exposed population in Sheboygan, Wis.

2. Establish the variation over time of the individual's cumulative levels of breast milk and blood serum PCBs and overall changes in the breast milk PCB and serum PCB through time.

3. Compare the overall changes of serum PCB in nonlactating mothers from natural metabolic processes to the overall changes in serum PCB in lactating mothers.

4. Determine the relationship between serum and breast milk PCB levels with the ingestion of sport and commercial fish from Wisconsin waterways.

5. Obtain preliminary data about infant health and development and the correlation with maternal blood and breast milk PCB levels, as it effects these two aspects of the infant's first four months of life.

Hypotheses

The principal hypotheses tested in this study were:

1. The amount of Lake Michigan fish and Sheboygan River fish eaten by any female of reproductive age will correlate positively with cumulative PCB levels in the woman's blood and breast milk.

2. The cumulative level of PCBs in the mother's breast milk and serum will drop significantly as she breast-feeds her child.

3. The child's health, development and behavior will reflect the amount of PCBs available to be passed from the mother to her child either transplacentally, or via both the placenta and the PCB levels in the breast milk.

Study Methods and Design

The mother and infant pairs were initially contacted by the Sheboygan City Public Health Department (SCPH) approximately three to four weeks post partum. Their names and addresses were taken from birth lists sent to the SCPH by the Department of Records after the hospital had registered the births. Each mother who delivered a child in a local Sheboygan hospital received a letter of introduction, a request for their participation and an

initial questionnaire (Appendix A). The women were requested to return the questionnaire whether they intended to participate or not.

Four hundred and ninety-two letters were sent out between September 1980 and September 1981. Two hundred and ninety-nine were returned, (61 percent return rate), with 73 women and their newborns participating in the study.

The three resulting groups of women selected for study may be defined as follows:

GROUP 1: Women who were breast-feeding their infants, ate Lake Michigan or Sheboygan River fish at least twice a month and had done so for at least three years.

GROUP 2: Women who were breast-feeding their infants, ate Lake Michigan or Sheboygan River fish not more than once or twice a year and had not done this for more than three years.

GROUP 3: Women who were not breast-feeding their children, ate Lake Michigan or Sheboygan River fish at least twice a month and had done so for at least three years.

Data Collection

All data was collected at the Sheboygan City Public Health Department. The infant evaluation was done first if the child was not crying, hungry or sleeping. If the child was having problems that prevented the researcher from working with him/her, other parts of the study were done first, until the child could also participate. Very few infants presented problems during the course of the evaluation.

The behavioral, motor, vocal and problem-solving section of the study was first (Appendix B). Next, the infant growth measurements were taken (Appendix C). The long maternal questionnaire followed (Appendix D), then the infant health questionnaire (Appendix E).

The mother's blood pressure, blood sample and body measurements were also taken, and she was asked to draw off a breast milk sample.

The second visit the mothers made to the SCPH followed the same format as the first. During the second visit, only a short infant health questionnaire was used (Appendix F), so this visit generally took only half the time as the first.

Blood Collection

The syringes used for drawing blood were the traditional ground glass syringes of 15 years ago rather than vacutainer tubes. Vacutainers were not used because there was some risk of contamination from the rubber tops or coatings in the tubes, and they could not be rinsed with ether before autoclaving. In those studies that have reported their blood collection techniques, this is the only one to use ground glass syringes.

Approximately 25 ml of blood was drawn off, and the clotted blood was allowed to sit in the centrifuge tubes for about 20 minutes, ringed and spun down for another 20 minutes. This process resulted in about 10 ml of serum or more. A blood specimen was not obtained from only one participant for the first interview/sample collection visit.

Breast Milk Collection

Up to 30 ml of breast milk was collected from each participant who was breastfeeding. They manually expressed milk into a beaker at the study site or, if they had difficulties drawing off the necessary amount, they were able to collect the milk at home with equipment provided by the staff. The women were instructed to place the milk sample in the freezer of their refrigerator and to return it within 7 days to the SCPH.

Duplicate Samples

There were plans in the original proposal to send 10 duplicate serum samples to Raltech to check for the accuracy of their analytical techniques, but it was not feasible to draw enough blood from a nursing mother so that two adequate samples could be created. As an alternative, six spiked serum samples (bovine) were obtained from the Center for Disease Control (CDC) in Atlanta; such samples are used in the CDC's program of checking labs for their analytical accuracy. Six of these samples were defrosted, placed in our serum culture tubes, numbered in proper sequence and sent in as human serum samples for PCB analysis.

There was also interest in checking the possible PCB levels of the most common infant formulas used by the bottle-feeding mothers. The formulas -- Enfamil, SMA, Similac and Isomil -- were mixed according to their instructions with water brought from Sheboygan in a properly prepared container, placed in breast milk culture tubes, numbered and sent to Raltech as breast milk samples.

Finally, in an attempt to check the preparation of glassware and handling of samples in both Madison and Sheboygan, a distilled water sample in prepared glassware from Madison and a Sheboygan public water sample were analyzed for PCB content.

Statistical Methods

The primary method of analysis used in this study was multiple regression analysis. The data consisted of more than 350 variables in binomial, continuous and ranked discontinuous format. Regression offered the most sensitive and revealing test to establish associations between variables as well as the relative weight or importance of that association. The data did not naturally fall into groups, except in a few cases, and thus the Chi Square test, or the Statistical Package for Social Sciences crosstab procedure, was used sparingly.

To formulate groups, it was necessary to arbitrarily assign boundaries and sacrifice some of the sensitivity of the testing process and the available data. Chi Square tests were useful in determining the statistical existence of differences between the specified case and control groups in instances of

high and low serum PCB and breast milk PCB. The same proved useful in the analysis of differences between male and female children.

Another method of analysis used in the data manipulation was the T test for the possible significant differences in means. Again, this was especially helpful in assessing the degree of difference among the three subject groups and between male and female children.

A final logistic regression technique was used to incorporate the binary data with the continuous variables. This independent program, found at the Madison Academic Computing Center (Graves 1980), is more sensitive and accurate when using binary data as dependent variables.

Description of Variables

Serum PCB was reported in parts per billion (ppb) in the Raltech analysis and measured on a whole serum basis. For purposes of calculation, the serum value was converted to parts per million (ppm), the same base measure of the breast milk PCB.

Breast milk was measured on a fat basis and a whole milk basis. Since the lipid content of breast milk varies greatly from feeding to feeding throughout the day, the whole breast milk measure of PCB would vary according to the amount of lipid in the sample acquired, so all calculations involving breast milk PCB were done with the measure of PCB on a lipid basis.

The infants' measurements were all taken by or converted to metric scales. The mother's physical measurements were made in much the same manner as the infant's, except that the weight was initially in pounds (to an eighth of a pound) before conversion to kilograms. The mother's height, as the infant's, was measured in inches and converted to centimeters.

The mother's occupation measurement was an estimate of risk of exposure to PCBs by occupational category. This ranking of exposure risk (1-4) was made from other publications on occupational risk of exposure to PCBs and the U.S. Department of Health, Education and Welfare's publication on Occupational Disease (1977 ed.). A list of jobs in (4) high exposure, (3) marginally high exposure, (2) marginally low exposure and (1) low exposure risk categories was drawn up according to lists of various uses for PCBs and concomitant exposure (Appendix G). The mothers and the fathers were assigned an occupational risk before their PCB values were analyzed to avoid possible biasing. Both the mother's and the father's occupations were ranked according to the list.

The mother's risk of PCB exposure through diet of fish was measured in two ways. First, the mothers were classified according to the list of multiple-choice questions categorizing the diet into various groups based on quantity and number of years these foods had been eaten. The risk was then ranked according to:

(5) Frequent diet of fish (twice a month or more) and of long duration (6 years or longer),

(4) Frequent diet of fish and a short duration (5 years of less),

(3) Infrequent diet of fish (less than once a month) and a long duration,

(2) Infrequent diet of fish and a short duration, and

(1) Doesn't apply; never eats fish from the Sheboygan River or Lake Michigan.

These rankings (1-5) were referred to as the woman's total dietary risk from fish consumption.

A second measure of fish in the diet was estimated from the woman's report of fish eaten during the four-month course of the study, from the birth of her child to the second visit to the health center. This was measured as a binomial "yes" or "no" answer called the Fish Eaten Since Birth variable, and it was measured by the estimated number of meals eaten during this period, referred to as the Number of Meals variable.

The Standard Metabolic Analysis of the serum metabolic elements was taken from the second serum sample and analyzed at Raltech Scientific Services. The 16 variables tested and their units of measure are listed in Appendix H.

The measure of cigarette smoking is in number of cigarettes per day, and the alcohol intake was in number of drinks per week prior to pregnancy. During pregnancy, an estimate of the total number of drinks during the nine-month period was used in the statistical analysis.

The "infectious illnesses" variable included colds, influenza, fevers, earaches, pneumonia, bronchitis, meningitis, urinary tract infections, skin and other infections. A second infectious illnesses variable added diarrhea and vomiting to that list.

"Total antibiotics" were the number of times a child had been prescribed antibiotics. In one case, an infant was given antibiotics as a preventive measure against infection when he had open heart surgery. This was measured in days the infant was on antibiotics, and thus he was omitted from all calculations that involved the antibiotic variable.

Results and Discussion

Population Description

The study population consisted of 73 mother/infant pairs who completed both visits to the SCPH. Six mothers who dropped out after the first visit were omitted from the final analysis. Thirty-six female infants and 37 male infants were studied and evaluated. These were divided into three groups:

GROUP 1: 23 mother/infant pairs (11 male infants and 12 female infants);

GROUP 2: 39 mother/infant pairs (19 male and 20 female infants); and

GROUP 3: 11 mother/infant pairs (7 male and 4 female infants).

The mothers proved to be very homogenous among the groups' classification for many of the basic demographic variables, such as mothers' ages (26.4, 26.5 and 26.2, respectively), fathers' ages (27.4, 28.6 and 28.6, respectively), mothers' educational level in years (13.9, 14.0 and 13.2, respectively), fathers' educational level (13.5, 14.6 and 13.0, respectively), mothers' height in centimeters (165.9, 164.1 and 163.6, respectively), and mothers' weight in kilograms at the first visit (69.6, 65.6 and 60.6, respectively). The variance on these variables shows a fairly even distribution of morphological and sociocultural characteristics throughout the study population.

In addition to these more common demographic and morphological variables, the two clear cultural variables provided for in the questionnaire also showed an unexpectedly high degree of consistency. The mothers were asked for their "national origins" or the ethnic group for which they feel cultural affiliation. This was intended to give some insight into possible genetic variations and potential subcultural variations. As it turned out, the study population was an ethnically homogeneous group. All of the subjects but three were of mixed European ancestry. Of the other three women, two were Hispanic or Chicano, and one was American Indian.

Not all of the ethnic homogeneity was self-selected. There is also a new settlement of Hmung (Laotian) refugees in Sheboygan, and several women of this group had babies during the study period and consented to join the study group. The Sheboygan staff and the researcher decided not to include these women because (1) they were very new to the area (less than six months at the time), (2) none of them spoke English and (3) they could have undergone some other extraordinary exposures to toxic materials (e.g., Agent Orange) during recent warfare in Southeast Asia.

Serum PCB Values

There are no known national averages for serum or breast milk PCB levels; only isolated experiments showing spot samples are available for comparisons.

It is difficult to rank the severity of the Wisconsin exposure data because there are no cross-sectional samples from the whole U.S. Also, few of the breast milk PCB studies include serum PCBs in their analysis, which further limits comparisons of this study to other U.S. studies of PCB exposure.

The mean levels of the serum PCB in the Sheboygan women was 5.76 ppb for the first sample and 5.48 ppb for the second sample. The range for the first sample was 1.29 ppb to 14.90 ppb, and for the second, 1.15 ppb to 14.10 ppb (Table 1). These levels indicate a relatively low exposure to PCBs, considering the amount of industry in the area.

A similar age-group of women, ages 18 to 36 (1979), on Washington Island, Wis., had levels ranging from 15.4 ppb to 22.8 ppb, with a mean of 19.54. This is a sample of five women from the 28 studied in a pilot research project conducted on Washington Island in 1979.

The difference between the mean PCB levels of the five Washington Island women ($\overline{X}$ = 19.54) and the 73 Sheboygan women ($\overline{X}$ = 5.76) was calculated using a T test for independent sample means. The two-tailed probability of these two populations being the same is less than .001. This indicates a large discrepancy between the two groups' relative PCB exposure, which may be partly due to the difference the amount of Lake Michigan fish in the diets of the two groups. Three of the five Washington Island women ate an average of about 30 pounds of fish per year, or a little more than one 8-ounce meal of fish per week. None of the Sheboygan women ate this many meals of the local fish. The most interesting comparison comes from the one woman who ate no fish, lived all of her life on Washington Island and never worked outside the home, yet still had a

TABLE 1

BLOOD SERUM P.C.B. LEVELS
(in parts per million)

	N	$\overline{X}$	σ	MIN	MAX
FIRST SAMPLE					
Group 1	22	.006	.003	.002	.015
Group 2	39	.005	.003	.001	.014
Group 3	11	.006	.002	.003	.010
TOTALS:	72	.006	.003	.001	.015
SECOND SAMPLE					
Group 1	23	.007	.003	.002	.014
Group 2	37	.005	.003	.001	.017
Group 3	10	.006	.002	.004	.009
TOTALS:	70	.005	.003	.001	.014

serum PCB level of 15.4 ppb -- higher than the highest serum PCB level recorded for Sheboygan (14.9 ppb).

Though there were no correlations between an individual's diet of fish and her serum PCB levels, there were too few subjects in the Washington Island Pilot study to accurately state that this was not the cause for the higher PCB values in the Washington Island population. Both breast-feeding women tested from Washington Island had breast milk PCB levels of 3.7 ppm on a fat basis. These two sets of study results either indicate some other source of PCBs for the Washington Island population other than the fish from Lake Michigan, or an exceptionally low exposure to PCBs in the Sheboygan population.

Other data on serum PCB levels in women of reproductive age comes from the rice oil poisoning in Japan (Yusho patients). The women of childbearing age in these studies had a mean serum PCB level of 11.2 ppb, with a standard deviation (SD) of 7.32 ppb and a range of 3.0 to 33 ppb.

A sample of normal mothers and infants who had not suffered any known extreme exposure to PCBs were also studied in Japan (Masuda et al. 1978) and showed mean serum levels of 2.5 ppb, with a SD of .14 ppb and a range of 0.4 ppb to 5.7 ppb.

The total sample of Yusho patients studied by Masuda and Kagawa (1974) about six years after the PCB accident had a mean serum PCB level of 5.9 with a SD of 4.5 ppb.

A PCB/DDT study done in Triana, Ala., (Kreiss et al. 1981) reported a PCB level of 13.7 ppb for all study females ranging (approximately) from 9 to 70 years in age. The serum PCB range for women of reproductive age was about 12 to 17 ppb. One other very credible study done in the southeastern U.S. by Finklea et al. (1972) showed a mean serum PCB level of 4.48 ppb for urban white females of all age ranges.

Serum PCB data from other U.S. and Canadian study groups did not segment their sample population by age and sex, preventing comparison with women of reproductive age only. Since there is a correlation between both the age of the individual (the older the individual, the higher the PCB accumulation) and their sex (males having higher levels), the other population PCB data is not directly comparable to the serum results of the Sheboygan study.

The Sheboygan PCB levels, as far as data available for U.S. women goes, seem to be low. The highest measured level is approximately equal to or less than the mean values for most of the previously mentioned PCB studies. This low exposure rate must be kept in mind when interpreting the results of the regression analysis that follows.

Breast Milk PCB Values

The breast milk PCB levels for the Sheboygan women ranged from .29 ppm to 4.02 ppm, with a mean of 1.13 ppm for the first sample; the second sample mean was 1.14 ppm, with a range of .34 to 3.79 ppm (Table 2). A comparison showing the breast milk PCB results from other studies is presented in Table 3. Of the samples reported on a milk fat basis, the Sheboygan population ranks in the lower half.

TABLE 2

BREAST MILK P.C.B. LEVELS
(in parts per million)

	N	$\bar{X}$	σ	MIN	MAX
FIRST SAMPLE					
Group 1	22	1.28	.501	.53	2.26
Group 2	38	1.05	.704	.290	4.02
Group 3	N/A	N/A			
Males	29	1.21	.764	.29	4.02
Females	31	1.07	.506	.38	2.77
TOTALS:	60	1.133	.642	.290	4.02
SECOND SAMPLE					
Group 1	21	1.23	.46	.59	2.75
Group 2	33	1.09	.701	.34	3.79
Group 3	N/A	N/A			
Males	27	1.26	.69	.47	3.79
Females	27	1.02	.517	.34	2.75
TOTALS:	54	1.141	.618	.34	3.79

Discussion of Serum PCB Equations

A total of seven variables are involved in predicting the serum PCB levels in the mothers: total serum bilirubin, serum cholesterol, serum phosphorus, the mother's occupational exposure risk, whether or not she had eaten fish in the four months after the birth of her child, and her suprailiac fat fold measure. All of the variables are positively correlated to serum PCB except the serum phosphorus and suprailiac fat fold.

The sociocultural and morphological variables (Appendix I, Table I-1) were the best predictors of the woman's serum PCB levels ($R = .602$, P value less than .0000). These were mother's diet of fish ($R = .178$, Sig. $T = .0099$), mother's occupational risk ($R = .263$, Sig. $T = .0104$), mother's education ($R = .383$, Sig. $T = .0001$) and mother's suprailiac fat fold ($R = -.324$, Sig. $T = .0106$). The three sociocultural variables in the equation are the most interesting and potentially inaccurate for interpretation. The mother's diet of fish in the interim four months between the infant's birth and the last visit to the SCPH for evaluation was positively associated with the mother's first serum PCB value.

The simple fact of eating any fish in the first four months post partum was actually a better estimate of overall dietary exposure than the exposure risk variable calculated from the mother's questionnaire.

The mother's education was also positively correlated to the serum PCB levels. There are three possible explanations for this association. First, the mother's education was negatively correlated to the length of time she had lived in Sheboygan, so the women may have been educated in other areas (most likely urban areas offering a higher PCB risk), or they are all native to other areas and arrived in Sheboygan after acquiring their education.

A second possibility is that the higher the woman's education, the more qualified she is for jobs that place her at risk of PCB exposure. Jobs such as laboratory technicians, chemical analysts, secretaries and teachers all run a slightly higher risk of PCB exposure than do clerks, waitresses and clerical workers. However, those women who work in the city's industries are not necessarily in a low exposure/high education classification. Nonetheless, a highly educated women may be more likely to stay with a job with a high exposure risk than an unskilled, less-educated woman in a high-risk job. The education variable should drop out of the equation when the job exposure risk is controlled, but this is not the case.

The last possibility is that a woman's education is being confounded with some other behavior that also leads to higher exposure to PCBs. Leisure-time activities, diet and travel could all have some impact on the accumulation of PCBs in the woman's system as well as being related to her education.

TABLE 3

BREAST MILK P.C.B. ON A LIPID BASIS
(in parts per million)

STUDY SITE	YEARS	NUMBER OF SUBJECTS	MEAN	STANDARD DEVIATION	RANGE
SHEBOYGAN, Wis.	1980-81	60	1.133	.642	.29 - 4.02
Michigan[1]	1977-78	1,057	1.496	.796	< .40 - 5.1
Hawaii[2]	1979-80	12[a]	.83	---	.13 - 1.8
		38[b]	.77	---	.02 - 1.4
Nova Scotia[3]	1973-74	9	1.86	.019	1.22 - 2.46
New Brunswick[4]	1973-74	6	1.53	.37	1.07 - 2.10
Colorado[5]	1973	39	----	---[c]	.04 - 0.1
Quebec[6]	1978-79	154	.837	.529	4.34
Ontario[7]	1973-74	19	1.2	---	.10 - 2.5
Japan[8]	1973-75	52	.35	.025	.03 - 0.87
Norway[9]	1975-76	45	.024	.009	----- [d]

[1]Wickizer et al. 1981
[2]Takahashi et al. 1981
[3,4]Musial et al. 1974
[5]Savage et al. 1973
[6]Dillon et al. 1980
[7]Grant et al. 1976
[8]Masuda et al. 1978
[9]Brevik and Bjerk 1978
[a]Neighbor Island residents.
[b]Oahu residents.
[c]Only 8 of 39 subjects had detectable levels.
[d]Measured on a whole-milk basis in parts per million.

The mother's occupational risk is positively associated with her serum PCB level -- which at the very least demonstrates some accuracy in the job risk assessment used for tnis study. Job PCB exposure ranks at least as important as the exposure risk from eating fish from the Sheboygan River or Lake Michigan.

Finally, the mother's suprailiac fat fold measure -- actually a measure of the fat deposition at her waist -- is negatively associated with the serum PCB levels. There are again several possible explanations for this phenomena, the most obvious being that the greater the lipid deposits on the mother, the greater the storage sites for available PCB (i.e., the fat deposits are acting as a "PCB sink," preventing the molecule from mobilizing into the blood stream).

One research study showed that as a person lost weight, presumably using up fat stores, the higher their serum PCB level became (Hesselberg and Scherr 1974). It is reasonable to assume that the exact opposite may be expected when there are greater fat stores on the body. However, there were no associations between other fat fold measures from the arm and the back, nor was the one measure of obesity or mass (weight/height squared) associated with serum PCB. Perhaps current research in lipid deposition patterns and lipid cell type will offer new insights into this finding. At present so little is known of deposition patterns, cell type and the relationship to PCB body burden that no absolute statements can be made now concerning this relationship.

Compared with the first sample serum PCB level, the statistical relationship among only the three blood chemicals previously mentioned -- serum bilirubin, cholesterol and phosphorus -- combined have an R value of .562 and a P value less than .0000 (Appendix I, Table I-2). It is difficult to explain these variables because they are not clearly understood. The relationship between serum PCB and total bilirubin has been examined in detail in only one study involving Yusho patients, and these results may be confounded by the Yusho patients' exposure to dibenzofurans as well as PCBs and the fact that both sexes and a wide age range were involved in the study.

While the Sheboygan study showed a strong positive association between serum bilirubin and serum PCB (R = .410, Sig. T = .0141), nearly opposite findings were discovered in Japan:

> "Recently, Hirayama et al. (1974) examined 121 adult patients with Yusho and 257 healthy adult controls for serum bilirubin, demonstrating a significantly lower average concentration in the patients group than in the control. They also showed significantly negative correlations between serum bilirubin and blood PCBs in concentration (R = -0.349, P less than 0.025)...They considered that a lowered concentration of serum bilirubin in patients seemed mainly due to an accelerated bilirubin disposal from the blood." (Kuratsune et al. 1976, p. 26.)

Fischbein et al. (1979) briefly mentioned the potential relationship between serum bilirubin and PCBs, but showed no significance.

It has been suggested (Peterson 1982) that PCBs act in a manner quite similar to estrogens under certain conditions. Estrogens in high levels in humans have been known to cause hyperbilirubinemia. While no case of abnormally high

levels of serum bilirubin was found in the Sheboygan sample, the subtle effects of PCBs acting on the liver in a similar fashion to estrogens could cause concomitant fluctuation between the two variables, leading to the strong association found in this equation.

The relationship between serum cholesterol and serum PCB (R = .353, Sig. T = .0082) may possibly be due to the lipophilic nature of PCBs. The higher the available serum lipids, the greater the number of attachment sites for PCBs and thus the higher the potential PCBs measured. Neither of the other two serum lipids -- triglycerides and LDH -- were correlated, nor were they significant in explaining the variation in serum PCB levels.

Other studies (e.g., Kreiss et al. 1981) also noted a rise in cholesterols and a related rise in blood pressure. In the Kreiss study, "serum triglycerides or [a] high-density lipoprotein-cholesterol (HDLC) level made no additional independent contribution and did not nullify the PCB effect [in explaining the relationship with HBP]...In contrast, the log PCB value as an independent variable was weakly associated with the level of cholesterol" (p. 2507). This study, done in Alabama to investigate the relationship between PCB and high blood pressure, showed some association with serum PCBs. There were no cases of high blood pressure among the Sheboygan study population, but high blood pressure is not a common disorder among women between the ages of 18 and 36. The Kreiss article offered no causal explanation for the relationship between cholesterol and serum PCBs.

The presence of these three variables in the equation do not necessarily present a direct causal relationship, but merely a correlation and the strength of that correlation between serum chemicals and serum PCB. It may well be that the levels of bilirubin and cholesterol are a function of PCB exposure in the women, rather than the reverse. A final regression model, combining all of the seven variables discussed earlier, resulted in a Multiple R correlation coefficient of .766 and a P value less than .0000 (Appendix I, Table I-3).

Breast Milk PCB Regressions

One of the primary reasons for testing the PCB level in both the women's serum and breast milk was to determine the degree of association between the two. In the final model for the variance in the breast milk PCB, serum PCB and serum cholesterol combine to produce an R value of .812 and a P value less than .0000 (Appendix I, Table I-4). The correlation coefficients of .812 for serum PCB and .168 for serum cholesterol indicate a very strong association with the amount of serum PCB available, and a milder concordant relationship with a serum lipid.

The research on Japanese women (Masuda et al. 1978) indicates a low but significant correlation coefficient of .29 between breast milk PCB on a fat basis and serum PCB, which raises the important question of possible discrepancies in analytical methods. It is also possible that U.S. women have higher serum lipids than Japanese women due to differences in their diets. Mobilization of PCB compounds on increased serum lipids could account for the closer association between serum and breast milk PCB levels in U.S. women. Other studies on breast milk PCB have not included serum PCB testing with their analyses, so we have no other population data for comparisons.

No available data discusses the relationship between serum calcium and PCBs in humans, though birds (which obviously do not breast-feed) tend to show decreases calcium levels when harboring high levels of serum PCB (Lindvall and Low 1980). This same relationship was not found with the serum calcium and PCBs in the Sheboygan study (R = .308, P value = .0185; Appendix I, Table I-5).

When analyzing the association of breast milk with the previously discussed sociocultural and morphological variables in the serum PCB model, all four of these variables are significantly correlated to the levels of PCB in breast milk as well (Appendix I, Table I-6). The total R value is .667 and the P value less than .0000 for the association of breast milk PCB with the mother's occupational risk, fish eaten since the birth of her child, suprailiac fat fold and the mother's education. While bilirubin, cholesterol and phosphorus have a strong association with serum PCB, absolutely no relationship was found between these three variables and breast milk PCB.

When testing the data using the T test for significant differences in the means, the differences between the groups for serum and breast milk PCB are not great, but the following differences were significant: Group 1 (the high PCB-fish exposure, breast-feeding mothers) had significantly higher levels of serum PCB on the second sampling than did the second group of women (the low PCB-fish exposure, breast-feeding mothers) (P less than .01; see Appendix I, Table I-7). The same differences were detected when Group 3 was combined with either Group 2 or Group 1, indicating that the 11 individual cases in Group 3 do not provide any differences in the mean values of the two larger study groups. There is no clear explanation for this finding, but perhaps the low-exposure women may have had lower stores of PCBs than the high-exposure women in Group 1, and as the infant nursed, these accumulated body burdens decreased proportionately.

In examining the changes in serum PCB levels between the second and the fourth month post partum in the total population, in breast-feeding mothers, bottle-feeding mothers and each individual group, the only significant change in serum PCB levels was found among the low-exposure breast-feeding women in Group 2. The other two groups actually increased slightly in their mean serum PCB levels. This finding may give additional weight to the preceding speculation about the decreases in total PCB body burden for the low-exposure women. Another likely explanation is that the women of the low-exposure group are less likely to have eaten any contaminated fish in the four months post partum during which they were a part of our study sample. The high-risk women are more prone to be consuming some fish during this period and thus accumulating more measurable amounts of PCB on top of those already stored in body tissues.

Table 4 illustrates the differences in the consumption of fish for each group during the four-month period in question. Table 4 shows that the women in the high-risk groups (1 and 3) ate considerably more fish during the four months after the birth of their children than the low-risk group (2).

Infant Birth-Weight Regression Equations

The infants' birth weight is an important variable to assess, because one of the more consistent findings in the cases of accidental exposure to PCBs was SFD birth weight in infants, or low birth-weight infants (Kuratsune et al. 1971, 1976; Taki et al. 1969).

TABLE 4

NUMBER OF MEALS CONTAINING FISH EATEN BY MOTHERS
IN THE FIRST FOUR MONTHS AFTER THE BIRTH OF THEIR INFANTS

	N	NUMBER OF MEALS WITH FISH						TOTAL*	$\bar{X}$
		None	1-2	3-5	6-10	11-20	Over 20		
GROUP 1	23	11	4	2	8	0	1	68	2.95
GROUP 2	39	33	3	3	0	0	0	16	.47
GROUP 3	11	3	5	2	1	0	0	21	1.99

*Total number, all meals.

Comparing birth weight with the first serum PCB sample (which was the closest estimate we nave of the infant's prenatal exposure to PCBs), the gestational age in weeks, smoking during pregnancy and the mother's weight on the first visit for evaluation had the first significant results for this problem (see Table 5). The correlation coefficients indicated a positive relationship for all variables, except smoking, with the birth weight of the infant (R = .514, P value = .0003). At first glance, this looks very important -- until one notices the positive association between serum PCB (R = .284) and the infant's birth weight, and not the expected negative association as was found in the Yusho and rhesus monkey data.

Infant Health

Statistical tests concerning the infants' health and their relationship to PCB exposure have been presented here. In all of these equations, illnesses were grouped either into total illnesses each child suffered for the four-month period, or further divided into illness types. The types used in running the analysis, though not all were found to be significant in interpreting the data, were total illnesses, infectious illnesses, gastrointestinal illnesses, and illnesses requiring the prescription of antibiotics. The components of these variables were discussed in the Study Methods and Design section.

The one male infant who was given antibiotics after heart surgery was omitted from the calculations done on illnesses. Even when he was included, the significance levels did not change much.

Research reported in Chang et al. 1981 revealed the potential immunosuppresive effects of PCB exposure "...the percentages of total T cells, active T cells and T_{μ} cells were decreased, while the percentage of β cells and T_{γ} cells were not effected. Thus the changes of lymphocyte subpopulations may be responsible for the reported immune deficiency associated with PCB exposure" (p. 58). The patients in this study were relatively young, ages 4-24, and had serum PCB levels of 15.47 to 98.43 ppb with a group mean of 45.03 ppb. A control group had no detectable levels of serum PCB.

Other studies that also confirm the immunosuppressive actions of PCBs in humans are Shigematsu et al. 1971, Shigematsu et al. 1974 and Saito et al. 1972. All three of these studies were conducted in Japan on Yusho patients. The studies' results included decreases in IgA and IgM and increases in IgG and chronic airways infections ranging from two to five years after the initial PCB poisoning.

The first equation results discussed here, presented in Table 6, are the total number of reported illnesses of breast-fed infants with serum PCB and breast milk PCB (R = .436, P value = .0028). The serum PCB (R = .261) and weaker breast milk PCB exposure value (.013) indicates an association predicted by the earlier Japanese research.

Looking at the coefficients in the regression equation, a negative value for breast milk PCB alters the interpretation of the equation. The breast milk PCB is also an indication of breast-feeding, which tends to protect against infectious illnesses and perhaps gastrointestinal disorders. The T tests for significant means (Tables 7 and 8) further indicate that breast-fed babies had added protection against gastrointestinal illnesses over bottle-fed babies, with the Group 2 breast-fed infants having significantly fewer cases of this type of illness than the Group 3 bottle-fed infants.

TABLE 5

BIRTH WEIGHT WITH SMOKING DURING PREGNANCY, MOTHER'S WEIGHT, GESTATIONAL AGE AND FIRST SAMPLE SERUM P.C.B.

(N = 72)

CORRELATION MATRIX	Birth Weight	Smoking During Pregnancy	Mother's Weight	Gestational Age
Smoking During Pregnancy	-.183			
Mother's Weight	.219	-.123		
Gestational Age	.293	.075	.041	
First Sample Serum PCB	.284	.035	-.180	.028

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.514	Standard Error:	400.37
R Squared	.264		
Adjusted R Square	.220	P Value	.0003

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Serum PCB(1)	49691.31	16234.81	.0032
Gestational Age	154.84	56.52	.0079
Smoking During Pregnancy	-15.39	8.78	.0841
Mother's Weight	9.06	4.01	.0271
Constant	-3431.32	2265.36	

TABLE 6

TOTAL NUMBER OF REPORTED ILLNESSES OF BREAST-FED INFANTS
WITH FIRST SAMPLE SERUM P.C.B. AND BREAST MILK P.C.B.
(N = 59)

CORRELATION MATRIX	Total Illnesses	Serum PCB
Serum PCB	.261	
Breast Milk PCB	.013	.819

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.436	Standard Error:	2.846
R Squared	.190		
Adjusted R Square	.161	P Value:	.0028

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Serum PCB	755.31	208.59	.0006
Breast Milk PCB	-2.92	1.01	.0053
Constant	1.009	.794	.2089

This is even more strongly demonstrated in an equation isolating only breast-fed infant females and their exposure to serum PCB, breast milk PCB and the number of weeks they were breast-fed vs. the number of weeks bottle-fed (R = .718, P value = .0009; Appendix I, Table I-8). The serum PCB and the weeks bottle-fed both have a positive correlation with the number of infectious illnesses suffered by the children (R = .321 and R = .314, respectively).

On the opposite end, breast milk PCB and weeks breast-fed have negative correlation coefficients with the total number of infectious illnesses each infant female suffers (R = -.038 and R = -.236, respectively). This same equation run on infant males did not produce significant results. The most important variable used in predicting the number of infectious illnesses the children suffered in both previously discussed models was the amount of serum PCB with which the children came in contact (i.e., the intrauterine PCB exposure).

The association between PCB exposure and illnesses were reconfirmed in two calculations dealing with the total number of diseases the child suffered that required prescriptions of antibiotics (Appendix I, Tables I-9 and I-10). In the first, the total number of breast-fed infants were assessed, and serum PCB (R = .319, Sig. T = .0054) was again the most important predictor. Breast milk PCB, though with its small positive correlation coefficient (R = .135), had a negative β coefficient (-.828) and shows a weak negative association with the total number of diseases severe enough to require antibiotics.

TABLE 7

T TEST OF MEANS FOR ILLNESSES
BETWEEN GROUP 1 AND GROUP 3

		N	$\bar{X}$	SD	T
TOTAL ILLNESSES	Group 1	23	2.17	4.16	-1.55
	Group 3	11	5.81	9.65	
INFECTIOUS ILLNESSES	Group 1	23	.65	.98	-1.92*
	Group 3	11	2.09	3.36	$p < .065$
GASTROINTESTINAL ILLNESSES	Group 1	23	1.13	3.15	-1.98*
	Group 3	11	4.64	7.27	$p < .065$
TOTAL ANTIBIOTICS	Group 1	23	.13	.34	-1.20
	Group 3	11	.45	1.21	

*Significant difference

TABLE 8

T TEST OF MEANS FOR ILLNESSES BETWEEN GROUP 3 (BOTTLE-FED INFANTS)
AND GROUPS 1 AND 2 (BREAST-FED INFANTS)

		N	$\bar{X}$	SD	T
TOTAL ILLNESSES	Group 3	11	5.82	9.65	2.40*
	Groups 1, 2	62	2.10	3.31	$p < .02$
INFECTIOUS ILLNESSES	Group 3	11	2.09	3.36	1.36
	Groups 1, 2	62	1.06	2.08	
GASTROINTESTINAL ILLNESSES	Group 3	11	4.64	7.27	2.10*
	Groups 1, 2	62	1.60	3.76	$p < .05$
TOTAL ANTIBIOTICS	Group 3	11	.45	1.21	.11
	Groups 1, 2	62	.40	1.41	

*Significant difference

The results were even even stronger when only male children were tested (R = .633, P value = .002). The regression results indicate that the intrauterine exposure to serum PCBs (R = .422, Sig. T = .0007) had a stronger effect on later illnesses in male children requiring prescriptions of antibiotics (e.g., earaches) than did breast milk PCB exposure (R = .147, Sig. T = .0065, β = -2.64; Appendix I, Tables I-10 and I-11).

One note must be made here as to the composition of the infectious illnesses variable. Table 9 lists the variables included in the overall category of infectious illnesses and their respective frequencies. No life-threatening infectious illnesses or their complications were encountered during the study. Only very common infectious maladies were listed in this category.

One other study result is presented here. In Table 10, the total number of infant illnesses are again compared to their exposure to serum and breast milk PCBs, but in this case only the infants whose mother's serum was less than 11.01 ppb (less than the 98 percent confidence limits of the study population) were included in the calculation. In this case, serum PCB and breast milk PCB were both still significant (R = .319, P value = .0323), but both of the breast milk coefficients were negative (R = -.247, β coefficient = -2.75).

When the mothers whose serum PCB levels were above the 98 percent confidence limits were included in the analysis, the correlation coefficient becomes positive, while the β coefficient stays negative. This may be an indication of the "break-even" point between the positive effects of breast-feeding and the negative effects of breast milk PCB exposure.

Table 11 further confirms this when the infants' serum and breast milk PCB exposure is regressed against the infectious illnesses variable (R = .328, P value = .0265). The two reported coefficients for breast milk PCB exposure are again negative (R = -.281, β = -1.434). This finding may prove to be more significant when a greater number of infants are researched, but for now the

TABLE 9

FREQUENCY OF INFECTIOUS ILLNESSES, ALL INFANTS

INFECTIOUS ILLNESSES*	NUMBER 1-2	3-4	5-6	More than 6
Colds	36	1		2
Fever 101+ degrees	3			
Ear Infections	6			1
Flu	2			

* Also included urinary tract infections, pneumonia, bronchitis, meningitis, skin infections and other infections, but none occurred.

NOTE: Long-term chronic infections were coded as "10."

TABLE 10

TOTAL ILLNESSES IN CHILDREN WHOSE MOTHER'S
FIRST SAMPLE SERUM P.C.B. LEVEL WAS LESS THAN 11.01 ppb
WITH FIRST SAMPLE SERUM P.C.B. AND BREAST MILK P.C.B. EXPOSURE
(N = 67)

CORRELATION MATRIX	Total Illnesses	Serum PCB
Serum PCB (first sample)	.112	
Breast Milk PCB Exposure	-.247	.321

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.319	Standard Error:	4.74
R Squared	.107		
Adjusted R Square	.074	P Value:	.0323

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Breast Milk PCB Exposure	-2.75	1.09	.0143
Serum PCB (first sample)	489.45	286.87	.0928
Constant	2.32	1.58	.1464

difference in the mean number of illnesses between the infants whose mother's serum PCB was less than 11.01 ppb serum PCB and those whose was above that is only one additional illness in a four-month period of time.

Additional Comments

While PCBs were not implicated in affecting a child's growth in this study, other studies showed some growth compromise in males that could be attributed to PCB exposure. The growth retardation was noticed in adolescent males, however, and thus could imply some form of PCB inhibition in the production of androgenous hormones and not directly associated with children in the age range of this study.

The logistic regressions did not present any results that would further enlighten the data on PCBs action on the infants' or mothers' health. As such, these analytical runs are not discussed in this report.

Duplicate Samples Results

The spiked bovine serum samples sent from the Center for Disease Control were accurately tested by Raltech at the lower levels (around 1-3 ppb serum PCB), but as the values increased so did the margin of error. The PCB levels in the second and third environmental pools (Table 12) were measured at twice their actual level by the Raltech Lab. The implications of these errors for this

study are uncertain, but since most of the Sheboygan samples fell within the range of the first and second environmental pools provided by CDC, it is assumed that the analytical results were not distorted much.

The Washington Island study also included duplicate sampling to test for sampling and analytical error. Table 13 presents these results. The mean of the differences in the duplicate samples was 1.7, and the coefficient of variation for the four sets of values results in a 5.7 percent estimated error in the laboratory analysis.

Commercial infant formulas (Table 14) tested very low for their PCB levels. The mean value for PCB on a fat basis for the formulas was .045 ppm. While this does not represent any sort of a random sample of available formulas (merely what the researcher had on hand at the time), there seems to be adequate compliance to the USFDA codes to ensure negligible PCB exposure through commercial infant formulas.

There were no measurable amounts of PCB in either the control, distilled water sample sent in to test for contamination in the cleaning of glassware, or in the Sheboygan tap water sample.

TABLE 11

INFECTIOUS ILLNESSES IN CHILDREN WHOSE MOTHER'S
FIRST SAMPLE SERUM P.C.B. LEVEL WAS LESS THAN 11.01 ppb
WITH FIRST SAMPLE SERUM P.C.B. AND BREAST MILK P.C.B. EXPOSURE

(N = 67)

CORRELATION MATRIX	Infectious Illnesses	Serum PCB
Serum PCB (first sample)	.070	
Breast Milk PCB Exposure	-.281	.321

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE			
Multiple R	.328	Standard Error:	2.3
R Squared	.107		
Adjusted R Square	.079	P Value:	.0265

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Breast Milk PCB Exposure	-1.434	.529	.0086
Serum PCB (first sample)	198.435	139.04	.1584
Constant	1.342	.764	.0838

TABLE 12

SPIKED SERUM SAMPLES FROM THE CENTER FOR DISEASE CONTROL

(in parts per billion)

	RALTECH		C.D.C.	CDC Samples Standard Deviation
Chlorinated hydrocarbon spiked	2.91		1.6	.306
Environmental Pool 1	1.33		1.6	.306
Environmental Pool 2*	18.8	20.7	9.	.736
Environmental Pool 3*	48.2	50.6	22.16	1.638
Environmental Pool 4	85.0		67.14	3.11

*Environmental pools 2 and 3 were duplicate samples.

TABLE 13

DUPLICATE SAMPLES FROM WASHINGTON ISLAND

SUBJECT	FIRST SAMPLE	SECOND SAMPLE	DIFFERENCE
1	20.5	17.7	2.8
2	21.7	35.5	.4
3	34.6	35.5	.9
4	47.7	50.5	2.8

TABLE 14

P.C.B. LEVELS IN COMMONLY USED INFANT FORMULAS

FORMULA	FAT BASIS (in parts per million)	WHOLE MILK BASIS (in parts per billion)
Enfamil (powdered)	.04	1.34
Similac (powdered)	.05	1.68
SMA (powdered)	.06	2.01
Isomil* (concentrate)	.03	1.0+

*Isomil is a soybean milk substitute.

Conclusions

Delimitations of the Study

There are several very important points concerning the limits for generalizing and interpreting the results of this study:

First, the primary study population was all female between the ages of 18 to 36. Attempts at comparisons between this and other important general population PCB studies must take the age and sex limits of this population into account.

Second, the population under study had experienced long-term, small-dose chronic PCB exposure -- not acute poisonings as were found in Japan and other accidental poisoning studies. This could well make a significant difference in the symptomology and pathology of diseases between the two groups. On the other hand, because most people exposed to PCBs today do usually encounter it in a small-dose chronic fashion, this makes the results more comparable to the rest of the U.S. female population.

Third, the compounds Kaneclor© and Aroclor© are not comparably made, and Kaneclor has been tested as having higher levels of contaminants like dibenzofurans. These contaminants confuse the pathological picture when an attempt is made to compare the studies done in Japan (where Kaneclor was made) and the U.S. (where Aroclor was made).

Fourth, the testing methods have improved over the last 10 years, greatly increasing our analytical capability to detect very minute amounts of PCBs in the serum and the breast milk and increasing the percentage of recovery from tissue samples as well.

Fifth, the only compound studied in the Sheboygan population was Aroclor 1254 -- not 1260 or 1248, other commonly tested PCB compounds. A study by the Michigan State Department of Epidemiology (Humphrey 1978) tested for both Aroclor 1258 and 1260, then added the two together for the data analysis. Adding the two compounds may artificially raise the tested PCB levels; but if one does not, the study results may be artificially small.

Finally, there are no direct measures of the infants' PCB levels, only indirect measures of exposure from the mother's serum and breast milk. This means these estimates of PCB exposure are more suspect than a direct serum sample from the baby or the cord blood taken at birth.

Conclusions to Study Objectives

This study had five objectives. Each objective will be reviewed and discussed here. The conclusions drawn from this research must of course be weighed according to the potential inaccuracies of any case control nonclinical field work.

OBJECTIVE 1: Establish the range of polychlorinated biphenyl (PCB) contamination of breast milk and blood of women having children between Sept. 1, 1980, and Sept. 30, 1981, of a potentially exposed population in Sheboygan, Wis.

The range of PCB contamination can be estimated to be from 1.29 to 14.90 ppb in the serum, with a mean of 5.76. The 98 percent confidence limits would cover a range of .17 ppb to 11.05 ppb. Breast milk PCB ranged from a low of .29 to 4.02 ppm, with a mean value of 1.13. The 98 percent confidence limits place this at a range of .23 ppm to 2.03 ppm (tested on a fat basis).

OBJECTIVE 2: Establish the variation over time of the individual's cumulative breast milk and blood levels of PCBs and overall changes in serum and breast milk PCB through time.

The T tests discussed in this report reveal a significant drop in the serum PCB levels for breast-feeding women who had a low exposure to PCBs through fish in their diets. This same test showed an actual mean increase in serum PCB for both of the high exposure groups, though not a significant increase. The two-month difference between blood samples indicates that the women of Group 2 are significantly decreasing their respective PCB body burdens as reflected by their serum PCB levels. It is reasonable to speculate that this is a result of breast-feeding their infants.

The total breast milk PCB decrease was not significant for the two groups of women who were breast-feeding their infants. The high exposure group, when analyzed separately from the low exposure group, had a slight decrease in breast milk PCB, but not a significant drop. The low exposure group, while they had a significant drop in serum PCB levels, had a slight but insignificant increase in their mean breast milk PCB levels. The serum PCB levels do actually drop in the low diet-PCB exposure women, while the breast milk PCB levels tend to remain constant. The reasons for this are unknown.

OBJECTIVE 3: Compare the cumulative changes of serum PCB in nonlactating mothers from natural metabolic processes to the cumulative changes in serum PCB in lactating mothers.

As alluded to in the previous paragraph, serum PCB levels did not decrease in the nonlactating mothers, but actually increased during the two-month interval between the two samples -- though this was not a statistically significant increase. The increases in the serum PCB levels of both of the high exposure women (Groups 1 and 3) may have been due to the amounts of fish eaten by some of the women in these groups during the four months between the birth of their children and the end of their participation in the study.

OBJECTIVE 4: Determine the relationship between serum and breast milk PCB levels with the ingestion of sport and commercial fish from Wisconsin waterways.

The calculated risk-level variable (see Description of Variables section) had no real detectable influence on serum or breast milk PCB levels when tested in the multiple regression equation procedure. However, when using a

cross-tabular Chi Square procedure, the high-risk level (5) was correlated with high serum PCB levels, and the low-risk level (1) was correlated with low serum PCB levels. The intervening risk values (2-4) had no detectable impact on the woman's serum PCB levels. This indicates a very general predictability of the amount of fish in the woman's diet and her serum PCB level. The more accurate measure of the association between the woman's serum/breast milk PCBs and her diet was the fact that she did or did not eat fish during the four months she was being studied by the Sheboygan City Public Health staff.

T tests for the significant differences in the means also indicate that women who had a low initial exposure to PCB through eating fish (Group 2) and ate no fish for the four months after study had lower levels of serum PCB than those women who started with higher levels of dietary fish and ate fish during the study period (Groups 1 and 3).

OBJECTIVE 5: Obtain preliminary data about infant health and development and the correlation with maternal blood and breast milk PCB levels as they effect the three infant data sets.

Infant Health: There were consistently significant findings in the regression analysis to confirm the relationship between the infants' experience with infectious illnesses and PCB exposure. However, the mode of exposure is very important. Maternal serum PCBs had a positive association with the number and type of infant infectious illnesses, while breast milk PCBs had a weak but significantly negative association with infant illnesses. The simple fact of breast-feeding an infant was still protective against total illnesses, infectious illnesses and gastrointestinal illnesses in the infant in spite of the presence of PCBs.

Infant Development: Infant development, as measured by post partum weight gain and behavior, showed no relationship with either the serum or breast milk PCB exposure. There were several positive correlations with other variables -- such as the infant's vocal response with the mother's education -- but all of these associations have been previously confirmed in earlier studies using this evaluation technique. This indicates that the infant evaluator was making judgements consistent with other researchers in infant development studies and that the infant evaluation was conducted accurately.

When infant development is measured by birth weight, there was the significant positive correlation between the mother's serum PCB level and the increase in the infant's birth weight even when maternal weight was controlled in the equation. There is no available explanation for this finding.

Conclusions to the Tested Hypotheses

HYPOTHESIS 1: The amount of Lake Michigan fish and Sheboygan River fish eaten by any woman of reproductive age will correlate positively with cumulative PCB levels in her blood and breast milk.

This hypothesis must be rejected, but with a conditional clause. The variable measuring dietary risk from the four months following the birth of the subjects' infants is significant with the first serum PCB level, it is not the strongest nor the most important variable for explaining the PCB accumulation

in the study population. The woman's occupation and education are far more important variables when assessing behaviors that place her at risk of accumulating a high PCB body burden. This relationship is obviously a nonrandom association, but it is so weak that research or PCB risk exposure assessments must never be based solely on the amount of fish in the woman's diet.

HYPOTHESIS 2: The cumulative level of PCBs in the mother's tissue will drop as she breast-feeds her child.

This hypothesis must be accepted as true -- within the context of this study. The tendency is for women who do not eat fish during the breast-feeding period to experience a significant drop in their cumulative PCB body burden as represented by their serum PCB. This may presumably be caused by passing the compound through the milk to the infant.

HYPOTHESIS 3: The child's health, development and behavior will be negatively effected by the amount of PCBs passed from the mother to her child either transplacentally, or via the placenta and breast milk.

Part of this hypothesis must be accepted, and part must be rejected. The infant's transplacental exposure to PCBs (measured by the mother's first sample serum PCB value) has a positive effect on the number of illnesses the infant suffered in the first four months of life. The breast milk PCB exposure does not have this same effect for these first four months; on the contrary, the fact of breast-feeding, at the PCB levels represented in this study, offers some protective advantage against total number of illnesses, infectious illnesses and gastrointestinal illnesses.

Recommendations for Further Research

It's often said that "good research raises more questions than it answers." By this standard at least, this study must be good research. Several areas requiring further research have previously been mentioned, but will be reviewed here.

First, the strong positive relationship between serum PCBs and total serum bilirubin found in this study goes entirely contrary to earlier research with people experiencing acute toxic exposure to PCB. More study must be done on low-level chronic exposure and the physiological effects from this, rather than focusing only on the acute accidental poisonings or the high-level exposures posed by industrial uses.

Second, the association between the mother's education and her accumulation of PCB body burden could reveal activities or behavior indicative of her education and responsible for her exposure to PCBs.

Further research must be done on the effects of long-term nursing, breast milk PCB levels and its associated risk for infant health. The present study only carries the data to the fourth month post partum, and at some level of PCB in breast milk or some length of time for nursing there must be a "break even" point or a point of diminishing returns beyond which it is no longer beneficial for the mother to nurse her child.

The exposure levels and time span in this study may have been reaching that break-even point. With both the "total illnesses" variable and the "total antibiotics" variable, the breast milk PCB had a weak positive correlation coefficient as well as a weak negative β regression coefficient. Further research is still required to determine the point beyond which a mother should not nurse her child, either in terms of PCB in her breast milk, or length of time the child is nursed.

Finally, the infants collected in this study cohort should be followed through time to determine their rate of PCB accumulation, if this is correlated to their breast milk or pre-partum PCB exposure, and how long this exposure effect lasts. Lastly, the children should be studied to determine if the PCBs have a lasting effect on their health, or if these previously determined relationships deteriorate with age and increases in the child's body mass.

Recommendations for Physicians and Mothers

It is hard to finally make some absolute statements concerning the study results and how they should effect the functioning of the "real world." However, something absolute must be said -- especially in consideration of the relative importance of the findings of this research and the length of time physicians, mothers and researchers have been waiting for someone to make an educated judgement on the available data:

1. The negative effects of breast milk PCBs were not discernable in this study up to approximately 2.5 ppm on a fat basis; beyond that point one may expect some health problems to be associated with breast-feeding. It is not recommended that women with breast milk PCB levels above 4 ppm on a fat basis nurse their infants for more than four months. The positive protective effects of breast milk seem to start wearing off close to that PCB level, indicating the point of diminishing returns has been reached.

2. Women should continue to breast-feed their infants four to six months if their serum PCB values are less than 11.01 ppb to help protect from the negative effects associated with prenatal exposure to the mother's serum PCB.

3. Women of reproductive age should discontinue eating fish from known polluted waterways during their entire reproductive career. While this offers little control over the total accumulated PCB body burden, every little bit helps. Even low levels of PCBs in the mother have some measurable detrimental effects on the subsequent health of the infant.

References

Abe, S.; Y. Inoue; M. Takamatsu. 1975. PCB Residues in Plasma of Yusho Children Born to Mothers Who Had Consumed Oil Contaminated by PCB. In: 5th Report of the Study On Yusho and PCBs, Abst.

Abrahamson, L.; J.R. Allen. 1973. The Biological Response of Infant Nonhuman Primates to a Polychlorinated Biphenyl. Environmental Health Perspectives (June).

Allen, J.R.; L.A. Abrahamson; D.H. Norback. 1973. Biological Effects of PCBs and PCTs on the Subhuman Primate. Environmental Research 6:344-54.

Allen, J.R.; D.A. Barsotti. 1976. The effects of Transplacental and Mammary Movement of PCBs of Infant Rhesus Monkeys. Toxicology 6:331-40.

Allen, J.R.; D.H. Norback. 1976. Pathobiological Responses of Primates to Polychlorinated Biphenyl Exposure. In: Proceedings of the National Conference on PCBs, Nov. 19-21, 1975, Chicago. Washington: U.S. Environmental Protection Agency, EPA-560/6-75-004:43.

Baker, E.L.; P.J. Landrigan; C.J. Glueck; M.M. Zack, Jr.; J.A. Liddle; V.W. Burse; W.J. Housworth; A.L. Needham. 1980. Metabolic Consequences of Exposure to PCBs in Sewage Sludge. Am. J. of Epidemiology 112:553-63.

Barr, M., Jr. 1981. Environmental Contamination of Human Breast Milk. American J. of Public Health 71:124-26.

Barsotti, D.A.; R.J. Marlar; J.R. Allen. 1976. Reproductive Dysfunction in Rhesus Monkeys Exposed to Low Levels of PCBs (Aroclor 1248). Food Cosmet. Toxicol. 14:9-103.

Bowman, R.E.; M.P. Heironimus; J.R.Allen. 1978. Correlation of PCB Body Burden With Behavioral Toxicology in Monkeys. Pharmacology, Biochemistry and Behavior 9:49-56.

Brevik, E.M.; J.E. Bjerk. 1978. Organochlorine Compounds in Norwegian Human Fat and Milk. Acta Pharmacol. et Toxicol. 43:59-63.

Butcher, R.L.; R.D. Page. 1981. Introductory Remarks: Environmental and Endogenous Hazards to the Female Reproductive System. Environ. Health Perspec. 38:35-37.

Chao, S.T.; C.J. Omiecinski; M.J. Namkunc; S.D. Nelson; B.H. Bvorchik; M.R. Juchau. 1981. Catechol Estrogen Formation in Placental and Fetal Tissues of Humans, Macaques, Rats and Rabbits. Dev. Pharmacol. 2:1-16.

Chang, K.J.; K.-H. Hseis; T.-P. Lee; S.-Y. Tang; T.-C. Tung. 1981. Immunologic Evaluation of Patients with Polychlorinated Biphenyl Poisoning: Determination of Lymphocyte Subpopulations. Toxicol. Appl. Pharmacol. 61:58-63.

REFERENCES (cont'd.)

Chen, P.H.; J.M. Gaw; C.K. Wong; C.J. Chen. 1980. Levels and Gas Chromatographic Patterns of Polychlorinated Biphenyls in the Blood of Patients after PCB Poisoning in Taiwan. Bull. Environ. Contam. Toxicol. 25:325-29.

Cook, W. 1972. Some Chemical Aspects of PCBs. Environmental Health Perspectives 1:3-13.

Dillon, J.C.; G.B. Martin; H.T. O'Brien. 1980. Pesticide Residues in Human Milk. Food Cosmet. Toxicol. 19:437-42.

Donald, H.P. 1939. Sources of Variation in Human Birth Weights. Proc. Royal Soc. Edinb. Sect. B Biol. 54:91-108.

Finklea, J.; L.E. Priester; J.P.Creason; T. Hauser; T. Hinner; D.I. Hammer. 1972. PCB residues in Human Plasma Expose a Major Urban Pollution Problem. American Journal of Public Health 62:645-51.

Fischbein, A.; M.S. Wolff; R. Lilis; J. Thornton; I.J. Selikoff. 1979. Clinical Findings Among PCB Exposed Capacitor Manufacturing Workers. Annals New York Academy of Science 320:703-15.

Goto, M.; K. Higuchi. 1969. The Symptomatology of Yusho in Dermatology. In: Reports of the Study for Yusho.

Grant, D.L.; J. Mes; R. Frank. 1976. PCB Residues in Human Adipose Tissue and Milk. In: Proceedings of the National Conference on Polychlorinated Biphenyls, Nov. 19-21, 1975, Chicago. U.S. Environmental Protection Agency Office of Toxic Substances publication EPA-560/6-75-004.

Graves, S. 1980. Logisitc Computer Program. Madison, Wis.: Madison Academic Computing Center.

Gustafson, C.G. 1970. PCBs -- Prevalent and Persistent. Environmental Science and Technology 4:814-19.

Habicht, J.P.; A. Lechtig; G. Yarbrough; R.E. Klein. 1974. Maternal Nutrition, Birth Weight and Infant Mortality. In: Size at Birth, pp. 354-77. CIBA Foundation.

Hammer, D.I.; J.F. Finklea; L.E. Priester; J.E. Keil; S.H. Sandifer; K. Bridord. 1972. PCB Residues in the Plasma and Hair of Refuse Workers. Environmental Health Perspectives 1:83.

Hara, I.; H. Harada; S. Kimura; T. Endo; K. Kawano. 1974. Followup Health Examination in an Electric Condenser Factory after Cessation of PCB Usage. Japanese Journal of Industrial Health 16:365-66, Abst.

Harrod, J.R. 1980. Pollutants in Breast Milk. The New England Journal of Medicine. 303(16):945-46.

REFERENCES (cont'd.)

Hasegawa, H.; M. Sato; H. Tsurta. 1972. PCB Concentrations in Air of PCB-Using Plants and Health Examination of Workers. In: (in Japanese) Report on Special Research on Prevention of Environmental Pollution by PCB-Like Substances, pp. 141-149 English Abst. Tokyo: Research Coordination Bureau of Science and Technology Agency.

Hesselberg, R.J.; D.D. Scherr. 1974. PCBs and p,p-DDEs in the Blood of Cachectic Patients. Bull. Environ. Contam. Toxicol. 11:202-205.

Hirayama, C.; M. Okumura; J. Nagai; Y. Masuda. 1974. Hypobilirubinemia in Patients With Polychlorinated Biphenyl Poisoning. Clin. Chim. Acta 55:97-100 (cited in Kuratsune 1976).

Hsu, I.C.; J.P. Van Miller; J.L. Seymour; J.R. Allen. 1975a. Urinary Metabolites of 2,5,2',5'-Tetrachlorobiphenyls in the Nonhuman Primate. Proc. of the Society for Experimental Biology and Medicine 150:185-88.

Hsu, I.C.; J.P. Van Miller; J.R. Allen. 1975b. Metabolic Fate of 3H 2,5,2',5'-Tetrachlorobiphenyl in Infant Nonhuman Primates. Bull. Environ. Contam. Toxicol. 14: 233-40.

Humphrey, H.E.B. 1978. Evaluation of Changes of the Level of PCB in Human Tissue. Lansing, Mich.: Unpublished final report, U.S. Food and Drug Administration research contract.

Jelinek, C.F.; P.E. Corneliussen. 1976. Levels of PCBs in the U.S. Food Supply. In: Proceedings of the National Conference on Polychlorinated Biphenyls, Nov. 19-21, 1975, Chicago. U.S. Environmental Protection Agency Office of Toxic Substances, EPA-560/6-75-004.

Kendrick, E. 1980. Testing for Environmental Contaminants in Human Milk. Pediatrics 66(3):470-72.

Kikuchi, M.; M. Hashimoto; M. Hozumi; K. Koga; S. Oyoshi; M Nagakawa. 1969. An Autopsy Case of Stillborn of Chlorobiphenyls Poisoning. In: Fukuoka Acta Medica, vol. 60, no. 6.

Kikuchi, M.; M. Hashimoto. 1969. Histopathological Studies of Skin Lesions of Patients with PCB Poisoning. In: Reports of the Study for Yusho, Abst. Fukuoka Acta Medica, vol. 60, no. 6.

Kleinert, S.J. 1977. Report on the PCB Contamination of the Sheboygan River. In: Wisconsin Natural Resources Bulletin. Madison: Wisconsin Department of Natural Resources.

Kolbye, A.C. 1972. Food Exposure to PCBs. Environmental Health Perspectives 1:85-88.

Kreiss, K.; M.M. Zack; R.D. Kimbrough; L.L. Needham; A.L. Simrek; B.T. Jones. 1981. Association of Blood Pressure and Polychlorinated Biphenyl Levels. JAMA 246(24):2505-09.

REFERENCES (cont'd.)

Kreiss, K.; M.M. Zack; R.D. Kimbrough. 1981. Cross-Sectional Study of a Community with Exceptional Exposure to DDT. JAMA 245:1926-30.

Kuratsune, M.; Y. Morikawa; T. Hirohata; M. Nishizumi; S. Kohchi; T. Yoshimura; J. Matsuzaka; A. Yamaguchi. 1969. An Epidemiologic Study on Yusho or Chlorobiphenyl Poisoning. In: Report on the Study on Yusho. English Abst. Fukuoka Acta Medica, vol. 60, no. 6.

Kuratsune, M.; T. Yoshimura; J. Matsuzaka; A. Yamaguchi. 1971. Yusho: A Poisoning Caused by Rice Oil Contaminated with PCBs. Technical Reports 86:1083-91.

Kuratsune, M.; T. Yoshimura; J. Matsuzaka; A. Yamaguchi. 1972. Epidemiological Study on Yusho, a Poisoning Caused by Ingestion of Rice Oil Contaminated with a Commercial Brand of PCBs. Environmental Health Perspectives 1:119-28.

Kuratsune, M.; Y. Masuda; J. Nagayama. 1976. Some of the Recent Findings Concerning Yusho. In: Proceedings of the National Conference on Polychlorinated Biphenyls, Nov. 19-21, 1975, Chicago. U.S. Environmental Protection Agency Office of Toxic Substances, EPA-560/6-75-004.

Kuroiwa, Y.; Y. Murai; T. Santa. 1969. Neurological and Nerve Conduction Velocity on 23 Patients with Chlorobiphenyl Poisoning. In: Report of Study for Yusho, Abst.

Kusuda, M. 1971. Study on the Female Sexual Function Suffering from the Chlorobiphenyl Poisoning. Sanka to Fujinka 4:1063-72, cited in Wasserman et al. 1979.

Lawrence, R. 1980. Breast-Feeding: A Guide for the Medical Profession. St. Louis: The C.V. Mosby Company.

Lindvall, M.L.; J.B. Low. 1980. Effects of DDE, TDE and PCBs on Shell Thickness of Western Grebe Eggs, Bear River Migratory Bird Refuge, Utah, 1973-74. Pesticides Monitor Journal 14(3):108-111.

Masuda, Y.; R. Kagawa. 1974. Comparison of PCBs in Yusho Patients and Ordinary Persons. Bull. Environ. Contam. & Toxicol. 11:213-16.

Masuda, Y.; R. Kagawa; H. Kuroki; M. Kuratsune; T. Yoshimura; I. Taki; M. Kusuda; F. Yamashita; M. Hayashi. 1978. Transfer of Polychlorinated Biphenyls from Mothers to Fetuses and Infants. Food Cosmet. Toxicol. 16:543-46.

Matthews, H.B.; M. Anderson. 1976. PCB Chlorination vs. PCB Distribution and Excretion. In: Proceedings of the National Conference on Polychlorinated Biphenyls, Nov. 19-21, 1975, Chicago. U.S. Environmental Protection Agency Office of Toxic Substances, EPA-560/6-75-004.

REFERENCES (cont'd.)

Mes, J.; D.J. Davies. 1979. Presence of PCB and Organochlorine Pesticide Residue and the Absence of PCTs in Canadian Human Milk Samples. Bull. Environ. Contam. a Toxicol. 21:381-87.

Musial, C.J.; O. Hutzinger; V. Zito; J. Crocker. 1974. Presence of PCB, DDE and DDT in Human Milk in the Provinces of New Brunswick and Nova Scotia, Canada. Bull. Environ. Contam. Toxicol. 12(3):258-67.

Okumura, M.; S. Katsuki. 1969. Clinical Observation on Yusho. In: Report on the Study for Yusho, Abst.

Okumura, M.; M. Yamanaka; S. Nakamuta; H. Uzawa. 1975. Consecutive Six-Year Followup on Serum Triglyceride Levels in Patients with PCB Poisoning. In: 5th Report of the Study on Yusho and PCBs, Abst.

Peterson, R. 1982. Personal Communication.

Polani, P.E. 1974. Chromosomal and Other Genetic Influences on Birth Weight Variation. In: Size at Birth, pp.127-64. CIBA Foundation.

Saito, R.; N. Shigematsu; S. Ishimaru. 1972. Immunoglobulin Levels in Serum and Sputum of Patients with PCB Poisoning. Fukuoka Acta Med. 63:408-11, cited in Wasserman et al. 1979.

Savage, E.P.; J.D. Tessari; J.W. Malberg; H.W. Wheeler; J.R. Bagby. 1973. A Search for PCBs in Human Milk in Rural Colorado. Bull. Environ. Contam. Toxicol. 9:222-26.

Shigematsu, N.; Y. Norimatsu; T. Ishibashi; M. Yoshida; S. Suetsugu; T. Kawatsu; T. Ikeda; R. Saito; S. Ishimaru; T. Shirakisa; M. Kido; K. Emori. 1971. Clinical and Experimental Studies on Respiratory Involvement in Chlorobiphenyl Poisoning. Fukuoka Acta Med. 62:150-56, cited in Wasserman et al. 1979.

Shigematsu, N.; S. Ishimaru; T. Hirose; T. Ikeda; K. Emori; N. Mivazaki. 1974. Clinical and Experimental Studies on Respiratory Involvement in Chlorobiphenyl Poisoning. Fukuoka Acta Med. 65:88-95 cited in Wasserman, 1979.

Skinner, M. 1980. Personal Communication.

Takahashi, W.; D. Saidin; G. Takei; L. Wong. 1981. Organochloride Pesticide Residues in Human Milk in Hawaii, 1979-80. Bull. Environ. Contam. Toxicol. 27:506-11.

Taki, I.; S. Hisanaga; Y. Amagase. 1969. Report on Yusho Pregnant Women and Their Fetuses. In: Report of the Study for Yusho, Abst.

Treon, J.F.; F.P. Cleveland; J.W. Cappel; R.W. Atchley. 1956. The Toxicity of the Vapors of Aroclor 1242 and Aroclor 1254. Am. Ind. Hyg. Assoc. Quart. 17:204-13.

REFERENCES (cont'd.)

Tucker, E.S.; W.S. Litschgi; W.M. Mees. 1975a. Migration of Polychlorinated Biphenyls in Soil Induced by Percolating Water. Bull. Environ. Contamin. Toxicol. 13:86-93.

Tucker, E.S.; V.W. Saeger; O. Hicks. 1975b. Activated Sludge Primary Biodegradation of Polychlorinated Biphenyls. Bull. Envirom. Contam. Toxicol. 14(16):705-13.

Uzawa, H.; Y. Ito; A. Notomi; S. Katsuki. 1971. Clinical and Experimental Studies on the Hyperglycerdemia Induced by Oral Ingestion of Chlorinated Biphenyls. Fukuoka Acta Med. 62:66-73.

Warshaw, R.; A. Fischbein; J. Thornton; A. Miller; I.J. Selikoff. 1979. Decrease in Vital Capacity in PCB-Exposed Workers in a Capacitor Manufacturing Facility. In: Health Effects of Halogenated Aromatic Hydrocarbons. New York: New York Academy of Sciences 32:277-83.

Wasserman, M.; D. Wasserman; S. Cucos; H.J. Miller. 1979. World PCB Map; Storage and Effects in Man and His Biologic Environment in the 1970s. Annals New York Academy of Sciences 320.

Wasserman, M.; B. Bercovici; S. Cucos; D. Wasserman; M. Ron. 1980. Storage of Some Organochloride Compounds in Toxemia of Pregnancy. Environmental Research 22:404-11.

Watanabe, I.; T. Yakushiji; N. Kunita. 1980. Distribution Differences Between Polychlorinated Terphenyls and Polychlorinated Biphenyls in Human Tissue. Bull. Environ. Contam. Toxicol. 25:810-15.

Wickizer, T.M.; L.B. Brilliant. 1981. Testing for Polychlorinated Biphenyls in Human Milk. Pediatrics 68(3):411-15.

Wickizer, T.M.; L.B. Brilliant; R. Copeland; R. Tilden. 1981. Polychlorinated Biphenyl Contamination of Nursing Mothers Milk in Michigan. Am. J. of Public Heatlh 71:132-37.

Yakushiji, T.; I. Watanabe; K. Kuwabara; S. Yoshida; K. Koyama; I. Hara; N. Kunita. 1978. Long-term Studies of the Excretion of Polychlorinated Biphenyls (PCBs) through the Mother's Milk of an Occupationally Exposed Worker. Arch. Environ. Contam. Toxicol. 7:493-504.

Yoshida, S.; A. Nakamura. 1979. Residual Status after Parturition of Methylsulfone Metabolites of PCBs in the Breast Milk of a Former Employee in a Capacitor Factory. Bull. Environ. Contam. Toxicol. 21:111-15.

Appendices

APPENDIX A

REQUEST FOR PARTICIPATION

AND

INITIAL QUESTIONNAIRE

UNIVERSITY OF WISCONSIN - DEPARTMENT OF PREVENTIVE MEDICINE
SHEBOYGAN DEPARTMENT OF PUBLIC HEALTH

Dear Parent:

The University of Wisconsin's Department of Preventive Medicine and the Sheboygan Department of Public Health wish to invite you to be part of a special study now in progress in the Sheboygan area. We want to find out if PCB's which we know are present in the environment can be found in mother's breast milk and her blood. Added to this is the need to discover if the infants have any developmental health problems or difficulties with growth which may be caused by these PCB pollutants.

The results of this study may help those people responsible for child care such as doctors and mothers, decide what is best for the growing child and for those children not yet born.

Other benefits will be important contributions to scientific research, and may provide protection and aid to our future generations.

We need your help if this project is to be successful. You do not need to be breast feeding your child to participate. If you choose not to be in the study, or if you do enter the study and for some reason cannot or do not wish to continue, you may withdraw at any time. This will in no way affect your relationship with the Sheboygan Health Department.

If you do wish to be a part of the study, please carefully read the following pages. This outlines the program and details exactly what your role is as a participating parent will be. If you have any questions, please contact the PCB Program Coordinator at the Sheboygan Department of Public Health (459-3485).

PLEASE!! PLEASE!! PLEASE!! Return pages 3 and 4 of this form. Even if you do not wish to participate in the study, we would appreciate your returning the answers to the questions on the 4th page.

All of the laboratory tests and developmental screenings will be free for the families involved. For those selected to participate in this study, the mother will receive $8.00 for each of the two visits.

Thank you.

Soloman Belinky, M.P.H., Director

** Because of the potential of harm from PCB's, breast feeding and pregnant mothers may wish to reduce their intake of Lake Michigan and Sheboygan River fish

- PROGRAM OUTLINE:

1. The participating mother and infant will be asked to come to the Sheboygan Health Department when the child is about two months old. Here she will answer some questions on her background, health, and most recent pregnancy.
2. The mother will then have some blood taken for a blood test and a sample of breast milk taken for a laboratory test. The only possible discomfort will be from the blood test. This is no different than the blood samples taken in your doctor's office. A trained technician will take the blood sample and assist in taking the breast milk sample.
3. At NO time will we be taking a blood sample from your child!!
4. There will then be a growth and developmental assessment done on your child.
5. The mother will also be asked questions about her child's health.
6. For mothers who are not breast feeding, only the blood sample will be taken. However, she will be given the same questions as the breast feeding mothers.
7. All mothers will be asked to return in two months. At this time, the infants will again be evaluated and the mothers asked questions about the baby's health.
8. Mothers who have been breast feeding will have another blood sample taken. If they are still breast feeding another breast milk sample will be taken.
9. Mothers who did not breast feed will have another blood sample taken when the infant is four months old.
10. We may wish to review and copy portions of the medical records on your baby and on this pregnancy. Because of this, we will ask you for permission to contact your doctor (the one who delivered the baby) and the baby's doctor.
11. Your privacy will be protected at all times. All information is completely confidential.
12. The risks and inconvenience of this study are quite small as compared to the amount of knowledge and potential benefits that may be gained.
13. All test results will be given to your physician when completed, if you agree and so wish.

CONSENT TO PARTICIPATE:

I, _____, age ____, hereby voluntarily agree to cooperate in the above named study and to undergo the tests listed above.

1. The procedures and tests to be followed are as stated in above Sections 1-9.

2. Any possible discomfort or risks as noted in Number 2 above, are minimal. Normal Health Department procedures are followed, when drawing blood.

3. Benefits of this program are as indicated in pages 1 and 2 of this letter.

4. I am free to terminate my consent and to discontinue participation in the project at any time without prejudice to myself. I do not have to furnish any information or participate in any part of the study I do not wish to.

5. My identity and my relationship to any information: (1) disclosed by me in completing any project questionnaire, and (2) reported by me or derived from me during my participation in the above named project shall be kept confidential and will not be disclosed to others without my written consent except as required by law and except that such information will be used for statistical and research purposes in such a manner that no individual can be identified.

6. If any of my medical records are required for assistance in this project, a separate written consent for release of the records will be requested from me.

7. There will be questions that I will be asked to answer. Inquiries concerning the questions will be answered by the PCB Program Coordinator.

8. PLEASE RETURN PAGES 3 AND 4 IN ENCLOSED ENVELOPE.

_____ _____

Name - Signature Phone Number

_____ _____

Address Date

CHILD'S BIRTH DATE:

PLEASE ANSWER THE FOLLOWING QUESTIONS:

1. Are you presently breast feeding your child? Yes No

2. If yes, how many months do you plan to breast feed?

_____months

3. In the last ten years have you eaten any fish caught from the Sheboygan River, or fish caught from around the Sheboygan harbor?

Yes No

If yes, in what years or year was this? Year _____

4. In the last four years, have you eaten fish caught from the Sheboygan River or the Sheboygan harbor?

Yes No

If yes, about how many meals of Sheboygan River fish or fish caught in or around the Sheboygan harbor do you eat in a single fishing season?

a. Less than once a month.
b. About once a month.
c. About once every two weeks.
d. About once every week.
e. More often than once a week.

5. How many meals of any Lake Michigan sport or commercial fish do you eat in one month?

a. Less than once a month.
b. About once a month.
c. About twice a month.
d. About three times a month.
e. About once a week.
f. More often than once a week.

Please remember to return this form even if you do not wish to participate in the study!!!!

*** THANK YOU FOR YOUR HELP AND COOPERATION ***

APPENDIX B

INFANT EVALUATION

1. HANDS ENGAGE IN MIDLINE.

Materials: None.

Procedure: Observe or ask parent whether child's hands ever meet in the midline position.

Scoring:
Pass: Hands engage in midline.
Emerging: It is questionable whether hands meet in midline position.
Fail: None of the above.

2. HEAD STEADY WHEN PROPPED FOR SITTING.

Materials: Stop watch or other reliable measuring device for counting seconds.

Procedure: Prop child in sitting position with legs straightened and spread to a fifty degree angle. Observe and record number of seconds child holds head erect. Three trials.

Scoring:
Pass: Head is held erect for fifteen seconds. 1/3 trials.
Emerging: Head is held erect for less than fifteen seconds.
Fail: Head is not held erect.

3. SECURES TWO OBJECTS.

Materials: Two objects that will fit into child's hands, such as blocks, keys, rattles, and a stop watch or other reliable measuring device for counting seconds.

Procedure: Place one object in each of child's hands. Observe and record number of seconds child holds object. Three trials.

Scoring:
Pass: Child holds objects for three or more seconds.
Emerging: Child holds objects for less than three seconds.
Fail: None of the above.

PROBLEM SOLVING
0 - 6 MONTHS

1. VISUALLY FOLLOWS OBJECT IN CIRCULAR MOTION.

Materials: A bright colored object, such as a string of beads or colored paper attached to a string about eight inches long.

Procedure: While child is supine, suspend the object approximately eight inches from his/her eyes and move to attract attention. When eyes focus on object, move it slowly in a circle with the diameter approximating that of child's head. Five trials.

Scoring:
- *Pass:* Follows object through a complete circle. 1/5 trials.
- *Emerging:* Follows only part of circle.
- *Fail:* None of the above.

2. REACHES PERSISTENTLY.

Materials: Rattle, bracelet, or beads.

Procedure: Hold out an object within child's reach. Three trials.

Scoring:
- *Pass:* Reaches for object and touches or takes it. 1/3 trials.
- *Emerging:* Randomly waves arms and accidentally touches object. 1/3 trials.
- *Fail:* None of the above.

3. VISUALLY FOLLOWS MOVING PERSON.

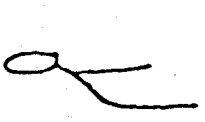
Materials: None.

Procedure: While child is supine, move across his/her line of vision. Three trials.

Scoring:
- *Pass:* Child tracks with eyes and/or moves head to follow person. 1/3 trials.
- *Emerging:* Glances at person but does not follow.
- *Fail:* None of the above.

TABLE 3

POSTURE CONTROL

Head	Body Pull-up from Supine  0	 1	 2		
Body	Sitting  0	 1	 2	 3	
	Standing w/Support	0 No Weight Bearing	1 Some Weight Bearing	2 Stands Unstable	3 Stands Stable
Active Movement	Locomotion	0 Automatic Stepping	1 Rolls Over F → B	2 Rolls Over B → F	3 Crawls

SOUND RESPONSE

0 - 6 MONTHS

1. RESPONDS TO SOUND OF NOISEMAKER.

Materials: Bell, rattle, snapper.

Procedure: Standing behind child, ring bell twelve inches from center back of head. If no response in one to five trials, select another noisemaker. Five trials each noisemaker.

Scoring:

Pass: Any response such as eye blink, increased bodily activity, cessation of activity. 2/5 trials for any noisemaker.

Emerging: 1/5 trials for any noisemaker.

Fail: None of the above.

2. LOCALIZES SOUND.

Materials: Bell, rattle, snapper.

Procedure: Standing behind child, ring bell six inches from left side of child's head. Repeat at right side of head. If no response in three sets (left and right), select another noisemaker. Three paired trials.

Scoring:

Pass: Turns head appropriately to left and to right in 1/3 responses to sets.

Emerging: Responses are questionable.

Fail: None of the above.

3. QUIETED BY HUMAN VOICE.

Materials: None.

Procedure: At time when child is cooing, babbling or crying, stand out of sight and talk to child in a normal voice. Three trials.

Scoring:

Pass: Ceases making sound for at least two seconds in 1/3 trials.

Emerging: Ceases making sound for less than two seconds.

Fail: Does not cease making sound.

VOCAL RESPONSE

0 - 6 MONTHS

1. LAUGHS OUT LOUD.

Materials: None.

Procedure: Engage child in playful activity designed to elicit laughter, such as tickling stomach, varying pitch of voice while talking, holding child in air and playing airplane.

Scoring:

Pass: Laughs out loud.

Emerging: Makes sounds but laughing questionable.

Fail: None of the above.

2. VOCALIZES WITH TWO IDENTIFIABLE VOWELS.

Materials: None.

Procedure: Engage child in activity that will elicit vocalization, such as talking or cooing.

Scoring:

Pass: Vocalizes two identifiable vowels when not crying.

Emerging: Vocalizes only one identifiable vowel when not crying.

Fail: None.

3. VOCALIZES WHEN ADULT COPIES INFANT.

Materials: None.

Procedure: Engage child in vocal play. When child produces sound, imitate it or talk back, then wait quietly for child to respond. Five trials.

Scoring:

Pass: Child reciprocates with vocalizations. 2/5 trials.

Emerging: Child reciprocates with vocalizations. 1/5 trials.

Fail: None of the above.

APPENDIX C

INFANT GROWTH MEASUREMENTS

AND

EVALUATION WORK-UP SHEET

WORKUP SHEET I.D.#_____

Infant Assessment

Head Circumfrence	____	____	____
Arm Circumfrance	____	____	____
Trunk (at nipple line)			
Circumfrence	____	____	____
Arm fat fold	____	____	____
Back fat fold	____	____	____
Abdominal fat fold	____	____	____
Overall length	____	____	____
Trunk length	____	____	____
Weight	_____		

Scores on subjective evaluation

Motor 1	____	____	____
Motor 2	____	____	____
Motor 3	____	____	____

Problem solving 1	____	____	____	____	____
Problem solving 2	____	____	____		
Problem solving 3	____	____	____		

Posture control

Head	____	____	____
Sitting	____	____	____

Vocal response 1 _____ (laughs out loud)

Vocal response 2 _____ (vocalizes with two identifiable vowels)

Vocal response 3 _____ (vocalizes when adult copies infant)

Sound response 1	____	____	____	____	____	(noise maker)
Sound response 2	____	____	____	____	____ ____	(localizes sound)

Baby's behavior during evaluation: Calm & happy_____

A little fussy _____

Too fussy to work with _____

UNIVERSITY OF WISCONSIN - DEPARTMENT OF PREVENTIVE MEDICINE

-

SHEBOYGAN DEPARTMENT OF PUBLIC HEALTH

INITIAL QUESTIONNAIRE

Date _____ ID# _____

Mother's Name _____

Father's Name _____

Baby's Name _____

Telephone # _____

Address _____

Your Doctor's Name _____

Address _____

Baby's Doctor's Name _____

Address _____

INITIAL QUESTIONNAIRE

ID # _____

Mother's Age _____ Birth Date _____

Father's Age _____ Birth Date _____

Baby's Date of Birth _____ Sex _____

Mother's National Origin _____
(Are you of English, Scandinavian, Irish, African, etc. descent?)

Father's National Origin _____

Church usually attended _____

How many years of school have you completed? _____

How many years of school has the baby's father completed? _____

I. WORK HISTORY OF MOTHER

Please list the jobs you hold now and have had in the past. Starting with your most recent job, please include your responsibilities, and length of time

_____

_____

_____

_____

_____

What is the present occupation and job responsibilities of the baby's father?

_____

_____

Where were you born? (City and State) _____

How many years have you lived in the Sheboygan area? _____

II. Background history of mother's health:

At what age did you begin menstruation? _____

What is the average number of days between your periods? _____
(From the first day of one period to the first day of the next)

What is the approximate date of your last period? _____

Do you have any problems with your periods? (i.e., too long, infrequent, severe pain, etc.)

_____

At what age did you have your first child? _____

Have you ever had difficulty becoming pregnant? Yes No ?

Did you ever experience a discharge from your breasts before you became pregnant?

Yes No

If yes, did it usually occur at the same time in your menstrual cycle?

Yes No

Did you experience a discharge from your breasts during pregnancy?

Yes No

Has any female in your family (going back to your grandmothers) had breast cancer?

Yes No

If yes, please specify _____

III. HISTORY OF THIS MOST RECENT PREGNANCY:

Did you receive prenatal care during this pregnancy? Yes No

In which month of pregnancy did you first visit a doctor? _____

From what doctor or clinic did you receive care during your pregnancy?

_____

During this pregnancy did you suffer from any of the following

				(if yes, in what month of pregnancy)
Spotting or Bleeding	Yes	No	?	_____
Threatened miscarriage	Yes	No	?	_____
High Blood Pressure	Yes	No	?	_____
Protein in Urine	Yes	No	?	_____
Sugar in Urine	Yes	No	?	_____
Water retention (severe) ...	Yes	No	?	_____
Abnormal swelling of feet or hands	Yes	No	?	_____
Kidney or urinary infection	Yes	No	?	_____
Pneumonia or severe bronchitis	Yes	No	?	_____
Flu	Yes	No	?	_____
Measles or other illness with a rash	Yes	No	?	_____
German Measles	Yes	No	?	_____

Other diseases or disorders that were diagnosed during your pregnancy. Please include the month of your pregnancy in which these problems were diagnosed or began.

_____

_____

_____

_____

Do you now suffer from any of the following health problems?

		(if yes, how long?)	
Sugar Diabetes	Yes	_____	No
High Blood Pressure	Yes	_____	No
Thyroid trouble	Yes	_____	No
Anemia or low blood count ...	Yes	_____	No
Sickle Cell Trait	Yes	_____	No
Arthritis	Yes	_____	No
Seizures, fits or epilepsy ..	Yes	_____	No
Heart disease of any kind ...	Yes	_____	No

Do you suffer from any other health problems for which you are now seeing a doctor? How long have you suffered from each?

_____

_____

Do you regularly take any of the following medications? If yes, please give the name of the drug and dosage, if known.

				(If yes, how long?)
Insulin (injection for diabetes)	Yes	No	?	_____
Dosage: _____				
Pills for Diabetes	Yes	No	?	_____
Dosage: _____				
Pills for depression	Yes	No	?	_____
Dosage: _____				
Tranquilizers, nerve pills or sleeping pills	Yes	No	?	_____
Name & dosage: _____				
Pills for seizures:				
Dilantin	Yes	No	?	_____
Dosage: _____				
Phenobarbitol	Yes	No	?	_____
Dosage: _____				
Other	Yes	No	?	_____
Name & dosage: _____				
Thyroid Pills	Yes	No	?	_____
Name & dosage: _____				
Water pills or diuretics	Yes	No	?	_____
Name & dosage: _____ _____				

Over the counter drugs such as cough medicine, aspirin, sleeping pills, decongestants, antacids, nasal sprays, hemorrhoid medications, headache or pain medication, etc. Please specify.

_____

_____

_____

_____

During this pregnancy, did you take any of the following special medications:

			(If yes, starting in what month of pregnancy?)
Vitamins and/or iron	Yes	No	_____
Diet supplements	Yes	No	_____
Pills for nausea or morning sickness	Yes	No	_____
Antibiotics	Yes	No	_____
Dilantin	Yes	No	_____
Phenobarbitol	Yes	No	_____
Sleeping pills or tranquilizers	Yes	No	_____
Others	Yes	No	_____

If you have answered yes for any of the above medications, please give the name and dose of each if you can.

_____

_____

_____

During this pregnancy, did you have any X-rays taken (any kind)?

Yes No

If yes, please list the kind, number and month of pregnancy below.

_____

_____

Did you have any radiation treatments or nuclear medicine studies?

Yes No

If yes, please list kind, number and month of pregnancy below.

_____

Have you ever been exposed to any unusual chemicals, solvents, fumes, dusts, or smoke?

Yes No

If yes, please specify the kind of exposure. If you know the name of the substance please include this here. Otherwise, please describe the occasion.

_____

Did this exposure take place during pregnancy? Yes No ?

If yes, then in what month of pregnancy? _____

Do you or any member of your family use pesticides? Yes No ?

If yes, where are they used? _____

What type of pesticides?

				(mo. of pregnancy)
Bug or insect killer (insecticide)	Yes	No	?	_____
Mold or mildew (fungicide)	Yes	No	?	_____
Weed killer (herbicide)	Yes	No	?	_____
Mouse or rat killer (rodenticide	Yes	No	?	_____
Other (name) _____.....	Yes	No	?	_____

IV. DIETARY INFORMATION

During your pregnancy, about how often did you have the following foods?

Meat (excluding fish and chicken): _____ (days per week)

Eggs: _____ (days per week)

Milk: _____ (days per week)

Chicken: _____ (days per week)

Were you on a special diet during this pregnancy or are you on a special diet now?

Yes No

If yes, was it for a specific reason other than being pregnant?

Yes No

If yes, was it due to:

Being overweight ..... Yes No

Being underweight ..... Yes No

Other (please specify) _____

_____

If you were on a special diet, was it:

Low salt ..... Yes No

Low calorie ..... Yes No

Low fat ..... Yes No

High Calorie ..... Yes No

High protein ..... Yes No

Other (or some combination of the above choices: _____

Do you smoke? Yes No

If yes, how much do you normally smoke? (number of cigaretts per day)

_____

How long have you smoked? (in years) _____

Did you smoke during your most recent pregnancy? Yes No

If yes, how many cigaretts per day did you smoke? _____

Do you drink alcoholic beverages? Yes No

If yes, when not pregnant, how many cans of beer do you drink per week (or per month)?

_____/week (or) _____/month

How many glasses of wine do you drink per week (or per month)?

_____/week (or) _____/month

How many drinks with hard liquor per week (or per month)?

_____/week (or) _____/month

<u>During this last pregnancy</u>, did you drink? Yes No

If yes, how many cans of beer did you drink per week (or per month)?

_____/week (or) _____/month

How many glasses of wine did you drink per week (or per month)?

_____/week (or) _____/month

How many drinks with hard liquor per week (or per month)?

_____/week (or) _____/month

Are you or your spouse:

a. commercial fishermen

b. sports fishermen

c. never fish

If you or your spouse are sports fishermen, or if any person in your families provides you with Lake Michigan or Sheboygan River fish, which of the following categories do you best fit?

a. Someone who does not eat any Lake Michigan or Sheboygan River fish.

b. Someone who eats some Lake Michigan or Sheboygan River fish, but less than one 8 oz. meal per month. (8 oz. is an average size serving, about 1 cup.)

c. Someone who eats from 1 to 3, 8 oz. meals of Lake Michigan or Sheboygan River fish per month.

d. Someone who eats 4 or more 8 oz. meals of Lake Michigan or Sheboygan River fish per month.

How many years have you been eating fish caught in either Lake Michigan or the Sheboygan River?

a. Less than one year

b. From one to five years

c. From six to ten years

d. More than ten years

e. Doesn't apply because you don't eat these fish

If you eat fish that are caught from Lake Michigan or the Sheboygan River, which of the following types do you eat most often?

Lake Trout	Perch	Bullhead
Steelhead	Northern Pike	Common Shiver
Whitefish	Menomonee	White Sucker
Whitefish livers	Smelt	Carp
Lawyers or Burbot	Chubs	Herring
Coho Salmon	Walleye	Other _____
Chinook Salmon	Rock Bass	

a. Most often eaten fish _____

b. Second most often _____

c. Third most often _____

V. REPRODUCTIVE HISTORY

How many times have you been pregnant, including this most recent child and including any pregnancies (miscarriages or still births) that did not end in a live birth?

_____

How many children are now alive? _____

How did you feed this baby for the first six weeks?

a. Breat feed only

b. Breast feed plus bottle feed

c. Bottle feed only

How many children, including this one, have you breast fed? _____

Have any of your pregnancies ended in:

				(If yes, which Pregnancy, first, second, etc.)
Miscarriage	Yes	No	?	_____
Therapeutic abortion	Yes	No	?	_____
Stillbirth	Yes	No	?	_____
Premature birth	Yes	No	?	_____
Normal birth	Yes	No	?	_____

What was the birth weight of each of your children and was he/she carried a full nine months or was premature? (pounds and ounces)

	Name	Sex	Birth weight	Full term ?
1.	_____	___	_____	_____
2.	_____	___	_____	_____
3.	_____	___	_____	_____
4.	_____	___	_____	_____
5.	_____	___	_____	_____
6.	_____	___	_____	_____

(If you have more than six children, please continue the list on the back.)

Were any of your children born with a birth defect or a health problem?

Yes No ?

If yes, please list the child (first, second, third, etc.) and the kind of health problem they were born with:

_____

_____

Did any of your children suffer from any of the following difficulties?

		(If yes, which child)	
Skin rash (other than diaper rash)	Yes	_____	No
Runny eyes	Yes	_____	No
Sores on the skin	Yes	_____	No
Lung problems	Yes	_____	No
Heart problems	Yes	_____	No
Problems with the hands or feet	Yes	_____	No
Problems with the spine	Yes	_____	No
Facial irregularities	Yes	_____	No
Head irregularities	Yes	_____	No
Problem with digestion, vomiting, diarrhea, poor weight gain	Yes	_____	No
Small for date	Yes	_____	No
Seizures	Yes	_____	No

If you have answered yes to any of the above, please explain and give the diagnosis if known:

_____

_____

_____

Are any of your children that were born alive, now dead?

Yes No ?

If yes, please give the number sequence of the child (first, second, third, etc.), the cause of death and the age of the child at death:

_____

_____

_____

UNIVERSITY OF WISCONSIN - DEPARTMENT OF PREVENTIVE MEDICINE

SHEBOYGAN DEPARTMENT OF PUBLIC HEALTH

To Doctor _____

Mother's name _____

Address _____

_____

Social Security # _____

Baby's name _____

Birth date _____

Dear Doctor:

Please make the hospital records of my delivery and baby's health available to investigators from the Sheboygan Department of Public Health.

Mother's signature

_____

Date _____

REQUEST FOR AUTHORIZATION FOR RELEASE OF INFORMATION

I _____, hereby request and authorize the Project Director to inform the following physicians whose names and addresses I have entered below of any significant findings from the above named study concerning me. (Do not leave blank. Write "NO" where you do not wish to give a name and address.)

1. My personal physician (s): Dr. _____

   Street: _____

   City: _____

2. Other physician: Dr. _____

   Street: _____

   City: _____

SIGNATURE _____ DATE _____

BREAST MILK AND FORMULA STUDY
UNIVERSITY OF WISCONSIN AND SHEBOYGAN DEPARTMENT OF PUBLIC HEALTH

(Complete this form with mother's assistance and review of baby's record and/or discussion with baby's doctor.)

MOTHER'S NAME: _____

BABY'S NAME: _____

ADDRESS: _____

_____

DATE: _____

DATE OF BIRTH (BABY): _____

1. Sex: _____
2. Ethnic Group: _____
3. Estimated gestational age: _____
4. Weight at birth (grams): _____
5. Length at birth (cm.): _____
6. Spontaneous delivery? _____
7. Was anesthesia used: _____

   if yes, what drugs? _____

   _____
8. Apgar rating: 1 min: _____

   5 min: _____
9. Jaundice? _____

   If yes, maximum bilirubin (mg.): _____

   Was it treated? _____
10. ABO incompatibility noted? _____
11. Rh incompatibility noted? _____

APPENDIX E

INFANT HEALTH QUESTIONNAIRE

UNIVERSITY OF WISCONSIN - DEPARTMENT OF PREVENTIVE MEDICINE
SHEBOYGAN DEPARTMENT OF PUBLIC HEALTH

INFANT HEALTH AND BEHAVIOR QUESTIONNAIRE

Code # _____

Date _____

Visit # _____

1. Baby's birth date _____
2. Baby's age today _____
3. Was this baby breast fed at all? Yes _____ No _____

   a. If yes, how many weeks was the baby breast fed most or all of the time (not more than 2 bottle feedings per day)? _____weeks

   b. Have you begun to wean the baby? Yes _____ No _____

   c. If yes, when was weaning begun? _____weeks

   d. If yes, why was weaning begun? (Circle the answer that best fits)

      1) felt that it was the usual time to wean

      2) became inconvenient to breast feed

      3) you (the mother) became ill

      4) baby became ill

      5) not enough milk

      6) baby allergic to milk

      7) breasts became irritated or infected

      8) baby had difficulty breast feeding

      9) Other (explain) _____

      _____

   e. Is this baby now completely weaned from breast feeding? Yes _____ No _____

   f. If yes, how old was the baby when weaning was complete? Yes _____ No _____

INFANT HEALTH AND BEHAVIOR QUESTIONNAIRE - continued

4. Was this baby bottle fed at all? Yes _____ No _____

   a. If yes, what formula do you feed the baby usually (circle one)

      1) cow's milk

      2) whole milk

      3) skim milk

      4) 2% milk

      5) Enfamil

      6) Similac

      7) Evaporated milk (brand) _____

      8) Other _____

   b. How many ounces of formula or milk does the baby drink per day? _____ oz.

5. How well does the baby eat? (Circle one)

   a. eats well all the time

   b. eats well most of the time

   c. has trouble feeding

6. Is this baby fussier or more active than you expected or than other children of the same age that you know? Yes _____ No _____

7. Has this baby had runny, red or irritated eyes at any time? Yes _____ No _____

   If yes, at what age did it occur? _____weeks

8. Has this baby had any rashes or skin irritations or skin color changes? Yes _____ No _____

   If yes, what kind? (Circle one)

   a. diaper

   b. cradle cap

   c. acne like rash

   d. Other _____

9. Has this baby had irritated or darkened gums? Yes _____ No _____

10. Has this baby been ill at all since birth? Yes _____ No _____

    a. If yes, how many times? _____ times

    b. If yes, what kind of illnesses?

    1) cold — How many times _____

    2) high fever (over 101°F. or 38°C) — How many times _____

    3) ear infection — How many times _____

    4) pneumonia — How many times _____

    5) bronchitis or croup — How many times _____

    6) meningitis — How many times _____

    7) diarrhea/vomiting — How many times _____

    8) urinary tract infection — How many times _____

    9) colic — How many times _____

    10) constipation — How many times _____

    11) seizures or fits — How many times _____

    12) heart problems — How many times _____

    13) kidney problems — How many times _____

    14) birth defects — How many _____

    15) Other (explain) _____

_____

c. Did this illness require a doctor's care? Yes _____ No _____

How many times _____

d. Did this require baby's hospitalization? Yes _____ No _____

How many times _____

e. Did the baby need antibiotics like ampicillin or penicillin? Yes _____ No _____

How many times _____

11. How much do you weigh now? _____lbs.

12. Since the last interview (or since birth of the baby) how often have you had:

a. milk _____ days per week

b. meat _____ days per week

c. eggs _____ days per week

d. seafood (commercial) _____ days per month

e. seafood (privately caught) _____ days per month

13. Where does this child get his health care?

Name of Clinic or Hospital _____

Address _____

_____

APPENDIX F

INFANT HEALTH QUESTIONNAIRE NO. 2

I.D.# _____

Infant 4 month Questionnaire

1. (There may be two answers to this question)
   Is the baby;
   1. breast feeding only
   2. bottle feeding only
   3. bottle and breast feeding
   4. eating solid foods

2. If the baby is bottle feeding, or taking a supplementary bottle, at what age (weeks) did the baby begin bottle feeding?
   _____

3. What formula do you use?
   1. cows milk
   2. whole milk
   3. skim milk
   4. 2% milk
   5. Enfamil
   6. Enfamil w/ iron
   7. Similac
   8. soybean substitute
   9. evaporated milk
   10. Others _____

4. Have you eaten any fish that came from Lake Michigan or the Sheboygan River since the birth of your baby?
   Yes_____ No _____ Maybe?_____

(if yes)

5. About how many meals has this been? _____

6. How much weight did you gain with this last pregnancy? _____

7. Has the baby suffered from any of the following skin conditions since your last visit?
   a. diaper rash_____
   b. cradle cap _____
   c. acne-like rash _____
   d. eczema _____
   e. other skin conditions____
   _____

8. Has the baby had any of the following since your last visit?

a. cold # of times _____
b. flu # of times _____
c. high fever (above 101) # of times _____
d. diarrhea # of times _____
e. bronchitis or croup # of times _____
f. ear infection # of times _____
g. constipation # of times _____
h. urinary tract infection # of times _____
i. pneumonia # of times _____
j. colic # of times _____
k. any skin infection # of times _____
l. any other kind of infection # of times _____
m. meningitis # of times _____
n. seizures or fits # of times _____
o. heart problems # of times _____
p. kidney problems # of times _____
q. lung problems # of times _____
r. other problems _____

_____

9. Has the baby been hospitalized since the last visit? Yes ___ No ___
If yes, how many times? _____ For What? _____

10. Have you taken the baby to see a physician for a health problem, or for any reason other than a check-up? Yes_____ No _____
If yes, how many times? _____ For What?_____

11. Has the baby received antibiotics at any time since birth?
Yes _____ No _____
If yes, how many times? _____ For What? _____

APPENDIX G

OCCUPATIONAL P.C.B. EXPOSURE RISK

(from the U.S. Department of Health, Education and Welfare's Occupational Disease Handbook, 1977)

RISK 4: Occupations with Potentially High Exposure to PCB-Bearing Material

Cable Coaters	Dye Makers
Electric Equipment Makers	Capacitor Factory Workers
Construction of Electrical Components	Herbicide Workers
Lacquer Makers	Transformer Mechanics
Power Plant Mechanics	Paper Treaters
Plasticizer Makers	Resin Makers
Rubber Workers	Textile Flameproofers
Transformer Workers	Wood Preservers

RISK 3: Occupations with Marginally High Exposure

Sewage Treatment Plant Workers	Mechanics of Ships and Cars
Use and Repair of Hydraulic Tools	House Painters
Commercial Fishermen	Printers (newspapers, copy)
Ink Makers and Workers	Artists (depending on medium)
Paper Mill Workers (recycling)	Heavy Equipment Maintenance
Firemen (urban and industrial areas)	Pottery Caster
Machine Cleaner	

RISK 2: Occupations with Minimal Exposure

Secretaries	Artists (depending on medium)
Firemen (rural and suburban areas)	Heavy Equipment Operators
Janitors	Bookkeepers
Teachers	Construction Workers

RISK 1: No Reasonable Indication for Occupational Exposure

Other White-Collar Workers	Salespersons
Cooks	Cashiers
Most Retail Workers (clerks, etc.)	Supervisory Personnel
Most Service-Oriented Industries	

APPENDIX H

STANDARD METABOLIC ANALYSIS OF SERUM METABOLIC ELEMENTS

HUMAN S.M.A. PROFILE

ELEMENT TESTED	NORMAL HUMAN RANGE
Glucose	61.0 - 114.4 MG/DL
Total Protein	6.3 - 8.3 GM/DL
Albumin	3.8 - 5.3 GM/DL
Globulin	2.4 - 3.5 GM/DL
A/G Ratio	1.0 - 2.2 Units
Total Bilirubin	0.0 - 1.5 MG/DL
Uric Acid	2.1 - 7.4 MG/DL
Cholesterol	140.0 - 240.0 MG/DL
Triglycerides	53.0 - 169.0 MG/DL
LDH	52.0 - 149.0 IU/L
SGOT	6.0 - 25.0 IU/L
SGPT	0.0 - 16.0 IU/L
Alkaline Phosphotase	23.0 - 71.0 IU/L
GGTP	5.3 - 24.0 IU/L
Calcium	8.6 - 10.5 MG/DL
Phosphorus	1.5 - 6.8 MG/DL

APPENDIX I

REGRESSION ANALYSIS TABLES

TABLE I-1
FIRST SAMPLE SERUM P.C.B. LEVELS
COMPARED WITH SOCIOCULTURAL AND MORPHOLOLIGICAL VARIABLES
(N = 72)

CORRELATION MATRIX	Serum PCB	Education	Occupation	Fish Diet
Education	.383			
Occupation	.263	-.042		
Fish Diet	.178	-.231	.034	
Suprailiac Fat Fold	-.324	-.118	-.052	-.004

REGRESSION EQUATION CORRELATION COEFFICIENT AND P VALUE

Multiple R	.602	Standard Error:	.245-002
R Squared	.362		
Adjusted R Square	.324	P Value:	.0000

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Fish Diet	.0017	.62-003	.0099
Suprailiac Fat Fold	-.865-004	.33-004	.0106
Occupation	.0013	.47-004	.0104
Education	.568-003	.14-003	.0001
Constant	-.0029	.002	.1947

TABLE I-2
FIRST SAMPLE SERUM P.C.B. COMPARED WITH
TOTAL SERUM BILIRUBIN, SERUM CHOLESTEROL AND SERUM PHOSPHORUS
(N = 69)

CORRELATION MATRIX	Total Serum PCB	Total Bilirubin	Cholesterol
Bilirubin	.414		
Cholesterol	.392	.390	
Phosphorus	-.089	.161	.436

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.562	Standard Error:	.247-002
R Square	.316		
Adjusted R Square	.284	P Value:	.0000

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Total Bilirubin	.0035	.0013	.0081
Cholesterol	.249-004	.739-005	.0013
Phosphorus	-.0012	.427-003	.0071
Constant	.0036	.0020	.0707

TABLE I-3

FINAL REGRESSION MODEL FOR FIRST SAMPLE SERUM P.C.B.
(N = 70)

CORRELATION MATRIX	Serum PCB	Total Bilirubin	Mother's Education	Mother's Occupation	Fish Eaten Since Birth	Phosphorus	Cholesterol
Total Bilirubin	.410						
Mother's Education	.390	-.010					
Mother's Occupation	.323	.140	-.034				
Fish Eaten Since Birth	.206	.084	-.237	-.027			
Phosphorus	-.094	.159	.171	.054	-.254		
Cholesterol	.353	.384	.176	.269	-.173	.437	
Mother's Suprailial Fat Fold	-.317	-.333	-.129	-.074	-.202	.143	.089

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.766	Standard Error:	.203-002
R Squared	.586		
Adjusted R Square	.54	P Value:	.0000

REGRESSION COEFFICIENTS	B	Standard Error B	Sig. T
Mother's Suprailial Fat Fold	-.585-004	.2953-004	.0521
Fish Eaten Since Birth	.00167	.5481-003	.0034
Mother's Occupation	.00122	.4361-003	.0070
Mother's Education	.5916-003	.1153-003	.0000
Phosphorus	-.0012	.3638-003	.0021
Total Bilirubin	.0028	.0011	.0141
Cholesterol	.1747-004	.6392-005	.0082
Constant	-.0037	.0025	.1460

TABLE I-6

FIRST SAMPLE BREAST MILK P.C.B. WITH FISH EATEN SINCE BIRTH, SUPRAILIAL FAT FOLD, OCCUPATION AND EDUCATION
(N = 58)

CORRELATION MATRIX	Breast Milk PCB(1)	Fish Eaten Since Birth	Suprailial Fat Fold	Mother's Occupation
Fish Eaten Since Birth	.370			
Suprailial Fat Fold	-.346	-.047		
Mother's Occupation	.383	-.017	-.090	
Mother's Education	.230	-.202	-.144	.015

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.667	Standard Error:	.494
R Squared	.445		
Adjusted R Square	.403	P Value:	.0000

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Mother's Occupation	.370	.105	.0009
Fish Eaten Since Birth	.583	.146	.0002
Mother's Education	.090	.035	.0127
Suprailial Fat Fold	-.018	.007	.0180
Constant	-.493	.552	.3763

TABLE I-7

T TESTS OF SERUM P.C.B. MEANS AMONG THE THREE GROUPS

GROUP 1 AND GROUP 2		N	$\bar{X}$	SD	T
FIRST SAMPLE	Group 1	22	6.5	3.	1.39
	Group 2	39	6.4	3.	
SECOND SAMPLE	Group 1	23	6.6	3.	2.86*
	Group 2	37	4.6	3.	$p < .01$

TABLE I-9

TOTAL ANTIBIOTICS PRESCRIBED TO BREAST-FED INFANTS
WITH FIRST SAMPLE SERUM AND BREAST MILK P.C.B.
(N = 58)

CORRELATION MATRIX	Total Antibiotics	Serum PCB
Serum PCB	.319	
Breast Milk PCB	.135	.814

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.385	Standard Error:	1.351
R Squared	.148		
Adjusted R Square	.117	P Value:	.0121

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Serum PCB	294.74	101.72	.0054
Breast Milk PCB	-.828	.479	.0896
Constant	-.323	.392	.4018

TABLE I-10

TOTAL ANTIBIOTICS PRESCRIBED FOR THE FIRST FOUR MONTHS
WITH FIRST SAMPLE SERUM AND BREAST MILK P.C.B. IN INFANT MALES

(N = 27)

CORRELATION MATRIX	Total Antibiotics	Serum PCB
Serum PCB	.422	
Breast Milk PCB	.147	.879

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.633	Standard Error:	1.66
R Squared	.400		
Adjusted R Square	.350	P Value:	.0022

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Serum PCB	848.95	218.06	.0007
Breast Milk PCB	-2.64	.885	.0065
Constant	-1.06	.669	.1265

TABLE I-11

TOTAL ANTIBIOTICS WITH FIRST SAMPLE SERUM P.C.B. IN INFANT MALES
(N = 35)

CORRELATION MATRIX	Total Antibiotics
First Sample Serum PCB	.401

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.401	Standard Error:	1.705
R Squared	.161		
Adjusted R Square	.135	P Value:	.0170

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Serum PCB	254.5	101.22	.0170
Constant	-.84	.642	.1985

APPENDIX J

INTERESTING ASIDES

While they have no relevance to this study, several very interesting relationships were discovered during its examination of the influences of PCBs on infant growth.

First, the change in the infant's weight for the first two months from birth was negatively affected by the mothers' age and bottle-feeding (Table J-1). The bottle-feeding variable was a binomial, where bottle-feeding was coded as 1 and breast-feeding was 0. The R coefficient for bottle-feeding was -.220, and the Sig. T value was .0317. The mother's age had an R = -.403 and Sig. T = .0003. The total regression equation R value was .467 and P value = .0003.

The bottle-feeding variable is a difficult value to incorporate here and should be discussed further. It is possible that infants who had the most serious health problems were also those who had been switched to the bottle, and thus the bottle-feeding variable may be confounding the relationship between growth and neonatal illnesses. But when weight gain was regressed against the number of total illnesses and infectious illnesses, no association was found between weight gain and health.

This may be due to the expected higher incidence of gastrointestinal disturbances associated with feeding cow's milk to a human infant. Allergic

TABLE J-1

CHANGE IN INFANTS' WEIGHT BETWEEN BIRTH AND TWO MONTHS
WITH BOTTLE-FEEDING AND MOTHERS' AGE
(N = 70)

CORRELATION MATRIX	Change in Weight	Bottle-Fed
Bottle-Fed	-.220	
Mothers' Age	-.403	-.041

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE			
Multiple R	.467	Standard Error:	479.18
R Squared	.218		
Adjusted R Square	.195	P Value:	.0003

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Bottle-Fed	-293.244	133.68	.0317
Mothers' Age	-58.83	15.42	.0003
Constant	3,479.79	411.63	.0000

reactions, diarrhea and other gastrointestinal problems are frequently found with bottle-feeding and so may reasonably be expected to result in poor weight gain (Lawrence 1980). However, it must also be noted that excessive weight gain in infants has also been associated with bottle-feeding (Lawrence 1980).

There is no apparent explanation for the maternal age results other than the possible compromising effects of late childbearing (in months) and the health of the infant, or merely the individual ability of the infant to gain weight. The birth order of the child was not significantly correlated with weight gain, thus one cannot blame multiparity, or the possible disturbing influences of older siblings.

When the infant population was separated by sex, the female infants (Table J-2) showed that they were strongly influenced by the bottle-feeding (R = -.368, Sig. T = .0248), but not so strongly by the mothers' age (R = -.327, Sig. T = .0462; total equation R = .485, P value = .0120).

The male infants (Table J-3) had no significant association with bottle-feeding, but showed a slightly stronger influence from the mothers' age (R = .389, P value = .0229).

The growth of female children, but not male children, showed a negative association with the mothers' prepregnancy pattern of alcohol consumption and the infants' weight gain between two and four months of age (Table J-4: R = -.395; P value = .0171). The mothers' alcohol consumption during pregnancy was not associated with any of the infants' growth, motor or behavioral

TABLE J-2

CHANGE IN WEIGHT OF FEMALE INFANTS FROM BIRTH TO TWO MONTHS WITH MOTHER'S WEIGHT AND BOTTLE-FEEDING (N = 36)

CORRELATION MATRIX	Change in Weight	Mother's Age
Mother's Age	-.327	
Bottle-Fed	-.368	.031

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE			
Multiple R	.485	Standard Error:	378.14
R Squared	.235		
Adjusted R Square	.189	P Value:	.0120

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Bottle-Fed	-342.58	145.62	.0248
Mother's Age	-36.05	17.4	.0462
Constant	2,797.99	472.85	.0000

TABLE J-3

CHANGE IN WEIGHT OF MALE INFANTS FROM BIRTH TO TWO MONTHS WITH MOTHER'S AGE

(N = 34)

CORRELATION MATRIX	Change in Weight
Mother's Age	-.389

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.389	Standard Error:	563.81
R Squared	.152		
Adjusted R Square	.125	P Value:	.0229

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Mother's Age	-62.93	26.32	.0229
Constant	3,599.0	688.92	.0000

TABLE J-4

CHANGE IN WEIGHT OF FEMALE INFANTS BETWEEN BIRTH AND FOUR MONTHS WITH MOTHER'S CONSUMPTION OF ALCOHOL BEFORE PREGNANCY

(N = 36)

CORRELATION MATRIX	Change in Weight
Prepregnancy Alcohol Consumption	-.395

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.395	Standard Error:	346.023
R Squared	.156		
Adjusted R Square	.131	P Value:	.0171

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Prepregnancy Alcohol Consumption	-61.52	24.53	.0171
Constant	1,305.19	84.68	.0000

evaluation measures, but the normal drinking patterns of the mother (measured on an estimated number of drinks per week) implies some interference with the growth of only the female children. This finding should be followed through in further research for the entire nursing period of both males and females and compared to the weight gain of bottle-fed infants. There is also the possibility that the higher reported estimate of drinking habits when not pregnant is closer to the true number of drinks the mothers had during pregnancy.

A mystery model that turned up unawares -- and with little active solicitation from the researcher -- is presented in Table J-5 merely for purposes of bringing this finding to light and possible discussion by people more enlightened than those who have already contemplated it. It shows that the effects of the mother's triglyceride level (taken when the child was four months old) is somehow associated with the number of infectious illnesses suffered only by female infants (R = .478, P value = .0037).

This is obviously some sort of spurious association where triglycerides are being confounded by some other unknown variable that may have a very strong effect on the female infants' susceptibility to infectious disease, but what this phenomena actually may be is open to great speculation. The mother's age, weight and education -- the most obvious intervening variables to try -- seemed to have no bearing on the mother's triglyceride levels or with the infant females' rate of infectious illnesses. Any suggestions that may be offered are certainly welcomed by the researcher.

The next two regression calculations are both descriptive of the woman's health or individual physical functioning aside from their PCB exposure. The first equation, presented in Table J-6, shows a correlation between the

TABLE J-5

INFECTIOUS ILLNESSES IN INFANT FEMALES WITH MOTHER'S TRIGLYCERIDE LEVEL
(N = 35)

CORRELATION MATRIX	Infectious Illnesses
Triglyceride Level	.478

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.478	Standard Error:	.938
R Squared	.228		
Adjusted R Square	.204	P Value:	.0037

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Triglyceride Level	.0096	.0031	.0037
Constant	-.2494	.3716	.5068

TABLE J-6

MOTHER'S SYSTOLIC BLOOD PRESSURE WITH HER SUPRAILIAL FAT FOLD

(N = 72)

CORRELATION MATRIX	Systolic Blood Pressure
Suprailial Fat Fold	.379

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.379	Standard Error:	8.155
R Squared	.143		
Adjusted R Square	.131	P Value:	.0010

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Suprailial Fat Fold	.37	.11	.0010
Constant	101.65	2.02	.0000

TABLE J-7

THE EFFECTS OF BIRTH ORDER OF INFANT FEMALES
ON THE MOTHER'S SERUM CALCIUM LEVELS

(N = 36)

CORRELATION MATRIX	Birth Order
Calcium	.427

REGRESSION EQUATION CORRELATION COEFFICIENTS AND P VALUE

Multiple R	.42697	Standard Error:	.898
R Squared	.18230		
Adjusted R Square	.158	P Value:	.0094

REGRESSION COEFFICIENTS	β	Standard Error β	Sig. T
Calcium	.701	.255	.0094
Constant	-4.655	2.381	.0589

mother's systolic blood pressure (there were no cases of clinically diagnosed hypertension among our subjects) and her suprailiac fat fold, or waist fat deposits (R = .379, P value = .0010). This information could be clarified by the current research on cell type, deposition patterns and resulting health problems such as diabetes and high blood pressure.

The next regression result pertains only to those women who gave birth to female children, not male children (for an unexplained reason). A strong relationship (Table J-7) was found between a woman's parity (dependent variable) and their serum calcium levels (R = .427, P value = .0094). The higher the woman's parity, the higher their serum calcium levels tended to be.

There is no immediate explanation for this association, but further investigation on hormone levels, woman's age, parity and the mobilization of calcium either through diet or decalcification of bone should be done.