Population-Based Surveillance and Etiological Research of Adverse Reproductive Outcomes and Toxic Wastes

PHASE III

Correlational Analyses of Adverse Reproductive Outcomes and Environmental Pollution

NEW JERSEY DEPARTMENT OF HEALTH
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POPULATION-BASED SURVEILLANCE AND ETIOLOGICAL RESEARCH OF ADVERSE REPRODUCTIVE OUTCOMES AND TOXIC WASTES

REPORT ON PHASE III: CORRELATIONAL ANALYSES OF ADVERSE REPRODUCTIVE OUTCOMES AND ENVIRONMENTAL POLLUTION

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EXECUTIVE SUMMARY

This report comprises the third phase of the NJDOH-CDC Cooperative Agreement: Population-Based Surveillance and Etiologic Research of Adverse Reproductive Outcomes and Toxic Wastes. Phase III demonstrated some of the potential uses, limitations and methodologic issues in conducting municipality-based ecologic analyses of health outcomes with estimated exposure variables, utilizing readily-available demographic characteristics of these geographic areas. The municipality-based rates of adverse reproductive outcomes, derived from the birth defects registry and vital records were computed in Phase I and linked with the databases considered most appropriate for estimating population exposures to environmental pollutants in Phase II. In addition, demographic variables for each municipality, six from the U.S. Census and six from vital records, were linked with the potential exposure and outcome variables.

Since there was special interest in toxic waste sites, variables were created to represent (although crudely) the potential population exposure to these sites. These variables were (a) the number of "Superfund" sites and/or other hazardous waste sites per square mile of a municipality and (b) the presence of any such site. The other variables used in the ecologic analyses were constructed from USEPA's Toxic Release Inventory (TRI) and NJDEPE's pesticide survey of agricultural applications. These were the databases selected in Phase II, Evaluation of Environmental Databases, as most suitable for such use. The specific variables which were constructed from the TRI and pesticide databases reflected the observed or suspected reproductive toxicity of component chemicals and on chemical groupings related to industrial use and/or chemical similarity.

Four weighting schemes were constructed in order to take into account the greatly disparate number of births among the 561 municipalities which were analyzed. These ranged from fully weighted, proportional to the number of births, to unweighted.

Regressions, simple correlations, and partial correlations, utilizing all four weighting schemes, were performed with the linked data. The partial correlations removed those portions of the variability in the exposures and outcomes which were accounted for by the demographic variables.

All the above analyses indicated that rates of perinatal mortality and stillbirths were related to sociodemographic characteristics of municipalities but that rates of birth defects were largely independent of the municipal demographic characteristics. In addition, a few statistically significant associations between exposure surrogates and reproductive outcomes were found, notably between limb reduction defects and waste sites per square mile (correlation coefficients of 0.11-0.12 for both Superfund and all sites, for all weighting schemes). These partial coefficients were similar to those for the simple correlations generated before removal of the effects of sociodemographic factors on exposure and outcome variables. Since limb reduction defects have previously functioned as sentinel effects (i.e. of thalidomide teratogenicity), these observations are being followed up currently utilizing the birth defects registry and hospital records. Several other observed significant correlations, some of them negative, do not appear to be related to prior toxicity data.

This study demonstrates techniques whereby potential associations between health outcomes and environmental characteristics can be explored through the analysis of aggregate data already in existence before embarking on more expensive individual-based investigations such as case-control studies.

CONTENTS

LIST OF TABLES

CORRELATIONAL ANALYSES OF ADVERSE REPRODUCTIVE OUTCOMES AND ENVIRONMENTAL POLLUTION

I. INTRODUCTION

In 1986, the New Jersey Department of Health (NJDOH) entered into a five-year cooperative agreement with the U.S. Centers for Disease Control (CDC) to develop and apply appropriate methodology to assess relationships between adverse reproductive outcomes (AROs) and population exposures to environmental pollutants, particularly toxic waste site contamination. The project was divided into four "phases" corresponding to its objectives and a research protocol was prepared (Fulcomer et al., 1987). This report describes the activities undertaken in the third phase of the project. Rather than a rigorous exploration of specific hypotheses about exposure-outcome relationships, the work on the the third phase is a demonstration of the potential uses and limitations of using data on environmental exposure surrogates and health outcomes, both aggregated at the municipality level of analysis, to investigate possible associations as an early step in identifying preventable hazards. Study designs using aggregated information in such a fashion are often referred to as "ecologic" or "correlational." Because other states may already be collecting such data as part of routine environmental and outcome surveillance programs, this report, as well as those for the project's first and second phases, may be of special interest to others who may plan to replicate the methods and results presented here.

This report links surveillance data from the 327,015 live births and 3,548 fetal deaths (stillbirths) that occurred to New Jersey residents from 1985 through 1987, derived from the project's first phase (Fulcomer et al., 1992b), with data on environmental pollution that resulted from its second phase (Bove, 1992). By combining information from this large group of births with that on potential exposures and on other sociodemographic attributes available on geographic areas, it was hoped that the correlational analyses could provide inexpensive alternatives to case-control studies to explore questions of possible exposure-outcome relationships.

Following the thalidomide tragedy of the 1960's interest has grown in monitoring the occurrence of birth defects and other adverse reproductive (or, perhaps more properly "developmental") outcomes and in identifying preventable causes. In the United States, this interest has led to a tremendous increase in the establishment of effective, population-based surveillance programs (Flynt et al., 1987; National Governors Association, 1987). Building on the success of two early programs sponsored by the Centers for Disease Control (Edmonds et al., 1981) and with considerable encouragement and assistance from CDC (Edmonds et al., 1988), many states have recently undertaken the development of registries for birth defects and other outcomes. Outside of the United States CDCs efforts have also included participation in the establishment and maintenance of the International Clearinghouse for Birth Defects Monitoring Systems (ICBDMS, 1980).

Historically, the desire to conduct etiological research studies has provided much of the impetus behind the development of surveillance programs. More recently, this etiological focus has expanded to include the rapidly escalating concerns about the possible roles of environmental pollution. Not surprisingly, there has been a growing interest in linking records from surveillance programs with environmental databases to perform ecologic (or correlational) studies and to identify populations for epidemiologic research. Unfortunately, researchers have encountered several major obstacles to these efforts. Most importantly, many of the emerging national and state environmental databases have been developed to track environmental pollution and are much less appropriate for epidemiologic applications such as estimating population exposures (Bove, 1992). In addition, there are severe maintenance and quality control problems with some of the databases, including the lack of validation procedures to ensure accurate coding of residential locations (using county/municipality identifiers) as well as errors with data entry and duplicate records; establishing data linkages between adverse reproductive outcomes and environmental databases are particularly difficult in the absence of accurate, common geographical identifiers.

Given the quantity and quality of its data, New Jersey has a unique opportunity to link records from outcome and environmental databases. With respect to adverse reproductive outcomes, NJDOH is now able to draw on its Birth Defects Registry (BDR) to complement the more traditional reliance on vital records. Based on one of the nation's oldest Crippled Children's Programs that traces its origins to the 1920's, NJDOH established a population-based birth defects registry in 1985 (Fulcomer et al., 1986). Through fetal death certificates and the matching of infants' birth and death records, NJDOH has also had well-developed capabilities regarding related outcomes, including low birthweights, infant mortality, and fetal mortality. Similarly, the New Jersey Department of Environmental Protection and Energy

(NJDEPE, but referred to as NJDEP before the agency's name was changed after June, 1991) has developed statewide databases as part of its monitoring and regulatory programs, particularly on agricultural pesticide applications (Louis et al., 1989), industrial air toxics emissions (Held et al., 1988), and contamination of public drinking water systems (NJDEP, 1987). NJDEPE's Geographic Information System (Rohardt et al., 1986) maps the precise locations and boundaries of the State's "Superfund" sites on the National Priority List (NPL). Finally, both NJDOH and NJDEPE employ similar systems for coding county/municipalities, so that accurate data linkages can be made.

A. SELECTED RESULTS FROM PREVIOUS STUDIES OF ENVIRONMENTAL POLLUTION AND AROs

This section describes selected results from some previous studies of environmental pollution and AROs. Because so-called "negative studies" (i.e., those failing to find significant associations) are seldomly published, this review is necessarily limited to the few "positive findings" that have appeared in print. In addition, it highlights relationships that might merit further investigation in analyses that may have the potential for adequate statistical power, even in instances in which the original study providing the initial result(s) was essentially negative or inconclusive. Therefore, this review should not be construed as a balanced assessment of the current state of knowledge.

A.1 AIR POLLUTION

A review of the literature revealed only one study on the effects of ambient air pollution on adverse reproductive outcomes, a study of the relationship between ambient air quality and spontaneous abortions in an industrial area of Finland (Hemminki et al., 1986). The ambient air contaminants evaluated in that study were sulfur dioxide, hydrogen sulfide and carbon disulfide. No significant associations between air quality and outcomes were found.

A.2 INDUSTRIAL PLANT EMISSIONS

A study of a community in the vicinity of a copper and lead smelter in northern Sweden found a statistically significant elevation in the prevalence of spontaneous abortion for those residents living within a few kilometers of the smelter (Nordstrom et al., 1978b). The mean birthweight for births to residents living near the smelter was also significantly lower (Nordstrom et al., 1978a). However, no associations were found with congenital anomalies (Nordstrom et al., 1979). The study controlled for parity but did not control for employment at the smelter or for other risk factors. The major contaminants emitted by the smelter included lead and arsenic.

A study of Ohio residents living in communities located near vinyl chloride polymerization plants found statistically significant elevations in the prevalence of central nervous system (CNS) defects compared to the prevalence in the state (Infante, 1976). Later reports failed to identify working in the plants as a causal explanation of elevated CNS defects, although the occupational information was derived exclusively from males whereas an analysis of community residents found a significant association between these defects and living within three miles of these plants (Edmonds et al., 1978). Unfortunately, a study of CNS defects and residence near two vinyl chloride plants in NJ had extremely low power and, therefore, provided results that were difficult to interpret (Rosenman et al., 1989).

A.3 DRINKING WATER CONTAMINATION

Another report prepared as part of the fourth phase of this cooperative agreement has reviewed studies of drinking water contamination and adverse reproductive outcomes elsewhere (Bove et al., 1992a). In general, studies in this area have been plagued by small sample size and other analytic problems. As a result, they have produced conflicting results.

Despite design problems and other flaws with research in this area, some isolated findings are important to note. One study found significant associations between chlorinated solvents in the drinking water (e.g., trichloroethylene) and certain groupings of birth defects (Lagakos et al., 1986). Another study has reported associations between drinking water contaminated with nitrates and neural tube and oral cleft defects (Dorsch et al., 1984). Finally, a third study described some slightly positive associations for certain inorganics in drinking water and cardiac defects (Zierler et al., 1988).

A.4 POTENTIAL COMMUNITY EXPOSURES TO PESTICIDES

In contrast to other exposures, the reproductive effects of phenoxy herbicides and their contaminants, particularly dioxin (TCDD), have been investigated extensively, even though many conflicting results have been reported. Studies of soldiers and civilians exposed to the herbicide Agent Orange during the Vietnam War share many design flaws, most notably extremely crude assessments of exposures. These flaws notwithstanding, elevated prevalences of several adverse reproductive outcomes such as spontaneous abortions among US Air Force veterans and neural tube, oral cleft and cardiac defects among Vietnamese veterans have been reported (Sharp et al., 1986).

Difficulties in defining the exposed population, along with poor statistical power and other design problems, have led to inconclusive results for investigations of spontaneous abortion and birth defects after the accidental release of TCDD at Seveso, Italy (Sharp, loc. cit.). Among these difficulties were the lack of reporting on induced abortions and the possible reluctance by parents in that country to allow the formal identification of children with birth defects. However, among residents potentially exposed for whom data were available, spontaneous abortions and neural tube defects appeared to have been elevated.

In other non-military settings, several ecologic studies have explored the possible relationships between adverse reproductive outcomes and applications of the Agent Orange component 2,4,5-T in farming, forestry, and at utility right-of-ways. Although results of these studies have generally been inconclusive, some suggestive relationships have been reported for neural tube defects, oral cleft defects and spontaneous abortions (Sharp, loc. cit.).

A New Brunswick, Canada, study that employed both ecologic and case-control methods examined the possible relationships between use of pesticides in forestry and agriculture and the occurrence of birth defects and stillbirths (White et al., 1988). The primary pesticides used in forestry during the study period (1973-79) were fenitrothion and aminocarb, although the Agent Orange components 2,4-D and 2,4,5-T were also applied. For the agricultural applications, there was no information available on the quantities of any pesticides used and, except for 2,4-D, nothing was known of the types of chemicals applied. No significant associations between the adverse reproductive outcomes and the use of pesticides in forestry were detected. However, some statistically significant relationships were reported between "agricultural chemical exposure opportunity", based on maps of soil capability, and the occurrence of spina bifida without hydrocephalus (first trimester exposure) and of stillbirths (second trimester exposure).

Some results suggestive of associations between agricultural pesticide usage and adverse reproductive outcomes have also emerged from case-control studies. For example, a study conducted in Iowa and Michigan reported an elevated prevalence of oral clefts (Gordon and Shy, 1981). Although a somewhat similar study of information derived from birth certificates (Schwartz and LoGerfo, 1988) failed to find relationships between congenital limb reduction defects and employment of either parent in agriculture (5.91% of cases and 7.43% of controls, although only 1.6% of all working mothers in the study were classified as agricultural workers), there were statistically significant associations for weaker exposure proxies (among those mothers residing in counties with a high cash value of agricultural productivity and a high per square mile usage of pesticides). Likewise, the study of the relationships between the 1981 and 1982 aerial application of Malathion (to control the Mediterranean Fruit Fly) and birth defects and low birthweight did find some statistically significant associations, while reporting "no biologically plausible pattern of association" (Grether et al., 1987). These elevations included clubfoot, bowed legs and ear anomalies (when compared to the 1981 unexposed reference group) and for tracheoesophageal fistula (when compared to the 1982 unexposed reference group).

A.5 STUDIES OF COMMUNITIES NEAR TOXIC WASTE SITES

Studies of the prevalence of adverse reproductive outcomes in communities near toxic waste sites have also been hampered by design problems, especially poor statistical power and crude surrogates for exposures (Phillips and Silbergeld, 1985). Chemicals usually detected at toxic waste sites include chlorinated solvents, aromatics and heavy metals. However, almost no information is available on the types and levels of chemicals in exposure pathways emanating from these sites (Bove, 1992 and Upton et al., 1989). Furthermore, studies done to date have been restricted to a few of the possible reproductive endpoints such as total birth defects, low birthweight, mean birthweight and spontaneous abortion. Specific categories of birth defects and groupings of such defects have not been reported in any study known to us.

Although no study has yet been able to demonstrate elevations in total birth defects or spontaneous abortions in communities near toxic waste sites, statistically significant associations between low birthweight and potential exposures to toxic waste have been reported in at least two studies. In the first study at Love Canal in New York State, births to residents living near shallow natural drainage pathways (or "swales") from the dump site had an elevated prevalence of low birthweight when compared to births in upstate NY during the years in which dumping occurred (Vianna and Polan, 1984). In the second study at the Lipari Landfill in NJ, residents living within 1 km of the site had an elevated prevalence of low birthweight infants as well as lower birthweights when compared to residents living further from the site during the years of heaviest potential exposure (NJDOH, 1989). In contrast, other studies have failed to detect significant elevations in the prevalence of low birthweight infants among residents living near toxic waste sites, including those of sites located in Lowell, MA (Ozonoff et al., 1987), Hamilton, Ontario (Hertzman et al., 1987), Clinton County, PA (Budnick et al., 1984), and Glen Avon, CA (Baker et al., 1988).

Because it referred to New Jersey municipalities and is tangentially related to adverse reproductive outcomes, a correlational study comparing rates of cancer mortality with the number of "chemical toxic waste disposal sites" per square mile is of some relevance (Najem et al., 1985). Although statistically significant correlations were reported for some cancers and the density of waste sites, it was noted that the partial correlations attempting to control for some sociodemographic factors by removing the linear influence of annual per capita income "diminished the significance" of these associations (Najem et al., loc. cit.). This study also attempted to explore possible relationships with adverse reproductive outcomes, including the reporting of some statistically significant correlations between some types of cancer and the prevalences of low birthweights and the rates of total birth defects. Unfortunately, the investigators did not compare the density of waste sites with the prevalences of the adverse reproductive outcomes, making it exceedingly difficult to address possible relationships between the exposure surrogates and the reproductive endpoints. In addition, the birth defects information pre-dated the state's population-based registry and might introduce bias into the interpretation of the results.

A.6 BRIEF SUMMARY

Although our review of selected positive results from previous studies reveals a lack of uniformity of reported findings, several suggestive relationships have been reported between adverse reproductive outcomes and potential community exposures to industrial pollution, drinking water contaminants, agricultural pesticide applications and toxic waste sites. Furthermore, suspected teratogens (or, perhaps more properly "developmental toxicants" in the context of the present study) such as trichloroethylene, vinyl chloride, benzene, toluene and lead are commonly detected at toxic waste sites (Shepard, 1986). In addition, trichloroethylene in drinking water and industrial emissions of vinyl chloride, arsenic and lead have had significant associations in some of the studies reviewed here. Finally, many of the pesticides used in agricultural applications are suspected teratogens (Watterson, 1988). Because the toxicological data support the biological plausibility of the relationships reported in some of the studies reviewed above, there is a solid rationale for pursuing correlational analyses of linked data as a first step in better understanding exposure-outcome relationships.

B. ORGANIZATION OF THIS REPORT

The second chapter of this report describes the methods and data employed in the analyses. After first describing simple (i.e., unadjusted) correlations, the analytic methods used here rely heavily on multiple and partial regression techniques, especially to control for selected background variables before evaluating potential associations between environmental exposures and adverse reproductive outcomes. The third chapter presents the results. A discussion of these results in the fourth chapter begins by addressing some important analytic and interpretational issues. In particular, the widely-acknowledged possibility of bias in such ecologic studies, along with the related limitations and cautions in making causal inferences about individuals from results aggregated at the municipality level, is among the issues addressed in the fourth chapter. The need to account for the large variation in population characteristics among the municipalities receives special attention throughout this report.

II. METHODS

A. STUDY AREA

For this correlational study, the units of analysis were the state's municipalities. Of New Jersey's 567 county/municipality units, six having no births in one or more years during the period from 1983 to 1986 were deleted from further consideration (Fulcomer et al., 1992b). The remaining 561 were included in this study.

B. ADVERSE REPRODUCTIVE OUTCOMES (AROs)

The gathering of information on adverse reproductive (or developmental) outcomes has been described in the report on the project's first phase (Fulcomer, loc. cit.). These variables included infant health indicators derived from three types of official records (birth certificates, death certificates, and fetal death certificates) maintained by NJDOH's Bureau of Vital Statistics (BVS) as well as individual-based data on a range of specific congenital anomalies obtained from NJDOH's Birth Defects Registry (BDR). Computer records for the 327,015 live births and 3,548 fetal deaths for the three birth-year cohorts were coded for municipality at the time of birth (and at the time of first notification of a qualifying diagnosis in the case of birth defects). This made it possible to calculate rates per 1,000 live births (or percents in a few instances) for the endpoints below, so that comparisons could be made across municipalities of widely-differing sizes.

Adverse Reproductive Outcome Variables

* Preterm births percent.
* Small-for-gestational age (SGA) percent.
* Very low birthweight (under 1500 grams) rate.
* Low birthweight (under 2500 grams) rate.
* Infant Mortality -
    - Neonatal death (up to 28 days after birth) rate.
    - Post-neonatal death (28 days to one year) rate.
    - Total infant death rate.
* Fetal mortality (greater than 20 weeks gestation) rate.

* Birth Defects - rates for the following defect groupings:
    - Down Syndrome.
    - Neural tube defects.
    - Eye defects.
    - Selected severe cardiac defects.
    - Oral clefts.
    - Reduction deformities.
    - Chromosomal anomalies.
    - Congenital anomalies.
    - Major anomalies.
    - Minor anomalies.
    - Central nervous system defects.
    - Heart defects.
    - Musculoskeletal defects.

A detailed description of the data acquisition, validation, and aggregation procedures are found in the report on the project's first phase (Fulcomer et al., 1992b). The selected birth defects are the same as those actively monitored by the US Centers for Disease Control (CDC, 1988) and incorporated in several recent surveillance reports for which rates were given in the Phase I report, including state programs in California (CBDMP, 1988) and Iowa (Hanson et al., 1989).

C. ENVIRONMENTAL VARIABLES

An informative review of computerized federal and state environmental databases is found in the report on the project's second phase (Bove, 1992). Evaluations of these databases led to the selection of those listed below for inclusion in the correlational analyses.

Environmental Databases

* NJDEP Toxic Release Inventory for 1988.
* USEPA Toxic Release Inventory for New Jersey for 1987.
* NJDEP Pesticide Survey for 1986.

In addition, because of the project's original focus on studying adverse reproductive outcomes around toxic waste sites, New Jersey sites on the National Priority List (Superfund) and a list of CERCLIS sites (toxic waste sites in the federal Comprehensive Environmental Responsibility and Cleanup Liability - Information System database), both maintained by NJDEP, were also used in this study. In contrast, NJDEP's drinking water databases were not used in this study because of difficulties in linking information on public drinking water purveyors with the populations served on a municipality basis.

C.1 VARIABLES FOR TOXIC WASTE SITES

NJDEP's information on the location of New Jersey sites on the National Priority List (NPL) sites is stored on its Geographical Information System (GIS). NJDEP has mapped state plane coordinates of the property boundaries of the NPL sites to determine the county and municipality of each Superfund Site. Because the U.S. EPA receives its information on NPL locations from NJDEP, there are no discrepancies in these data between the two agencies.

For the correlational analyses, the variables used to represent population exposure to NPL sites were the number of NPL sites per square mile in a municipality (**"NPL-density"**) and a dichotomous variable indicating whether or not a municipality contained one (or more) NPL sites (**"NPL-presence"**). Admittedly, these two variables are extremely crude indicators of population exposure to NPL sites. Therefore, we explored the possibility of developing more suitable NPL variables by incorporating a site's hazard ranking score as well as information from its remedial investigation. Unfortunately, the general absence of reliable information with respect to population exposure led to no practical alternatives to the use of site location as the sole surrogate for NPL exposures (Bove, 1992).

NJDEP's CERCLIS (i.e., toxic waste) list covers all sites identified in New Jersey, ranging in pollution severity from small dumping areas with a few barrels of waste to man-made lagoons at operating industries and, finally, to sites ranked highly on the U.S. EPA's NPL list. Except for NPL sites, no information other than the location of the site is available in the CERCLIS database. Thus, for the correlational analyses, the variable used to represent population exposure to the CERCLIS sites were the number of CERCLIS sites per square mile in a municipality ("CERCLIS-density") and a dichotomous variable indicating whether or not a municipality contained one (or more) such sites ("CERCLIS-presence").

C.2 VARIABLES FOR INDUSTRIAL EMISSIONS

The U.S. EPA's Toxic Release Inventory (TRI) for 1987 was used to obtain air emissions data for all New Jersey manufacturing plants (SIC codes 20-39) which used any of the 308 chemicals or 20 chemical categories specified in the federal Community Right-To-Know Act and which had a workforce of at least 10 full-time employees. Similar data were obtained from NJDEP's Right-To-Know Program for 1988. [Because they were not available at the time of this study, information on air emissions from the EPA TRI database for 1988 was not included here.]

Although the TRI relies on the employers to furnish emissions data, it contains information on how the employers estimated their emission rates. However, while there are standard methods for estimating emissions using mass balance or throughput modeling (USEPA/OAQPS, 1989), as well as standard methods for actual monitoring of releases, most of the data on emissions in the TRI have been based on so-called "best engineering judgments", so that estimates were not performed using a standardized method. In addition, the

TRI has excluded several important emitters such as gas stations, dry cleaners, incinerators, sewage treatment plants and power plants. These limitations notwithstanding, the TRI air emission database was considered satisfactory for use in the correlational analyses.

For releases of 1,000 pounds or greater, facilities were required to report the estimated number of pounds emitted. In contrast, for releases less than 1,000 pounds, an estimated number of pounds was often specified even though not required; or, two ranges may have been checked by a facility (1-499 and 500-999 pounds, respectively). If the estimated number of pounds was not specified <u>and</u> if one of the two ranges for releases less than 1,000 pounds was not checked, a value was treated as representing zero pounds of emissions. In the present study, the midpoint of 750 pounds, inserted by NJDEP, was considered a reasonable estimate for unspecified emissions in the range 500 to 999 pounds. However, considering the total amount of emissions reported (in excess of 39.5 million pounds), including some reporting of approximate emissions even in the lowest category, it seemed reasonable to assume that unspecified emissions in the range from 1 to 499 pounds (i.e., those for which no midpoint or other estimate was inserted by NJDEP) were essentially negligible and a value of zero was inserted. [Revising the survey forms to record smaller releases could be used to evaluate this assumption in the future.]

(a) <u>PRELIMINARY TRI VARIABLES</u>

The first set of variables created from the TRI database were the overall quantities of air emissions of all TRI chemicals per square mile in a municipality ("air-density"). [Note that the separately-recorded "stack" air emissions (i.e., those emitted through an intended discharge point) and "fugitive" air emissions (i.e., those escaping from a plant unintentionally during any phase of industrial processing or waste treatment) were combined into a single variable for each of the TRI categories used in the correlational analyses. Then, "total" variables were created representing emission quantities per square mile for each municipality , during the year to which the TRI survey pertained.] Similarly, separate "total" variables were created for the hydrocarbons, halogenated hydrocarbons, and inorganics ("inorganics-density").

(b) TRI VARIABLES BASED ON TOXICOLOGICAL INFORMATION

A second set of TRI variables were created based on available toxicological information. One group of variables included those chemicals known or suspected of being human teratogens ("teratogen-density") using a published list (Jelovsek et al., 1989) as well as one provided by NJDOH's Right-To-Know Program. Another group of variables ("cancer-density") was formed by incorporating known or suspected carcinogens and mutagens from a published list (USEPA, 1989) as well as that compiled by NJDOH's Right-To-Know Program to the list of teratogens. Because statistically significant associations have been reported between adverse reproductive outcomes and industrial air emissions of lead, arsenic, and vinyl chloride in the studies reviewed earlier. the three chemicals were also combined in a single variable ("special-density").

(c) VARIABLES BASED ON INDUSTRIAL USE

A published list of organic solvents (NIOSH, 1987) was used to create a variable for "solvent-density".

(d) VARIABLES BASED ON CHEMICAL STRUCTURES OR PHYSICAL PROPERTIES

All hydrocarbons were combined to create the variable "hydrocarbon-density". Next, all halogenated hydrocarbons were grouped together to form the variable "halogen-density".

C.3 VARIABLES FOR AGRICULTURAL PESTICIDE APPLICATIONS

The third set of environmental variables were derived from data on agricultural pesticide use in New Jersey obtained from NJDEP's Pesticide Control Program. In 1986, NJDEP surveyed all agricultural pesticide applicators in the state requesting the pesticide(s) applied, the number of acres treated, the types of crops treated, the method of application, and the municipality where the pesticide was applied (Louis et al., 1989). Not included in the survey were the non-agricultural use of pesticides such as applications in homes, lawns and golf courses, mosquito and gypsy moth control, among others. [Note that most of the agricultural use of pesticides occurred in the southern portion of the state.] Much like the TRI database, the pesticide survey relied solely on the information as it was supplied by the applicators, and no independent assessment of reliability or validity was attempted.

Compared to other exposures such as industrial air emissions or contaminated drinking water, the link between agricultural applications of pesticides and community exposures is more tenuous because it is unclear which, if any, route of exposure would be dominant. While there is a possibility of direct occupational exposures in the process of application, it is extremely difficult to estimate other types of indirect exposures to residents of surrounding areas. However, drift from aerial spraying and runoff from farms can contaminate air, surface water, and soil, thereby increasing exposures to nearby communities.

For all pesticide variables, air and ground applications were combined. The amount of active ingredients applied (in pounds) was then used to form the variables below for the amount applied per square mile for each municipality, during the year to which the pesticide survey data pertained.

Agricultural Pesticide Variables

- Total Pesticides ("**pesticide-density**")
- Phthalimides ("**phthalimide-density**")*
- Organophosphates ("**organophosphates-density**")
- Carbamates ("**carbamate-density**")
- Herbicides, especially 2,4-D ("**herbicide-density**")
- Halogenated Organics ("**halogens-density**")

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* N-sulfenyl phthalimide pesticides are structurally similar to thalidomide (Klaassen et al., 1986)

D. SOCIODEMOGRAPHIC VARIABLES

Twelve demographic variables were also included in the correlational analyses. The variables selected for inclusion were a representative subset of those described in the report on the project's first phase (Fulcomer et al., 1992b). In the context of exploring possible exposure-outcome relationships, it should be pointed out that the demographic variables may represent partial surrogates for probabilities of exposures.

Six of the demographic variables were derived directly from the 1980 U.S. Census and are listed below.

<u>Sociodemographic variables from the 1980 U.S. Census</u>

* Per capita income (in dollars).
* Mostly rural (a dichotomous variable indicating if more than
* 50% of a community's population resided in rural areas).
* Population density (number of persons per square mile in a
* municipality).
* Percent of housing units with 1.01 or more persons per room ("% crowded housing").
* Percent of housing units built before 1960 ("% old housing").
* Percent of female-headed households with related children under six years of age living below poverty status ("% female-headed poverty").

The remaining six sociodemographic variables given below were created by aggregating birth-certificate information for each municipality. [Fetal death certificate information could not be aggregated because many of the variables appear on the certificates but are not entered onto computerized records.]

Sociodemographic variables aggregated from birth certificates

* Average age of mothers at the time of birth ("mother's age").
* Percent of mothers over age 35 at the time of birth ("% mothers > 35").
* Percent of mothers who did not have at least a high school education ("% mothers < H.S.").
* Percent of primiparous mothers ("% primiparous").
* Percent of white mothers ("% white").
* Percent of births with "inadequate" prenatal care ("% inadequate prenatal care").

Based on "covariates" often reported in the literature on adverse reproductive outcomes (including an earlier correlational study of the occurrence of Sudden Infant Death Syndrome at the census-tract level in Philadelphia described by Fulcomer et al., 1981), the U.S. Census variables were incorporated into the present analyses to control for some aspects of socioeconomic status (SES). Because New Jersey has experienced considerable growth and changes in the dispersion of its population since the 1970's, additional background variables such as maternal age, education, and race, were obtained from birth certificates to provide more recent information than the 1980 Census. The percent of mothers over age 35 at the time of birth was selected to explore some possible non-linear effects, particularly with respect to recent increases in maternal ages and well-documented elevations in Down Syndrome in births to women in that age category (e.g., see Fulcomer et al., 1988). An earlier algorithm (NAS, 1973) was employed to calculate values for the prenatal care adequacy variable. The algorithm accounts for the month prenatal care began, the number of prenatal visits, and the gestational age at birth.

E. STATISTICAL METHODS

E.1 DATA LINKAGES

The linking of records for the municipalities from the various sources of variables was accomplished using several of the MADMANager Utility Programs (Fulcomer and Kriska, 1989). In particular, because different geocoding systems are used in some of the databases (see Fulcomer et al., 1992b or a brief description of this issue), the MADMATCH program was used to combine information from multiple databases to form unified, continuous records. Some "weighting" variables described below were also incorporated into the combined records.

E.2 WEIGHTING

In order to account for differences among the municipalities with respect to the number of births (e.g., ranging from 6 to 17,439 in the three years covered by this study), it was important to consider how to "weight" the municipality-based data in the correlational analyses. In particular, because the precision of a disease rate can be affected by the size of the population under study and because ecologic correlations based on aggregated data are generally highly inflated over those found at the individual-case level of analysis, it was clearly desirable to explore how alternative methods for weighting the "size" of a community might affect associations between variables.

To illustrate the wide variations among New Jersey's communities, a grouped frequency distribution of the number of births for the three years of the study is presented in Table 1; later work on this topic would likely benefit from attention to graphical displays of this type of information. Table 1 lists the values corresponding to 1st, 5th, 25th, 50th, 75th, 95th, and 99th percentiles.

TABLE 1
Frequency Distribution of Births in New Jersey Municipalities (1985 to 1987)

Number of Births in Mun.	Frequency (Number of Muns.)	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
1 - 12	6	1.07%	6	1.07%
13 - 37	22	3.92%	28	4.99%
38 - 124	113	20.14%	141	25.13%
125 - 289	139	24.78%	280	49.91%
290 - 602	141	25.13%	421	75.04%
603 -1850	112	19.96%	533	95.01%
1851 -4377	22	3.92%	555	98.93%
4378+	6	1.07%	561	100.00%

Although the median number of births per municipality over the three-year period was 290, the mean of 581 and standard deviation of 1192 births reveals that the distribution is affected by the extremely large municipalities (i.e., it has considerable positive skew). Thus, while the majority of the state's municipalities have a relatively small number of births, there are a few which contribute disproportionately to the total. For example, residents of the city of Newark had 17,439 live births in 1985 to 1987, representing 5.33% of the total for the entire state during that period. Similarly, the 28 cities at or above the 95th percentile accounted for 36.45% of the live births in the state (119,196 infants).

Pocock and associates (Pocock et al., 1981; Pocock et al., 1982; and Cook and Pocock, 1983) have identified three sources of variation in the rates of a disease across geographic areas: (1) sampling variation; (2) explained variation; and (3) unexplained variation. The distribution of population sizes across geographic units contributes to sampling variation. Explained variation represents the degree to which the independent variables in a regression model are associated with, or "explain", a disease. Similarly, the unexplained variation of a disease rate is that due to unknown or unmeasurable factors.

In general, techniques of weighting units by their population size address only the sampling variation component of the total variation of a disease rate across geographic areas. Typically, weights are chosen to be proportional to the inverse of the variance of the sampling error of the disease rate. In the present study, this method is equivalent to selecting weights proportional to the number of births in a community. Use of this weighting scheme assumes that 100% of the variation in the rates of an outcome that is not explained by the independent variables in the model is due to sampling variation (i.e. that there is no unexplained variation other than sampling variation). As the unexplained variation due to unknown or unmeasurable factors increases in size, the use of this weighting scheme will lead to bias in parameter estimation. In particular, the geographical units with relatively large birth population sizes will dominate the analysis.

Ideally, an optimal set of weights could be determined by a maximum likelihood approach (e.g., Pocock et al., 1981), which requires iterative computations. The multiple outcomes to be investigated and the need to develop sets of weights for each would have made computations and interpretations prohibitively complex. However, sophisticated weighting schemes may improve future analyses dealing exclusively with single outcomes (vs. emphasis on an entire set of outcomes) and in which stronger assumptions such as underlying Poisson distributions (in contrast to the essentially distribution-free nature of the present data) may be tenable. For such analyses, a Poisson method suggested by Breslow (1984) may be of particular interest.

Instead, as a consequence of the unequal dispersion of births throughout New Jersey, the present study concentrated on presenting results for each of four simple alternative approaches for weighting the geographic units included in the analyses. The four schemes are described below and ranged from an unweighted strategy (i.e., treating each area as being equal in size) to one that was fully-weighted (i.e., proportional to the number of births). The two intermediate approaches (common logarithms and square roots) were calculated using simple transformations of the number of births. Similar methods for weighting observations by frequency-related information are also available in standard statistical packages such as BMDP (Dixon et al., 1988, p. 529), SAS

(SAS, 1985), and SPSS (SPSS, 1988). These approaches to the weighting of the geographic units in the present study have the added advantages of applicability to all of the adverse reproductive outcomes simultaneously and ease of interpretation. Treating the weight for each municipality as a probability estimate (i.e., a converted value for a municipality divided by the sum of the converted values over the 561 geographic units) made it possible to calculate weighted univariate and bivariate parameter estimates using well-known formulae for grouped frequency distributions that are (except for adjusting for degrees of freedom) analogous to those based on the algebra of expectations (Hays, 1973). Table 2 lists some values summarizing each of the four weighting schemes, including the minimum and maximum weights observed and the weighted number of births (both the mean and the standard deviations) obtained.

TABLE 2

Summary Values For The Four Weighting Schemes

Weighting Scheme	Minimum Weight	Maximum Weight	Weighted Number of Births: Mean	Weighted Number of Births: Standard Deviation
Unweighted	.0018	.0018	581	1192
Logarithm	.0006	.0031	740	1479
Square Root	.0002	.0118	1305	2494
Fully-weighted	.0000+	.0533	3019	4427

1. UNWEIGHTED. [Weight value=1 for each town/561]. In this type of scheme, differences among the 561 municipalities in the number of births were not considered at all. That is, Newark with its 17,439 births in the three-year period was given the same weight as the municipality with only 6 births from 1985 to 1987. Although this is clearly an unrealistic assumption,

earlier ecologic studies (e.g., Najem et al., 1985) have often not specified that any such weights were used, thereby implying that analyses were performed on unweighted data. Therefore, the unweighted scheme was included here so that comparisons to previous values could be made.

2. LOG(10). [Weight value=LOG(number of births)/(Sum of LOGS)]. The common logarithms (i.e., base 10) of the municipalities' number of births in the three-year study period, divided by the sum of the logarithms (1,370.95), comprised the second set of weights. With this approach, Newark's weight was 5.45 times that of the municipality with the smallest number of births. However, while having the advantage of giving slightly more influence to the larger communities when contrasted to the unweighted approach, this method has the drawback of being a non-linear transformation which complicates its application to outcomes with certain distributional characteristics. For the logarithms themselves, the unweighted and weighted means are 2.4438 and 2.5540, respectively; interestingly, the anti-logs of these two means are 278 and 358, respectively, indicating the effectiveness of weighting by the logarithms in reducing the impact of the extremely large communities.

3. SQUARE ROOT. [Weight value=SqRt(Number of births)/(Sum of SqRts)]. A third weighting scheme was based on the square root of the municipalities' number of births. Newark's weight under the scheme was 53.91 times that of the municipality with the fewest births. The method gives considerably more influence to the extremely large communities, and correspondingly less emphasis to the areas with fewer births, than was evident for the scheme based on common logarithms. Like its logarithmic counterpart, the square root scheme has the potential drawback of being a non-linear transformation.

4. FULLY-WEIGHTED. [Weight value=number of births/total sum of births]. The fourth weighting scheme utilized the total number of births in a municipality over the three years included in the study. Not surprisingly, Newark's weight value was a staggering 2906.5 times that of the municipality with the fewest births. Thus, while this scheme may be "democratic" (in the sense of weighting communities by their contribution to the total number of births), a serious drawback is its potential for allowing larger communities to completely swamp the influences of those municipalities with fewer births.

E.3 INITIAL UNIVARIATE AND BIVARIATE PARAMETER ESTIMATES

In order to base the later regression analyses on stored results of sufficient statistics rather than requiring cumbersome recalculation with the entire set of records, MAD03C of the Madstat Statistics Programs (Fulcomer and Kriska, 1992) was employed to calculate univariate (means and standard deviations) and bivariate statistics (correlations) for all variables included in the final linked data file. Four sets of parameter estimates were prepared as input into the regression analyses, one for each of the weighting schemes described above.

E.4 MULTIVARIATE METHODS

Simple bivariate correlations provide some interesting relationships between estimated exposures to toxic wastes and adverse reproductive outcomes. However, it is generally accepted that controlling for other possible contributing factors improves the interpretation of such exposure-outcome associations. Removing the influences of extraneous variables can be accomplished using regression techniques (Anderson, 1958; Cohen and Cohen, 1983; Kerlinger and Pedhazur, 1973). In the present study, multivariate multiple regression techniques found in MADSTAT (Fulcomer and Kriska, 1992) were used to explore possible toxic waste-outcome relationships, after the effects of the sociodemographic variables had been removed, through the use of partial and semipartial (or "part") correlations. [Note that a variety of packages, including SPSS, SAS, DBASE, were also used for some of the preliminary univariate analyses and particular care was taken to see that similar results were obtained across different packages.]

The MADSTAT regression algorithm was selected because of its ability to calculate and display results for several dependent variables in juxtaposition, so that parallel explanatory models could be evaluated across similar, potentially correlated, outcomes. That is, unlike an ordinary multiple regression analysis that would treat each outcome separately (including the use of stepwise variable-selection techniques to maximize the variance accounted for in a specific dependent variable), the approach focused on results for several outcomes simultaneously, each based on a common set of explanatory variables, to explore the partial correlations between exposures and outcomes. Moreover, this approach did not deal with the issue of forming composite outcomes as would be called for in such multivariate strategies such as canonical correlational analysis (e.g., to create "the most predictable criterion" as first suggested by Hotelling, 1935). In particular, because the data file used in this report is one of the first examples of linkages between AROs and exposure variables, each with multiple measures from several distinct sources, we believed it would have been premature to begin weighting these outcomes (although this may well be a fruitful area for future investigations).

The twelve sociodemographic variables (six from the 1980 U.S. Census and six aggregated from information found on birth certificates) listed earlier in Section D (i.e., the multiple independent variables forced into the models before the exposure-outcome relationships were evaluated) were selected to account for traditional "confounders" reported in the literature on adverse reproductive outcomes (Fulcomer et al., 1981). The second chapter of the Phase I report (Fulcomer et al., 1992b) contains a description of how these twelve variables were selected.

III. RESULTS

This chapter presents the primary results of the multiple regression and partial regression analyses of the exposure-surrogate and adverse reproductive variables controlling for the sociodemographic variables. The next chapter interprets the more important findings that are listed here. With the set of twelve sociodemographic variables, three subsets of exposure variables, and two subsets of outcomes, there are six distinct groupings of information covered in the total of 51 variables included in the simple correlation matrices required for these analyses:

(a) the twelve sociodemographic characteristics treated as independent variables;

(b) the three subsets of data on environmental exposures, i.e.
- toxic waste sites (4 variables),
- industrial air emissions (8 variables), and
- agricultural pesticide applications (6 variables); and

(c) the two subsets derived from different sources of information on adverse reproductive outcomes to serve as dependent variables, i.e.,
- the 8 outcome rates based on vital records and
- the 13 outcome rates derived from the Birth Defects Registry.

For univariate statistics, 51 is a manageable number of variables. However, once bivariate correlations must be considered for the regression analyses, the number of off-diagonal values for the pairs of variables becomes enormous (2550 for each weighting scheme). Although separate correlation matrices were computed to evaluate the linear relationships within and between all groupings of variables in the multiple and partial regression analyses, only the subset of results most relevant to exposure-outcome associations are listed in this chapter. While intermediate univariate and bivariate are briefly mentioned here as a complete reference source for the reader, those results not directly addressing regression-related questions have either been described more fully in the report on the project's first phase (Fulcomer et al., 1992b) or appear in the appendices of this report.

Because the report is intended as an exploration of issues and methods for conducting correlational analyses of exposure-outcome data from geographic areas, values for each of the four weighting schemes (i.e., unweighted, common logarithms, square roots, and fully-weighted by the number of births) are listed here in juxtaposition. It is hoped that future studies will be able to address this consideration more parsimoniously.

A. DESCRIPTIVE STATISTICS FOR THE SOCIODEMOGRAPHIC (INDEPENDENT) VARIABLES

As a first step in approaching the multiple regression analysis, univariate descriptive statistics and the simple (i.e., unadjusted for any covariates) bivariate correlations were calculated among the twelve sociodemographic characteristics serving as the independent variables; the report for the project's first phase (Fulcomer et al., 1992b) lists these results in Appendices A and B, respectively. Given the ecologic nature of the study, the substantial magnitudes of these correlations are not surprising, including many of the relationships involving poor prenatal care. Some regression results presented in conjunction with the univariate statistics illustrate that the correlation matrices involve considerable redundancy (e.g., 97% of the variance of mother's average age is explained by the regression of the other eleven sociodemographic variables obtained under the fully-weighted scheme).

B. DESCRIPTIVE STATISTICS FOR THE EXPOSURE VARIABLES

This section discusses three types of descriptive statistics for the three subsets of exposure variables. The first section reviews the tables of correlations within and between the three exposure subsets. Correlations between the twelve sociodemographic variables and the exposure variables are described in the second section. Finally, some regression statistics for the exposure variables are given in the third section.

B.1 CORRELATIONS WITHIN AND BETWEEN THE SUBSETS OF EXPOSURE VARIABLES

Simple bivariate correlations within the three subsets of environmental exposure variables are found in Appendices A, B, and C for the toxic waste sites, industrial air emissions, and agricultural pesticide applications, respectively. Similarly, the correlations between the variables in the toxic waste site subset and the industrial air emissions and agricultural pesticide applications appear in Appendices D and E, respectively, while the values between the air emissions and pesticide subsets are found in Appendix F.

Correlations Among Toxic Waste Site Variables. The simple correlational results for the toxic waste sites variables found in Appendices A, D, and E were based on the 108 NPL and 1436 CERCLIS "facilities" in New Jersey (see Bove, 1992). Five of the NPL facilities have locations in two different communities and, therefore, were treated as 10 separate sites; this also increased the total number of CERCLIS sites to 1441. Removing the six municipalities with no births in any of the three years did not change the number of NPL sites included in the analyses, while only one of the CERCLIS sites was eliminated. The final set of 113 NPL sites included in the present study were located in 89 (15.86%) of the 561 geographic units considered here, with up to five NPL sites possible in a single unit. The 1440 CERCLIS sites included here are more widely-dispersed throughout the state with over 338 (60.25%) of the state's communities having at least one such facility; the maximum number of CERCLIS sites in any community is 109 (in Newark). Because NPL sites also appear on the CERCLIS list and because the two "density" variables depend on the two "presence" variables, the positive correlations in Appendix A are not surprising.

Correlations Among Industrial Air Emissions Variables. The correlational results for the industrial air emissions data found in Appendices B, D, and F were derived from reports provided by 857 facilities for the 1987 TRI database. Only the variables for the totals of both stack and fugitive emissions were included in the present analyses. For the 561 geographic units retained, Table 3 summarizes the number of different towns to which the reports referred (with per cents of 561 given in parentheses) and the number of pounds of emissions reported (the total from which the "density" variables were calculated along with the minimum and maximum nonzero values observed) for each of the industrial air emissions variables used here.

TABLE 3

Summary Of Information From The 1987 TRI Database

Industrial Air Emissions Variable	Number of Communities	Pounds of Emissions Reported Total	Minimum	Maximum
Air	211 (37.61%)	39,504,406	42	3,111,392
Teratogens	149 (26.56%)	22,715,186	90	2,858,104
Solvents	155 (27.63%)	30,907,907	21	2,965,783
Special*	36 (6.42%)	218,256	5	82,007
Inorganics	139 (24.78%)	2,595,516	5	386,817
Hydrocarbons	118 (21.03%)	11,669,935	57	2,635,155
Halogens	92 (16.40%)	5,015,649	5	904,675
Carcinogens	112 (19.96%)	4,521,117	68	911,782

* Includes lead, arsenic, and vinyl chloride.

Given the overlapping groupings of chemicals in the set of air emissions variables, substantial intercorrelations among the variables were expected; this is especially evident in the correlations between the air-density variable and six of the remaining seven variables (all of which are also included in the air-density variable as well) and between the teratogen-density and solvent-density variables (which are nearly redundant). The lone exception is the grouping of special chemicals which, based on low levels of reported emissions, appears to be largely unrelated to the other seven variables.

Correlations Among Agricultural Pesticide Applications Variables. The correlations for the agricultural pesticide applications variables presented in Appendices C, E, and F came from survey results conducted by NJDEP's Pesticide Control Program (described by Bove, 1992). For the 561 communities retained for the present study, Table 4 summarizes the number of different towns in which such applications were reported (with percents of 561 given in parentheses) and the number of pounds applied (the total from which the "density" variables were calculated along with the minimum and maximum nonzero values observed) for each of the agricultural pesticide applications variables included here. [Note that fractional pound figures reflect the estimation of chemical composition.]

TABLE 4
Summary Of Information On Agricultural Pesticide Applications

Agricultural Pesticide Applications Variable	Number of Communities	Pounds Applied Total	Minimum	Maximum
Pesticides	247 (44.03%)	1,591,348.30	.09	153,564.10
Thalidomides	132 (23.53%)	88,807.58	.01	18,287.41
Organophosphates	225 (40.11%)	177,368.47	.01	19,560.06
Carbamates	215 (38.32%)	186,142.17	.03	23,797.18
Herbicides	81 (14.44%)	12,253.72	.39	985.90
Halogens	170 (30.30%)	48,636.19	.05	10,812.80

Except for the herbicide-density variables, the set of pesticide variables are highly correlated with one another. Correlations involving the herbicide variable are considerably lower, most likely reflecting both the low levels with which that type of application was reported as well as its use on different crops and for purposes other than pesticides.

<u>Correlations Between The Subsets Of Environmental Exposure Variables</u>. An inspection of the correlations in Appendix D shows that the two Superfund variables ("density" and "presence") are essentially unrelated to the industrial air emissions variables. In contrast, the two variables derived from the CERCLIS sites are probably more reflective of industrial activity and, therefore, it is not surprising that they are modestly correlated with

seven of the eight air emissions variables; the exception is the grouping of the special chemicals, which was also not associated with the other items within its own subset.

The remaining appendices of simple correlations between subsets of exposure variables both involve the agricultural pesticide application variables. These two tables reveal the expected underlying linear independence between the pesticide variables and the other subsets of exposure items, with the between-subset correlations to the toxic waste site and industrial air emissions variables appearing in Appendices E and F, respectively.

B.2 CORRELATIONS BETWEEN THE SOCIODEMOGRAPHIC (INDEPENDENT) AND EXPOSURE VARIABLES

The simple bivariate correlations between the sociodemographic and the three subsets of exposure variables are listed in Appendices G, H, and I for the toxic waste sites, industrial air emissions, and agricultural pesticide applications, respectively. Although some researchers (most notably Najem et al., 1985) have reported findings based on such "apparent" (or unadjusted) relationships, these values are presented here only as intermediate descriptive statistics. These values are the predictor-criterion correlations used for the next section's multiple regression analyses treating the exposure variables as dependent variables. The much more important role of the exposure variables in partial correlations with the adverse reproductive outcomes will be discussed later in this chapter.

B.3 REGRESSIONS FOR THE SUBSETS OF EXPOSURE VARIABLES

The multiple regression analyses for explaining each of the exposure variables as a weighted linear combination of the twelve sociodemographic variables were calculated using the correlations mentioned in the last section. These analyses have been summarized here because they address the issue of removing influences of the sociodemographic variables (in this case from the exposure variables) before evaluating exposure-outcome partial correlations. Some summary regression statistics for each exposure variable are presented in Tables 5, 6, and 7 for the toxic waste site, industrial air emissions, and agricultural pesticide applications, respectively. For each exposure (i.e., dependent) variable, these tables provide some relevant statistics, including the adjusted, or "shrunken", R^2 as a per cent to estimate the population R^2 [$= 1-(1-R^2)((N-1)/(N-p-1))$, where p is the number of independent variables] originally due to Wherry (1931); and the F-ratio for R^2.

An inspection of Tables 5 to 7 shows that there are some relationships between the sociodemographic and exposure variables that should be accounted for in the later analyses of the partial correlations between the exposures and the adverse reproductive outcomes. In Table 5, there are significant R^2 values for the CERCLIS variables ("density" and "presence"), regardless of the type of weighting scheme considered. However, the large number of sites and births in Newark alone (109 and 17,439, respectively) clearly distorts the regression results for the scheme that accounts for the actual number of births in a community (i.e., the fully-weighted approach). The analysis forces extreme values (such as Newark in the case of sites and births) to fall very close to the best-fitting regression lines. Although six of the eight R^2

TABLE 5

Summary Regression Statistics For Explaining Each Toxic Waste Site Variable From The Twelve Sociodemographic Variables

VARIABLE	TYPE OF WEIGHTING	MEAN	INTERCEPT VALUE	STANDARD DEVIATION	STANDARD ERROR	MULTIPLE R	MULTIPLE R-SQUARE PER CENT	ADJUSTED R-SQUARE PER CENT	F-RATIO FOR R-SQUARE
NPL-density	Unweighted	.0338	.3299	.1559	.1554	.1666	2.7764	.6474	1.3041
	Log(10)	.0346	.1833	.1501	.1491	.1849	3.4187	1.3037	1.6165
	Square Root	.0348	.0550	.1370	.1357	.2002	4.0084	1.9063	1.9069*
	Fully-wgtd.	.0337	-.2198	.1098	.1084	.2164	4.6828	2.5956	2.2435**
CERCLIS-density	Unweighted	.4813	1.5843	.9045	.8355	.4062	16.5018	14.6734	9.0251**
	Log(10)	.5216	-.1055	.9213	.8290	.4558	20.7727	19.0378	11.9734**
	Square Root	.6396	-3.0868	1.0162	.8240	.5971	35.6543	34.2452	25.3041**
	Fully-wgtd.	.9963	-5.1656	1.3063	.7950	.7985	63.7545	62.9608	80.3261**
NPL-presence	Unweighted	.1586	-1.0339	.3657	.3592	.2357	5.5540	3.4858	2.6855**
	Log(10)	.1794	-1.2649	.3838	.3746	.2609	6.8083	4.7676	3.3362**
	Square Root	.2259	-2.4627	.4182	.3976	.3398	11.5466	9.6096	5.9613**
	Fully-wgtd.	.3195	-3.0154	.4663	.4087	.4981	24.8073	23.1608	15.0662**
CERCLIS-presence	Unweighted	.6025	1.1265	.4898	.4685	.3236	10.4728	8.5124	5.3420**
	Log(10)	.6451	.6460	.4787	.4575	.3254	10.5914	8.6336	5.4097**
	Square Root	.7140	.2895	.4519	.4288	.3448	11.8902	9.9608	6.1626**
	Fully-wgtd.	.8131	.0402	.3898	.3638	.3844	14.7753	12.9091	7.9172**

* significant at $p < .05$.

** significant at $p < .01$.

TABLE 6

Summary Regression Statistics For Explaining Each Industrial Air Emissions Variable From The Twelve Sociodemographic Variables

VARIABLE	TYPE OF WEIGHTING	MEAN	INTERCEPT VALUE	STANDARD DEVIATION	STANDARD ERROR	MULTIPLE R	MULTIPLE R-SQUARE PER CENT	ADJUSTED R-SQUARE PER CENT	F-RATIO FOR R-SQUARE
Air-density	Unweighted	14382.9819	21551.7502	65980.3253	62491.6932	.3495	12.2174	10.2952	6.3558**
	Log(10)	16104.6049	-26359.3420	70483.8520	66501.2565	.3590	12.8890	10.9815	6.7569**
	Square Root	20132.6604	-205074.8499	78567.1717	73898.6703	.3664	13.4268	11.5310	7.0825**
	Fully-wgtd.	28173.6162	-371690.7936	84819.3594	79406.7495	.3773	14.2336	12.3555	7.5787**
Teratogen-density	Unweighted	7518.5529	168490.8345	38032.9842	37910.9149	.1664	2.7700	.6409	1.3010
	Log(10)	8111.4308	147206.2130	37733.1588	37565.0203	.1736	3.0130	.8892	1.4187
	Square Root	9730.6037	149558.5344	37033.6465	36570.3044	.2139	4.5762	2.4866	2.1900**
	Fully-wgtd.	13873.0305	141541.2654	36169.8246	34033.9764	.3655	13.3587	11.4614	7.0410**
Solvent-density	Unweighted	10405.3525	213536.8870	45658.1485	44881.1914	.2333	5.4450	3.3744	2.6297**
	Log(10)	11309.8974	194489.2776	45703.6736	44888.1914	.2367	5.6038	3.5367	2.7110**
	Square Root	13635.8167	209658.1406	45348.0246	44211.5629	.2643	6.9862	4.9494	3.4300**
	Fully-wgtd.	19551.6317	185421.3881	44872.2254	41264.3715	.4153	17.2462	15.4341	9.5171**
Special-density	Unweighted	27.2376	682.1004	300.9712	299.9417	.1677	2.8112	.6829	1.3209
	Log(10)	28.9735	829.8103	305.1521	304.0827	.1682	2.8275	.6997	1.3288
	Square Root	33.1658	1356.7745	300.2941	298.5725	.1806	3.2617	1.1434	1.5397
	Fully-wgtd.	44.2200	1101.3178	267.0574	263.1130	.2239	5.0121	2.9321	2.4097**
Inorganics-density	Unweighted	814.0588	2464.2650	4501.2673	4420.7224	.2369	5.6136	3.5467	2.7160**
	Log(10)	938.7179	-1606.7183	4805.0043	4694.7211	.2566	6.5833	4.5377	3.2182**
	Square Root	1243.4941	-18785.6812	5347.0976	5116.4483	.3225	10.4030	8.4410	5.3023**
	Fully-wgtd.	1900.6705	-47590.1752	6030.6270	5459.0309	.4451	19.8140	18.0581	11.2842**
Hydrocarbon-density	Unweighted	3509 3009	79311.3012	20694.5184	20719.9296	.1379	1.9024	.0000	.8856
	Log(10)	3739.9539	67234.8749	20193.4986	20190.9836	.1472	2.1672	.0249	1.0116
	Square Root	4412.6704	60994.8973	19537.3640	19435.7566	.1777	3.1581	1.0374	1.4892
	Fully-wgtd.	6037.8827	29316.5810	18436.3873	17866.0423	.2847	8.1038	6.0915	4.0271**
Halogen-density	Unweighted	1210.8003	-9238.7977	6562.2881	6548.4743	.1598	2.5544	.4206	1.1971
	Log(10)	1386.2141	-15622.2712	6981.1822	6956.6425	.1682	2.8296	.7018	1.3298
	Square Root	1749.2284	-38619.4471	7522.8594	7463.2776	.1920	3.6868	1.5777	1.7481
	Fully-wgtd.	2332.0560	-50309.2742	7655.3884	7516.6614	.2379	5.6574	3.5915	2.7384**
Carcinogen-density	Unweighted	1218.9104	-6386.8807	6756.8898	6729.3337	.1714	2.9394	.8140	1.3830
	Log(10)	1405.7407	-11688.4243	7201.0993	7159.2523	.1810	3.2769	1.1589	1.5471
	Square Root	1794.7854	-30189.5785	7774.3334	7691.4842	.2054	4.2174	2.1200	2.0108*
	Fully-wgtd.	2458.5246	-39596.4775	7956.4507	7748.0339	.2684	7.2024	5.1703	3.5444**

* significant at $p < .05$.
** significant at $p < .01$.

TABLE 7

Summary Regression Statistics For Explaining Each Agricultural Pesticide Applications Variable From The Twelve Sociodemographic Variables

VARIABLE	TYPE OF WEIGHTING	MEAN	INTERCEPT VALUE	STANDARD DEVIATION	STANDARD ERROR	MULTIPLE R	MULTIPLE R-SQUARE PER CENT	ADJUSTED R-SQUARE PER CENT	F-RATIO FOR R-SQUARE
Pesticide-density	Unweighted	238.4054	6662.8198	1346.7525	1338.5878	.1824	3.3258	1.2088	1.5710
	Log(10)	218.9142	4843.8979	1268.6180	1266.0790	.1592	2.5342	.3999	1.1874
	Square Root	180.9269	5460.7769	1124.0915	1123.6647	.1489	2.2171	.0759	1.0355
	Fully-wgtd.	117.7977	4010.3484	854.7031	855.8404	.1372	1.8823	.0000	.8761
Thalidomide-density	Unweighted	10.9933	431.7314	60.2933	59.5290	.2147	4.6082	2.5193	2.2061**
	Log(10)	10.3787	374.6061	57.7281	57.2411	.1946	3.7870	1.6801	1.7974*
	Square Root	8.9480	514.8076	53.2802	52.7975	.1977	3.9080	1.8038	1.8573*
	Fully-wgtd.	6.1063	435.0744	43.8236	43.5394	.1846	3.4078	1.2926	1.6111
Organophosphates-density	Unweighted	22.6345	363.2466	103.9250	103.6631	.1623	2.6355	.5035	1.2361
	Log(10)	21.7532	287.4147	101.7341	101.6776	.1500	2.2515	.1110	1.0519
	Square Root	19.0029	387.7477	93.8948	93.8615	.1487	2.2124	.0711	1.0332
	Fully-wgtd.	13.2760	366.5819	75.2257	75.1427	.1536	2.3587	.2206	1.1032
Carbamate-density	Unweighted	21.3379	125.0968	123.9790	124.2974	.1280	1.6395	.0000	.7612
	Log(10)	20.7063	99.5913	122.3843	122.6948	.1283	1.6457	.0000	.7641
	Square Root	17.6649	155.3158	110.8742	111.1496	.1287	1.6560	.0000	.7690
	Fully-wgtd.	11.5208	174.8341	84.0807	84.2496	.1323	1.7494	.0000	.8131
Herbicide-density	Unweighted	2.0918	-2.6372	23.7579	23.8114	.1305	1.7021	.0000	.7907
	Log(10)	1.7437	.5393	19.9656	20.0320	.1221	1.4911	.0000	.6912
	Square Root	1.2387	4.4598	14.4911	14.5552	.1130	1.2758	.0000	.5901
	Fully-wgtd.	.6630	3.6294	7.5589	7.5895	.1162	1.3493	.0000	.6246
Halogens-density	Unweighted	11.4232	-135.8366	160.0312	161.4351	.0647	.4183	.0000	.1918
	Log(10)	11.2128	-145.5239	158.2091	159.5468	.0694	.4811	.0000	.2208
	Square Root	9.5658	-176.0148	142.3569	143.5414	.0713	.5077	.0000	.2330
	Fully-wgtd.	6.1599	-94.9458	105.1217	106.0039	.0702	.4934	.0000	.2264

* significant at $p < .05$.
** significant at $p < .01$.

the Superfund sites are significant, the proportions of variance explained in the density variable across the four weighting schemes are substantially lower than their counterparts on the CERCLIS list. Moreover, the R^2's are substantially lower than those for explaining each sociodemographic variable (from the remaining 11 variables in that set) that are listed in Appendix A of the Phase I report (Fulcomer et al., 1992b). This suggests that there is considerable variance in the toxic waste site variables that is unrelated to the independent variables.

The summary regression statistics for the industrial air emissions variables listed in Table 6 also show the importance of accounting for some covariates before interpreting exposure-outcome relationships. Although there are considerable proportions of unexplained variance for the industrial air emissions, there are significant R^2's for explaining three of the eight exposure variables (air-density, solvent-density, and inorganics-density) from the twelve independent variables, regardless of the type of weighting scheme employed. Each of the air emissions variables also has a significant R^2 under the fully-weighted scheme, while there are two other significant relationships found with weighting by the square root method. Within each variable, the R^2's increase across the weighting schemes, again highlighting the distortions of regression results that are possible as the communities with more births are permitted to exert more influence in the formation of the initial correlations. Much like the situation with the CERCLIS sites, Newark by itself accounts for a large proportion (5.66%) of the total air emissions reported for the entire state.

In contrast to the toxic waste site and industrial air emissions exposure variables, the summary regression statistics found in Table 7 indicate that the agricultural pesticide applications variables remain largely unexplained by the twelve sociodemographic variables. Except for weak associations for the phthalimide-density variable with three of the four weighting schemes (the fully-weighted method is the only exception), there are no other significant results for the pesticide variables. Because there is little agricultural activity in the northern, industrialized areas of the state (e.g., Newark and Paterson both have <u>no</u> agricultural applications of pesticides), the overall independence between the pesticide variables and the sociodemographic variables is not surprising.

C. DESCRIPTIVE STATISTICS FOR THE OUTCOME (DEPENDENT) VARIABLES

This section briefly summarizes some important descriptive statistics for the two subsets of the adverse reproductive outcome dependent variables. [Several of these results are described more fully in the Phase I report (Fulcomer et al., 1992b).] Correlation matrices within and between the subsets are described in the first section below. The second section reviews the correlations between the sociodemographic (independent) and the birth outcome (dependent) variables. Initial (i.e., simple or "unadjusted") correlations between exposure and outcome variables are discussed in the third section.

C.1 CORRELATIONS WITHIN AND BETWEEN THE TWO SUBSETS OF OUTCOME VARIABLES

The simple bivariate correlations within and between the subsets of outcome variables derived from vital records and the BDR are described in the Phase I report, for which the appendix locations in that report are indicated in parentheses here. These correlations provide the initial values from which some of the later partial correlations are derived and, not surprisingly, are often significant and substantial.

Correlations Within Vital Records Variables (Phase 1 Appendix C). All but 10 of the 112 correlations in Appendix C of that report are significant (93 at $p<.01$ and 9 at $p<.05$ alone).

Correlations Within Birth Defects Registry Variables (Phase 1 Appendix D). While there is a lower proportion of significant values than for the set of vital records outcomes (despite the inflation of some of the pairings because variables appear both individually and as part of a total), 203 of the 312 are significant (174 of $p<.01$ and 29 at $p<.05$ alone).

Correlations Between Vital Record And Birth Defects Registry Variables (Phase I Appendix E). Although there is substantial overlap between the two subsets of variables (138 of the 416 correlations are significant, 104 at $p<.01$ and 34 at $p<.05$ alone), the correlations are generally lower than their within-subset counterparts.

C.2 CORRELATIONS BETWEEN THE SOCIODEMOGRAPHIC AND OUTCOME VARIABLES

The Phase I report also describes the simple correlations between the sociodemographic (independent) variables and the two subsets of adverse reproductive outcome (dependent) variables, which play important roles in the calculation of regression coefficients. Again, the appendix location in the Phase I report are given in parentheses.

Correlations Between Sociodemographic And Vital Records Variables (Phase I Appendix F). Beyond pointing out the many significant values (300 at p<.01 and 19 at p<.05 alone) and the substantial levels of many of the associations, it is also important to note that the directions of the significant relationships are all consistent with "risk factors."

Correlations Between Sociodemogrpahic And Birth Defects Registry Variables (Phase I Appendix G). An inspection of these correlations reveals a much lower proportion of significant values (129 of the 624 values are significant, 72 at p<.01 and 57 at p<.05 alone) and generally lower magnitudes than those outcome variables based on vital records. Also, the directions of the relationships do not follow the same consistent pattern of positive correlations noted for the vital records outcomes.

C.3 CORRELATIONS BETWEEN THE OUTCOME AND EXPOSURE VARIABLES

This section presents the simple bivariate correlations between the dependent variables and the three subsets of exposure variables. These results are treated here only as an intermediate step in the calculation of partial correlations and are shown in the appendices of this report. They should be interpreted cautiously. The partial correlations presented later will address the issue of exposure-outcome relationships after the predictive influences of the sociodemographic variables have been removed.

Correlations With Toxic Waste Site Variables. Appendices J and K of this report provide the correlations between the toxic waste site variables and the dependent variables based on vital records and birth defects registry information, respectively. The values in Appendix J involving vital records information give some early indications of potential exposure-outcome relationships, especially with respect to the CERCLIS-density variable. Of the 128 correlations (32 for each of 4 weighting schemes), 32 exceed the critical value for significance at $p<.01$ (i.e., $|r_{xy}| \geq .115$), while eight of the remaining values are significant at $p<.05$ (i.e., $.088 \leq |r_{xy}| < .115$). In contrast, the correlations in Appendix K demonstrate the difficulty in establishing significant relationships with outcomes involving birth defects; of the 208 correlations, 10 are significant at $p<.01$, while another six are significant at the 5% level.

Correlations With Industrial Air Emissions Variables. Appendices L and M of this report list the correlations between the industrial air emissions variables and the two subsets of dependent variables. For the dependent variables based on vital records, the values in Appendix L suggest some potential exposure-outcome relationships, similar to the toxic waste variables; of the 256 correlations (64 for each of 4 weighting schemes), 39 exceed the critical value for significance at $p<.01$, while 26 of the remaining values are significant at $p<.05$. However, the much smaller proportion of significant correlations for the birth defects variables found in Appendix M also parallels that for the toxic waste variables; of the 416 correlations (104 for each of 4 weighting schemes), just two are significant at $p<.01$, while another 10 of the pairings are significant at $p<.05$.

Correlations With Agricultural Pesticide Applications Variables. Appendices N and O of this report contain the correlations between the agricultural pesticide applications variables and the dependent variables based on vital records and birth defects registry information, respectively. For the values in Appendix N involving information based on vital records, only four of 192 correlations (48 for each of 4 weighting schemes) are significant (1 at $p < .01$ and an additional 3 at $p<.05$). Similarly, only one of the 312 correlations in Appendix O for the birth defects outcomes is significant at the 5% level.

D. REGRESSION STATISTICS FOR THE OUTCOME (DEPENDENT) VARIABLES

This section presents some results from the multiple regression analyses attempting to explain each of the outcome variables from a prediction equation based on the twelve sociodemographic variables. Although the tables that appear in this section were also listed in the report on the first phase (Fulcomer et al., 1992b), their inclusion here is especially relevant, since the development of the equations was the final computational step prior to the calculation of the exposure-outcome partial correlations described in the next section.

D.1 REGRESSION RESULTS FOR THE VITAL RECORDS VARIABLES

For the dependent variables derived from vital records, Table 8 shows that the regression equations explain significant proportions of variance. With one exception, all of the overall F-tests for the R^2's are significant at the $p<.01$ level; the exception involves the application of the unweighted scheme to the rate of fetal deaths, which is significant at the 5% level. Beyond mere statistical significance, however, the proportions of variance explained give evidence of predictive strength that suggests applications to program planning and evaluation. For example, the adjusted R^2 percents range from 2.13% (for the unweighted scheme applied to the rate of fetal deaths) to an exceptionally high 86.68% (for the percent of preterm births under the fully-weighted scheme). In terms of the weighting schemes, the adjusted R^2's for the unweighted scheme are lowest, followed by those based on common logarithms, square roots, and the actual number of births (i.e., fully-weighted). It is also evident that the results for the square root transformations are appreciably greater than those for either the unweighted or log(10) schemes, but still are considerably less than those for the fully-weighted scheme.

D.2 REGRESSION RESULTS FOR THE BIRTH DEFECTS REGISTRY VARIABLES

In contrast to the dependent variables derived from vital records, Table 9 conveys much weaker regression results for those based on the BDR. First, the overall F-ratios for the R^2's are not uniformly significant. Of the 52 values (4 weighting schemes for each of the 13 variables), 21 are significant (16 at the $p<.01$ level and an additional five at $p<.05$). Furthermore, even

TABLE 8

Summary Regression Statistics For Explaining Each Vital Records Variable From The Sociodemographic (Independent) Variables

VARIABLE	TYPE OF WEIGHTING	MEAN	INTERCEPT VALUE	STANDARD DEVIATION	STANDARD ERROR	MULTIPLE R	MULTIPLE R-SQUARE PER CENT	ADJUSTED R-SQUARE PER CENT	F-RATIO FOR R-SQUARE
Preterm births percent	Unweighted	8.1143	48.9888	3.5011	2.6924	.6491	42.1275	40.8602	33.2424**
	Log(10)	8.2004	35.4795	3.2682	2.3447	.7045	49.6332	48.5302	45.0015**
	Square Root	8.6243	37.9345	3.3543	1.9024	.8278	68.5236	67.8343	99.4154**
	Fully-wgtd.	9.8792	21.4097	3.8870	1.4188	.9325	86.9623	86.6768	304.5994**
Small-for-gestational age percent	Unweighted	10.1453	20.5737	3.0433	2.7763	.4309	18.5632	16.7799	10.4095**
	Log(10)	10.2555	14.8874	2.7489	2.4534	.4695	22.0465	20.3395	12.9153**
	Square Root	10.5095	15.8276	2.4428	2.0478	.5589	31.2332	29.7273	20.7413**
	Fully-wgtd.	11.1511	5.4554	2.1896	1.5283	.7234	52.3282	51.2842	50.1271**
Very low birthweight rate	Unweighted	10.7042	13.4926	11.4321	10.8973	.3329	11.0838	9.1368	5.6926**
	Log(10)	10.6736	20.5956	9.8858	9.2746	.3724	13.8695	11.9835	7.3537**
	Square Root	11.1457	31.1709	8.4368	7.3261	.5120	26.2132	24.5974	16.2233**
	Fully-wgtd.	12.9099	38.9659	7.5325	4.9153	.7637	58.3314	57.4189	63.9282**
Low birthweight rate	Unweighted	55.9390	201.7679	25.8503	22.2059	.5272	27.7895	26.2082	17.5743**
	Log(10)	56.8128	170.6982	24.1056	19.4861	.6005	36.0548	34.6545	25.7486**
	Square Root	59.8551	205.6308	23.9894	15.8368	.7573	57.3532	56.4193	61.4144**
	Fully-wgtd.	68.7379	147.8255	27.2254	11.2055	.9134	83.4231	83.0601	229.8175**
Neonatal death rate	Unweighted	5.8728	31.1302	7.2140	7.0876	.2354	5.5426	3.4742	2.6797**
	Log(10)	5.9073	22.2913	6.3972	6.2427	.2610	6.8115	4.7709	3.3379**
	Square Root	6.0906	26.4334	5.3089	5.0336	.3468	12.0292	10.1028	6.2445**
	Fully-wgtd.	6.7102	23.8850	4.0735	3.4528	.5449	29.6955	28.1560	19.2889**
Post-neonatal death rate	Unweighted	2.4211	-10.1002	5.1187	4.9490	.2920	8.5244	6.5213	4.2556**
	Log(10)	2.4278	-3.2981	4.1843	4.0032	.3229	10.4295	8.4681	5.3174**
	Square Root	2.6201	1.5431	3.3843	3.1166	.4124	17.0099	15.1926	9.3600**
	Fully-wgtd.	3.1936	5.1492	2.6631	2.0421	.6516	42.4627	41.2027	33.7021**
Total infant death rate	Unweighted	8.2941	21.0260	8.7649	8.3771	.3258	10.6120	8.6546	5.4215**
	Log(10)	8.3353	18.9866	7.6934	7.2352	.3668	13.4518	11.5566	7.0978**
	Square Root	8.7111	27.9574	6.5688	5.8318	.4782	22.8679	21.1789	13.5391**
	Fully-wgtd.	9.9046	28.9950	5.5765	4.0205	.7010	49.1335	48.0196	44.1108**
Fetal mortality rate	Unweighted	6.9253	22.7398	7.9773	7.8918	.2057	4.2301	2.1329	2.0171*
	Log(10)	6.9347	8.9757	7.0011	6.9073	.2179	4.7472	2.6614	2.2760**
	Square Root	7.0895	1.0189	5.7390	5.5512	.2905	8.4414	6.4364	4.2103**
	Fully-wgtd.	7.6948	1.5630	4.3227	3.8105	.4895	23.9576	22.2924	14.3875**

* significant at p < .05.
* significant at p < .01.

TABLE 9

Summary Regression Statistics For Explaining Each Birth Defects Registry Variable From The Sociodemographic (Independent) Variables

VARIABLE	TYPE OF WEIGHTING	MEAN	INTERCEPT VALUE	STANDARD DEVIATION	STANDARD ERROR	MULTIPLE R	MULTIPLE R-SQUARE PER CENT	ADJUSTED R-SQUARE PER CENT	F-RATIO FOR R-SQUARE
Down syndrome	Unweighted	1.4198	-13.5659	4.3478	4.3460	.1491	2.2244	.0834	1.0389
	Log(10)	1.3475	-5.9486	3.3598	3.3618	.1423	2.0247	.0000	.9437
	Square Root	1.2845	-1.1152	2.5351	2.5384	.1374	1.8877	.0000	.8786
	Fully-wgtd.	1.1862	3.1069	1.6153	1.6062	.1799	3.2374	1.1185	1.5279
Neural tube defects	Unweighted	1.9911	8.3697	3.9144	3.8730	.2050	4.2020	2.1042	2.0031*
	Log(10)	1.9959	9.4255	3.5353	3.5004	.2016	4.0632	1.9624	1.9341*
	Square Root	1.9924	14.7112	2.9092	2.8821	.1988	3.9539	1.8507	1.8800*
	Fully-wgtd.	2.0478	11.7121	2.0457	2.0044	.2461	6.0547	3.9975	2.9432**
Eye defects	Unweighted	.2121	-.9528	1.0125	1.0193	.0906	.8212	.0000	.3781
	Log(10)	.2162	-.8148	.9732	.9790	.0978	.9557	.0000	.4407
	Square Root	.2101	-.4525	.8539	.8579	.1111	1.2340	.0000	.5705
	Fully-wgtd.	.1963	.7381	.6362	.6359	.1497	2.2422	.1015	1.0474
Selected severe cardiac defects	Unweighted	1.3779	-6.9161	3.1674	3.1617	.1580	2.4955	.3604	1.1688
	Log(10)	1.3511	-5.2168	2.8293	2.8305	.1433	2.0541	.0000	.9577
	Square Root	1.3095	-2.6914	2.2953	2.3024	.1240	1.5364	.0000	.7126
	Fully-wgtd.	1.2872	3.0891	1.5705	1.5671	.1601	2.5636	.4300	1.2015
Oral clefts	Unweighted	1.3450	-4.4956	2.8932	2.8977	.1356	1.8392	.0000	.8556
	Log(10)	1.3401	-4.1310	2.6216	2.6273	.1309	1.7139	.0000	.7963
	Square Root	1.3101	-3.5220	2.1769	2.1845	.1206	1.4553	.0000	.6744
	Fully-wgtd.	1.2599	-.2964	1.5526	1.5590	.1154	1.3312	.0000	.6161
Reduction deformities	Unweighted	.4378	.6883	1.4981	1.5042	.1159	1.3444	.0000	.6223
	Log(10)	.4438	.9969	1.4048	1.4101	.1185	1.4045	.0000	.6505
	Square Root	.4358	2.0165	1.2041	1.2089	.1170	1.3699	.0000	.6343
	Fully-wgtd.	.4204	1.7536	.8806	.8834	.1232	1.5167	.0000	.7033
Chromosomal anomalies	Unweighted	2.0124	-17.1261	4.7591	4.7617	.1427	2.0359	.0000	.9490
	Log(10)	1.9567	-8.8550	3.8296	3.8384	.1300	1.6907	.0000	.7853
	Square Root	1.9091	-4.1499	2.9935	3.0047	.1187	1.4099	.0000	.6531
	Fully-wgtd.	1.8273	1.5649	2.0039	2.0039	.1463	2.1415	.0000	.9994
Congenital anomalies	Unweighted	28.2671	53.1675	25.0865	24.5347	.2530	6.4010	4.3514	3.1230**
	Log(10)	27.7806	68.2228	21.9362	21.5775	.2306	5.3165	3.2432	2.5642**
	Square Root	27.2878	145.1566	18.2189	17.9741	.2181	4.7555	2.6698	2.2801**
	Fully-wgtd.	27.0898	175.9276	13.5644	13.2885	.2467	6.0842	4.0277	2.9585**

TABLE 9 (continued)

VARIABLE	TYPE OF WEIGHTING	MEAN	INTERCEPT VALUE	STANDARD DEVIATION	STANDARD ERROR	MULTIPLE R	MULTIPLE R-SQUARE PER CENT	ADJUSTED R-SQUARE PER CENT	F-RATIO FOR R-SQUARE
Major anomalies	Unweighted	21.8319	2.1828	19.7944	19.1366	.2922	8.5387	6.5359	4.2634**
	Log(10)	21.4571	22.6626	17.7063	17.2166	.2735	7.4810	5.4550	3.6926**
	Square Root	20.9822	72.5735	14.8180	14.5105	.2482	6.1626	4.1078	2.9991**
	Fully-wgtd.	20.6488	96.4496	10.9744	10.7530	.2460	6.0516	3.9943	2.9416**
Minor anomalies	Unweighted	6.4351	50.9895	10.2648	10.1834	.1921	3.6884	1.5794	1.7489
	Log(10)	6.3234	45.5652	8.3933	8.3853	.1526	2.3291	.1903	1.0890
	Square Root	6.3056	72.5879	6.7436	6.6844	.1963	3.8540	1.7486	1.8305*
	Fully-wgtd.	6.4408	79.4781	4.9560	4.7627	.3103	9.6280	7.6490	4.8652**
Central nervous system defects	Unweighted	2.3125	7.4071	4.1813	4.1468	.1936	3.7498	1.6422	1.7791*
	Log(10)	2.3112	8.9093	3.7842	3.7544	.1919	3.6824	1.5732	1.7459
	Square Root	2.2870	14.8164	3.1154	3.0927	.1888	3.5662	1.4545	1.6888
	Fully-wgtd.	2.3118	12.6967	2.1840	2.1490	.2292	5.2544	3.1796	2.5326**
Heart defects	Unweighted	4.9757	9.5225	6.1269	6.0975	.1755	3.0798	.9575	1.4511
	Log(10)	5.0704	11.8802	5.7063	5.6820	.1725	2.9762	.8516	1.4008
	Square Root	5.1780	23.7546	4.9666	4.9306	.1886	3.5587	1.4468	1.6851
	Fully-wgtd.	5.3954	28.3944	3.8619	3.7692	.2605	6.7845	4.7433	3.3237**
Musculoskeletal defects	Unweighted	7.8740	-9.1620	9.4364	9.2270	.2538	6.4389	4.3902	3.1428**
	Log(10)	7.7790	-3.5389	8.3248	8.1751	.2373	5.6308	3.5643	2.7248**
	Square Root	7.8220	12.5166	7.0767	6.9336	.2462	6.0624	4.0053	2.9471**
	Fully-wgtd.	8.1600	32.3502	5.5455	5.2970	.3274	10.7168	8.7617	5.4814**

* significant at $p < .05$.
** significant at $p < .01$.

when significant, the adjusted per cents of variance accounted for are at modest levels, ranging up to a maximum of 8.76% for musculoskeletal defects under the fully-weighted scheme. Unlike the vital records variables, there is no discernible pattern for the subset from the BDR with respect to the four weighting schemes. Given the general absence of consistent findings from studies of birth defects at the individual-case level as noted earlier, it is hardly surprising that results for such outcomes at the social-area level would demonstrate a similar lack of strong findings.

E. PARTIAL REGRESSION RESULTS

The principal focus of this correlational study is on the significance and magnitude of exposure-outcome relationships after removing the predictive influences of the sociodemographic variables. Using well-known matrix algebraic formulations (Anderson, 1958), the computation of prediction equations from the multiple regression analyses permits the calculation of several partial correlation matrices among residual variables. For a typical residual variable, the value for a typical observation accounts for the influences of the independent variables by subtracting the predicted value from the observed value of a dependent variable. This section begins by presenting partial correlations within the subsets of outcome (dependent) variables as well as between the exposure and outcome variables before describing those between the exposure and outcome variables controlling for the influences of the twelve sociodemographic (independent variables that are of particular interest.

E.1 PARTIAL CORRELATIONS FOR THE SUBSETS OF OUTCOME (DEPENDENT) VARIABLES

The partial correlations among the dependent variables are of interest because they deal with issues of overlap among outcome variables after the influences of the independent (sociodemographic) variables have been removed. Appendices P and Q of this report list them for the variables derived from vital records and the BDR, respectively. The partial correlations between these two subsets are given in Appendix R.

Partial Correlations Within Vital Records Variables. Despite the large proportions of variance explained by the regressions of the twelve sociodemographic variables on the vital records dependent variables, the partial correlations in Appendix P are still substantial and reflect the general persistence of overlap among those outcomes. Of the 112 off-diagonal correlations (28 for each of 4 weighting schemes), 50 are significant at the $p<.01$ level, while an additional 19 are significant at $p<.05$. Although more of the variable-pairs fail to attain statistical significance after partialling than was true for the simple correlations (43 vs. 10), the non-significant values are still concentrated among the correlations involving post-neonatal and fetal deaths.

In addition, it may be observed that all of the significant values in Appendix P are less than the corresponding simple correlation found in Appendix C of the Phase I report (Fulcomer et al., 1992b). Thus, while considerable overlap among the outcomes still remains, the regressions of the twelve sociodemographic variables do remove some redundant covariation. Second, in contrast to the simple correlations for which the fully-weighted scheme has the highest value for each the 28 variable-pairings, the full weighting produces the largest partial correlation in only 7 of the pairs. This indicates that the twelve sociodemographic variables may account for some important components of "size-related" covariation. Finally, the residual values for prematurity and small-for-gestational-age are uncorrelated with one another, as would be expected after controlling for the sociodemographic variables, but still have significant predictive validity with respect to the rates of neonatal deaths.

<u>Partial Correlations Within Birth Defects Registry Variables</u>. Appendix Q of this report lists the partial correlations among the variables derived from the BDR after controlling for the twelve sociodemographic variables. Given the generally low proportions of variance explained in these outcomes by the regressions of the independent variables (see Table 8), the similarity of these values to the simple correlations found in Appendix D of the Phase I report is not surprising. Of the 312 off-diagonal partial correlations (78 for each of 4 weighting schemes), 206 are still significant (172 at the 1% level and an additional 34 at the 5% level).

<u>Partial Correlations Between Vital Records and Birth Defects Registry Variables</u>. The partial correlations between the eight vital records variables and the thirteen rates derived from the BDR are given in Appendix R of this report. Of the 416 correlations (8x13 = 104 for each of 4 weighting schemes), 110 are significant (71 at the $p<.01$ level and an additional 39 at $p<.05$). Although there are fewer significant correlations among variable-pairs after controlling for the twelve sociodemographic variables (i.e., 138 of the simple correlations in Appendix E of the Phase I report were significant), a substantial amount of overlap between the two subsets of outcomes still

remains. Because previous literature at the individual-level of analysis would lead us to expect some associations between these sets of outcomes, some of the correlations are of particular interest with respect to predictive validity of geographically-based data such as that used here, most notably those between the chromosomal anomalies (both the overall category and Down Syndrome which comprises the majority of reported chromosomal anomalies) and the rates of post-neonatal deaths as well as those between central nervous system defects, all congenital anomalies, and major congenital anomalies with the rates of neonatal deaths. Thus, even after controlling for several possible socioeconomic factors, selected birth defects contribute significantly to explaining rates of subsequent infant deaths at the municipality-level of analysis.

E.2 PARTIAL CORRELATIONS BETWEEN THE OUTCOME AND EXPOSURE VARIABLES

This section describes the exposure-outcome partial correlations between the two subsets of dependent variables and the three subsets of exposure variables. Because the significant relationships are presented here, the complete tables of partial correlations are listed in the appendices of this report. Note that the calculation of partial correlations means that all pairs of correlations have the influences of the twelve sociodemographic (sociodemographic) variables removed from <u>both</u> the exposure and outcome variables.

<u>Partial Correlations With Toxic Waste Site Variables</u>. Appendices S and T of this report provide the partial correlations between the four toxic waste site variables and the dependent variables based on vital records and BDR

TABLE 10

Significant Exposure-Outcome Partial Correlations Involving Toxic Waste Variables: New Jersey 1985 to 1987

Outcome	Exposure	Weighting	Correlations: Simple	Correlations: Partial
Preterm births percent	CERCLIS-density (Sites per square mile)	Unweighted	.1489**	.0235
		Log(10)	.2102**	.0532
		Square Root	.3607**	.0978*
		Fully-weighted	.5743**	.1584**
Low birthweight rate	CERCLIS-density (Sites per square mile)	Unweighted	.1266**	-.0183
		Log(10)	.1857**	-.0031
		Square Root	.3505**	.0348
		Fully-weighted	.5984**	.1132*
Low birthweight rate	CERCLIS-presence (At least one site)	Unweighted	.0137	-.0957*
		Log(10)	.0335	-.1013*
		Square Root	.0965*	-.0952*
		Fully-weighted	.1712**	-.0573
Limb reduction deformities rate	NPL-density (Sites per square mile)	Unweighted	.1151**	.1054*
		Log(10)	.1260**	.1170**
		Square Root	.1307**	.1245**
		Fully-weighted	.1202**	.1209**
Limb reduction deformities rate	CERCLIS-density (Sites per square mile)	Unweighted	.1138**	.1111*
		Log(10)	.1138**	.1142*
		Square Root	.1027*	.1138*
		Fully-weighted	.0944*	.1164**
Musculoskeletal	NPL-density (Sites per square mile)	Unweighted	.0321	.0276
		Log(10)	.0505	.0419
		Square Root	.0702	.0610
		Fully-weighted	.0942*	.0929*

* significant at $p < .05$, two-tailed.
** significant at $p < .01$, two-tailed.

information, respectively, while Table 10 summarizes the subset of significant relationships. Although 40 of the earlier simple correlations involving vital records variables found in Appendix J of this report were significant, only 6 of the partial correlations in Appendix S remain significant (1 at the 1% level and an additional 5 at the 5% level). That is, controlling for the independent (sociodemographic) variables virtually eliminated associations between the exposure and outcome variables. Although the significant correlations that remain were addressed by some previous findings in the literature that were reviewed in the first chapter, only the three relationships with CERCLIS-density (two with preterm births percent and one with low birthweight rate) are in the expected positive direction; that is, the three significant correlations involving CERCLIS-presence and low birthweight rate are negative.

Most of the partial correlations between the waste site and birth defects rates are also weak after accounting for the twelve independent (sociodemographic) variables. In particular, only nine of the 208 values in Appendix T are significant (4 at the 1% level and an additional 5 at the 5% level). Only 16 of the corresponding simple correlations in Appendix K of this report were also significant. However, after partialling, eight of the nine significant correlations that remain are concentrated within the pairings between the "dump-density" variables and the rates of reduction deformities. Furthermore, these significant partial correlations closely resemble their corresponding simple correlations, suggesting that controlling for the sociodemographic variables does not affect the rates of reduction deformities.

TABLE 11

Significant Exposure-Outcome Partial Correlations Involving Industrial Air Emissions Variables: New Jersey 1985 to 1987

Outcome	Exposure	Weighting	Correlations: Simple	Correlations: Partial
Preterm births percent	Human teratogens (Special-den. in pounds per square mile)	Unweighted	.1345**	.0830
		Log(10)	.1409**	.0881*
		Square Root	.1452**	.0827
		Fully-weighted	.1625**	.0842
Preterm births percent	Inorganics-density (pounds per square mile)	Unweighted	.0712	-.0265
		Log(10)	.0899*	-.0331
		Square Root	.1279**	-.0549
		Fully-weighted	.1678**	-.1302**
Low birthweight rate	Inorganics-density (pounds per square mile)	Unweighted	.0749	-.0231
		Log(10)	.0942*	-.0283
		Square Root	.1389**	-.0424
		Fully-weighted	.1911**	-.1028*
Low birthweight rate	Toxic emissions total (Air-density pounds per sq. mile)	Unweighted	.0624	-.0007
		Log(10)	.0667	-.0135
		Square Root	.0836	-.0405
		Fully-weighted	.1249**	-.0919*
Total infant death rate	Hydrocarbon-density (pounds per square mile)	Unweighted	.0778	.0719
		Log(10)	.0824	.0734
		Square Root	.0929*	.0760
		Fully-weighted	.1313**	.0930*

* significant at $p < .05$, two-tailed.
** significant at $p < .01$, two-tailed.

TABLE 12

Significant Exposure-Outcome Partial Correlations Involving Agricultural Pesticide Applications Variables: New Jersey 1985 to 1987

Outcome	Exposure	Weighting	Correlations	
			Simple	Partial
Very low birthweight rate	Herbicide-density (pounds per square mile)	Unweighted	.1047*	.0952*
		Log(10)	.0984*	.0950*
		Square Root	.0716	.0839
		Fully-weighted	.0035	.0506
Low birthweight rate	Herbicide-density (pounds per square mile)	Unweighted	.1276**	.1541**
		Log(10)	.1070*	.1432**
		Square Root	.0598	.1199**
		Fully-weighted	-.0152	.0715
Low birthweight rate	Phthalimide-density (pounds per square mile)	Unweighted	-.0427	-.0970*
		Log(10)	-.0384	-.0886*
		Square Root	-.0378	-.0801
		Fully-weighted	-.0545	-.0493

* significant at $p < .05$, two-tailed.
** significant at $p < .01$, two-tailed.

Partial Correlations With Industrial Air Emissions Variables. Appendices U and V of this report give the partial correlations between the industrial air emissions variables and the two subsets of dependent variables, while Table 11 lists the subset of significant relationships. Although the 65 significant simple correlations in Appendix L of this report had been suggestive of important exposure-outcome relationships, only 5 of the 256 partial correlations in Appendix U remain significant (1 at the 1% level and an additional 4 at the 5% level); based on the review of findings in the first chapter, none of these associations would have been expected. Similarly, Appendix V reveals the complete absence of significant partial correlations between the air emissions variables and the information derived from the BDR.

Partial Correlations With Agricultural Pesticide Applications Variables. Appendices W and X of this report contain the partial correlations between the agricultural pesticide applications variables and the dependent variables based on vital records and BDR information, respectively, while Table 12 presents the subset of significant relationships. Earlier, Appendices N and O of this report had shown a general lack of significance among the corresponding simple correlations. An inspection of the partial correlations reveals the persistent lack of association after controlling for the twelve sociodemographic variables. Of the 192 partial correlations involving vital records variables given in Appendix W, only 7 are significant (3 at the 1% level and an additional 4 at the 5% level), all involving either low or very low birthweights and the application of herbicides, although these associations would not have been expected from any previous results available to us. None of the partial correlations in Appendix X between the pesticide exposures and the information from the Birth Defects Registry are significant.

IV. DISCUSSION

This chapter reviews and discusses the major results of this correlational study. The first section presents some issues of statistical analysis and interpretation for an ecologic study using several different sets of variables at the municipality level. Then, a summary of the exposure-outcome relationships appears in the second section, followed by a discussion of other results and issues in the third section.

A. ISSUES OF STATISTICAL ANALYSIS AND INTERPRETATION

This report employs a true "ecological" design in which both the exposure and outcome variables involve aggregated data and at least two major statistical issues arise from the use of geographic units (i.e., the county/ municipalities used here) in such a study. The first is the weighting of each unit's contribution to the estimation of the parameter(s) of interest when the units vary widely in the size of their populations. A second issue is the potential similarity of adjacent units or among communities in close proximity, sometimes referred to as "spatial autocorrelation" (Wartenberg, 1985).

Similarly, there are at least two major issues of interpretation that arise in the ecologic study of numerous variables estimating environmental exposures to toxic wastes and adverse reproductive outcomes. The first is the so-called "multiple comparisons" problem when two or more results are evaluated in a non-independent fashion in the same study. The second is the potential occurrence of bias in ecologic studies.

A.1 WEIGHTING

The present study has incorporated four simple alternative approaches for weighting the municipality-level used in this based on simple transformations of the number of live births. Definitions and some other salient aspects of the four weighting schemes were presented earlier in the second chapter.

Although a suitable resolution to the issue of how to best accomplish such weighting is beyond the scope of this report, the complete set of results for all four methods used in this study is intended to draw attention to the need to account for wide variations in the number of births among geographic units. In general, the two extreme approaches to weighting fail to properly account for the amounts of sampling variability, with underestimation by the equally-weighted (i.e., unweighted) method and severe overestimation by the fully-weighted scheme. The two middle strategies do not suffer such obvious shortcomings, but perform well enough and have sufficient theoretical merits to be more satisfactory. Because of its similarity to weighting by the inverse of the standard deviation and its performance for the vital records variables, the square root transformation may provide a computationally attractive approach to this issue until the identification of a <u>single</u> optimal method (e.g., Pocock et al., 1981 and Breslow, 1984) can be better understood and successfully implemented. However, additional analyses of the distribution of population size using methods of Tukey (e.g., see Mosteller and Tukey, 1977) may lead to weighting by logarithms being the most preferable methods for similar studies.

A.2 SPATIAL AUTOCORRELATION

In general, one would expect that communities in close proximity would be similar in social indicators, including patterns of disease outcomes even after various risk factors have been taken into account, when compared to geographic units that are widely separated. Thus, the underlying assumption of statistical independence among the analytic units included in the regression analyses may not be tenable. The usual consequence of positive spatial autocorrelations is to inflate the values of the coefficients of determination and the associated tests of statistical significance, in large part because of the tendency for ecologic studies to understate the lack of fit for a model (Cliff and Ord, 1981).

Because positive spatial autocorrelations were expected, the interpretation of statistically significant results has been approached with considerable caution. In particular, special care has been given to evaluating the magnitudes of the R^2's, sometimes referred to as "effect sizes" (Hays, 1973; Cohen and Cohen, 1983).

A.3 MULTIPLE COMPARISONS

Given the large number of exposure-outcome partial correlations to be evaluated in this study (nearly 400 for each of four weighting schemes), several significant associations would be expected "by chance", sometimes referred to as "multiple comparisons" (e.g., Winer, 1971). Under a null hypothesis of underlying independence among the members of an entire set of variables, the alpha-level (i.e., the level of significance selected in advance) would set a minimum lower bound for the number of significant correlations "expected by chance"; for the 400 or so values in the present study, such a minimum would be approximately four or 20 correlations per weighting scheme, depending on whether or not the alpha-level was set at the $p<.01$ or $p<.05$ levels, respectively. Therefore, additional caution in interpreting results is merited. A priori hypotheses utilizing evidence from previous environmental and occupational studies, as well as available toxicologic data, should be considered and attempts made to find support for the biological plausibility of new findings. Unfortunately, the rudimentary level of knowledge concerning the effects of exposures to environmental pollutants on reproduction and the lack of comparable ecologic studies made it unsuitable to state a priori hypotheses, including specifications of the direction and magnitude of relationships. In turn, this made much of the present study exploratory and led to the use of two-tailed tests of significance for the partial correlations. Therefore, in order that other researchers may benefit from any preliminary findings reported here, all exposure-relevant correlations evaluated in this study are listed (Thomas et al., 1985).

A.4 ECOLOGICAL BIAS

Ecological bias involves the tendency to severely overestimate the magnitude of associations when aggregated units such as counties or municipalities are employed in an analysis (Piantadosi, et al., 1988). As a result, associations found at the aggregate or group level of analysis may not be replicated at the individual level (Morgenstern, 1982). Some of this bias may be the result of confounding by the geographic units themselves, such as variations in the rate of a disease across municipalities due to the differential distribution of extraneous risk factors (Greenland and Morgenstern, 1989).

Another source of ecological bias occurs when an environmental effect is modified by (or, "interacts with") the units of analysis. For example, in the present study the exposure-outcome effects may vary across municipalities depending on the values of some other individual-level effect modifiers influenced by differences in socioeconomic status. Unfortunately, the general lack of information on effect modifiers makes it difficult to address this source of bias.

Ecological bias will not occur if the background rate of a disease, as well as the effects of the exposures of interest, do not vary across the geographic units <u>and</u> if there is no confounding at the individual level (Greenland and Morgenstern, 1989). But, in the present study it is reasonable to assume that <u>some</u> ecological bias is present, thereby adding another reason to interpret the size of relationships with special caution.

<u>Exposure misclassification</u>. There is also a countervailing tendency for the magnitudes of exposure-outcome relationships to be "attenuated" (i.e., deflated) by unreliability and other measurement problems, often referred to as exposure misclassification, although these problems are quite difficult to

document. Because the environmental variables used in the present study were, at best, extremely crude surrogates of actual population exposures, it is expected that some of the exposure-outcome partial correlations would be adversely affected. In fact, given the ecologic nature of this study, particularly the process of assigning a single exposure measure to a municipality, exposure misclassification may well comprise the greatest barrier to observing underlying associations in this report.

B. REVIEW OF EXPOSURE-OUTCOME RELATIONSHIPS

Throughout this report we have emphasized the need to control for the influences of some background sociodemographic characteristics before any potential exposure-outcome relationships were evaluated. Unfortunately, variations in measuring exposures and outcomes across different studies make it extremely difficult to directly compare findings to results previously reported by other investigators. In particular, many previous studies in this area have been "semi-ecological"; that is, while the exposure surrogates often refer to geographic areas, the outcome data are derived directly from observations or interviews at the individual level.

B.1 PARTIAL CORRELATIONS WITH TOXIC WASTE SITE VARIABLES

Table 10 in the prior chapter has summarized the significant partial correlations between the four toxic waste site variables and the outcome variables derived from vital records and BDR information, respectively. Six of the 128 partial correlations involving the toxic waste site variables and vital records variables are significant. Three of these six relationships are significant and positive (i.e., two involving preterm births percents and one involving low birthweight rate, each correlated with the density of all toxic waste sites). Although the partials are substantially lower than the corresponding simple correlations and are not consistent across the four weighting schemes, they are at least consistent with expectations based on previous studies at the individual level (Viana and Polan, 1984; NJDOH, 1989). The significant partial correlations for all but the fully-weighted scheme between the low birthweight rate and the presence of at least one CERCLIS site are negative and are not consistent with earlier findings from other studies.

In contrast, of the 208 partial correlations involving the toxic waste site variables and the BDR variables, the eight significant positive associations for the limb reduction deformities rate and the NPL- and CERCLIS-density variables (i.e., the correlations were significant for all four weighting schemes) represent a new finding that bears some resemblance to earlier findings based on other exposures (e.g., Schwartz and LoGerfo, 1988). The similarity of the simple and partial correlations indicate the independence between the limb reductions and the background variables and, along with the results for all four weighting schemes, suggests that elevations in this type of outcome may have some association with high exposure-density areas throughout the state, regardless of the number of births. However, while significant, the relationships are quite "weak" (generally accounting for slightly over 1% of the residual outcome variances) and, therefore, should be interpreted with considerable caution. In addition, since site density is one of the crudest of the exposure surrogates employed in this study and since no specific human exposure pathways have been identified, much work to establish biological plausibility would be required.

Despite the extremely crude nature of the exposure surrogates, these results for the toxic waste site variables provide some encouraging evidence that the methods employed in this study may be sufficiently sensitive to detect some elevations in outcomes. However, this initial optimism regarding the current method is balanced by the realization that the partial correlations, even when significant, are relatively small and that three of the values are in the opposite direction to that expected. Nonetheless, much like the efforts in the project's first phase to enhance the reporting of the adverse reproductive outcomes with only modest investments of resources (Fulcomer et al., 1992b), improving the quality of exposure measurements would increase reliability and tend to make future studies more sensitive, including the case-control and cross-sectional studies of individual-level data in this project's fourth phase (Bove et al., 1992a and 1992b). Given the relatively low proportions of variance in these variables explained by the socio-demographic variables, prioritization of efforts in this area following the suggestions listed in the Phase II report (Bove, 1992) should lead to substantial progress and be well within the financial resources available to NJDEP. Although the acquisition of even better measures would be an expensive undertaking, it would address the tendency of attenuated findings (or "bias towards the null") to result from exposure misclassifications.

The limb reduction finding is currently being explored further for some other, non-exposure explanation to the elevations among the approximately 136 cases affected in the three-year period before embarking on an extensive case-control study. This new finding is particularly interesting because of its consistency across all four weighting schemes and because of the specific teratogen-malformation relationship with thalidomide. Extraction of records for these and subsequent cases from the BDR and the maternity hospitals has been completed.

B.2 PARTIAL CORRELATIONS WITH INDUSTRIAL AIR EMISSIONS VARIABLES

In the last chapter, Table 11 summarized the significant partial correlations between the eight industrial air emissions and the outcome variables derived from vital records and BDR information, respectively. Two of the significant relationships (between special-density and preterm births percent and between hydrocarbon-density and total infant death rate) are positive and the other three significant partial correlations are negative and occur only under the fully-weighted scheme, strongly suggesting underlying independence (i.e., possibly results due to multiple comparisons). Given the disproportionate number of births and air emissions in some communities in northern New Jersey (e.g., Newark with 5.33% of the total births and 5.66% of the total air emissions in the state), the fully-weighted scheme may be subject to statistical artifacts with respect to the air emissions variables as employed in this study. In addition, each partial correlation in Table W is lower than its corresponding simple correlation.

Unfortunately, as pointed out in this report as well as in that for the project's second phase (Bove, 1992), the primitive nature of the available air emissions data for estimating population exposures may contribute to the failure to detect a higher level of positive associations for these variables through the serious problem of exposure misclassification. In particular, values assigned to the geographic units from which the emissions are reported are of unknown reliability as indicators of actual exposures of individuals, especially since only 211 of the municipalities reported any industrial emissions. Potential exposure misclassification may be especially severe in the northern portion of the state, where the population densities are the highest in the nation but where some municipalities with no reported emissions are in close proximity, often downwind, to sources of large pollutant emissions. Although their development and implementation may be expensive, computer simulation techniques to develop more refined exposure estimates may merit consideration for inclusion in future studies.

B.3 PARTIAL CORRELATIONS WITH AGRICULTURAL PESTICIDE APPLICATIONS VARIABLES

Table 12 given in the results chapter has summarized the significant partial correlations between the six agricultural pesticide variables and the outcome variables derived from vital records and BDR information, respectively. The two significant correlations between low birthweight rates and phthalimide-density are negative. In contrast, the significant positive correlations between herbicide-density and very low birthweight rates (for the unweighted and logarithmic schemes) and between herbicide-density and low birthweight rates (for all but the fully-weighted scheme) may merit consideration in future investigations.

Unfortunately, the pesticide variables are also crude exposure surrogates and likely to be unreliable indicators of actual exposures. For example, agricultural activity in New Jersey is concentrated in the less-densely populated southern portion of the state and 314 of the municipalities report no agricultural pesticide applications at all. However, many municipalities in the state, including several in northern New Jersey with no agricultural applications, are affected by commercial and residential pesticide applications which are not covered in the Pesticide Survey. Again, future studies may benefit from computer simulation techniques and improved quality and breadth of exposure information collected, although the cost of such enhancements should be carefully considered before extensive new efforts are undertaken.

C. SOME ADDITIONAL OBSERVATIONS

Building on earlier work of the project's first and second phases to improve the quality of outcome and environmental data, respectively (Fulcomer et al., 1992b and Bove, 1992), this study has applied well-known and widely-available analytic procedures to some newly-emerging data on environmental exposure-surrogates and adverse reproductive outcomes in New Jersey's municipalities. Some of the study's other features, notably the use of four different weighting schemes to account for wide variations in the number of births among geographic areas, were included to draw attention to some important issues to be considered in future studies.

However, the results obtained in this third phase have led to only a few environmentally-related findings that may merit further consideration and investigation, despite other work throughout the project. More importantly, as pointed out earlier, the necessity to employ crude exposure surrogates and the use of large geographic areas may have contributed to the failure to detect more statistically significant elevations in this ecologic study. Such reliability problems with the exposure data, especially with substances for which some potentially harmful effects have been noted in the literature, is quite problematic in that, in light of the associated "bias towards to the null", the failure to detect "positive" results is unlikely to reassure the public that the true, but unknown, partial correlations between exposures and outcomes are precisely zero.

Reliability and stability problems among the outcome variables may have also made it more difficult to detect positive associations. Although there is general temporal stability in the rates of the birthweight and other outcomes with higher prevalences, some of the rarer outcomes such as specific birth defects may be considerably less reliable and, thus, may have also contributed to the attenuation of some results. Clearly, the temporal stability of all outcomes, including specific birth defects, needs to be addressed in future studies. [Ecologic designs such as the present study are well-suited to this purpose.] Furthermore, in contrast to fully-funded systems in Metropolitan Atlanta (Edmonds, 1981), California (CBDMP, 1988), and Iowa (Hanson et al., 1989), the somewhat passive nature of New Jersey's Birth Defects Registry may affect the ascertainment of some defects. Thus, while all occurrences of some more serious and obvious defects may be registered in certain locations (Fulcomer et al., 1988), some less-involved conditions, perhaps not so readily apparent at birth, may not be reported on a timely basis to be incorporated into a monitoring database.

Reliability issues with the exposures and outcomes notwithstanding, the regression results for the outcomes involving the vital records variables are noteworthy. In particular, all 32 of these proportions of variance explained in Table 4 are significant (31 at the 1% level and 1 at the 5% level) and substantial, ranging from 2.13% (for the unweighted scheme applied to the rate of fetal deaths) to an exceptionally high 86.68% (for the percent of preterm births under the fully-weighted scheme). Even for the unweighted scheme which tends to be the least explanatory of the four weighting strategies, the regression results provide considerable encouragement for the use of these outcomes for program planning and evaluation, particularly in designing interventions to encourage early prenatal care to improve birthweight and other, related pregnancy outcomes. The forthcoming availability of the 1990 census results and efforts to improve the quality of New Jersey's vital records (Fulcomer et al., 1992b) should enhance future efforts to employ these outcomes.

Despite some appropriate enthusiasm for using the predictive results to monitor existing programs as well as locate new interventions, it is imperative to reiterate the caution of "overfitting" that may result from the use of aggregated geographic units in the analyses (Fulcomer et al., 1981). Moreover, the "ecologic fallacy" (i.e., inferring from social-area results to the level of individuals) should generally be avoided, but most certainly in environmental studies in geographic areas in which individuals who are "exposed" may be different than those individuals who are affected by health outcomes. If available for <u>both</u> environmental and outcome data, the use of geographically-based data for areas smaller than municipalities (e.g., for census tracts or blocks) might help address this problem, although such an approach might also be unduly expensive.

In contrast to the outcome variables derived from vital records, the regression results for the variables from the Birth Defects Registry found in

Table 5 are much weaker. Undoubtedly, some of this weakness in the failure to detect positive associations reflects reliability problems in these outcomes, especially with respect to temporal stability. However, the lack of findings may more accurately portray some general difficulties inherent in understanding the underlying causes of birth defects. Certainly, the lack of a consistent body of research findings, even those derived from much more detailed case-control designs rather than from correlation studies, illustrates the problems in researching those risk factors associated with birth defects. Thus, despite a few new findings, the present study appears to mirror the current lack of definitive results. It is hoped, however, that our methods and findings will be helpful to future efforts to understand environmental causes of adverse reproductive outcomes.

V. SUMMARY

This report has described in detail the activities undertaken in the third phase of a cooperative agreement between the New Jersey Department of Health (NJDOH) and the U.S. Centers for Disease Control (CDC). The overall goal of the project was to develop and apply appropriate methodology to assess relationships between adverse reproductive outcomes (AROs) and population exposures to environmental pollutants, particularly toxic waste site contamination. Rather than a rigorous exploration of specific hypotheses about exposure-outcome relationships, the work on the the third phase comprised a demonstration of the potential uses and limitations in employing data on environmental exposure surrogates and health outcomes, aggregated at the municipality level of analysis, to investigate possible associations as an early step in identifying preventable hazards.

This report has linked surveillance data from the 327,015 live births and 3,548 fetal deaths (stillbirths) that occurred to New Jersey residents from 1985 through 1987, derived from the project's first phase (Fulcomer et al., 1992b), with some data on environmental pollution that resulted from its second phase (Bove, 1992). By combining information from this large group of births with that on potential exposures and on other sociodemographic attributes available on geographic areas, it was hoped that such timely correlational analyses might provide early, inexpensive alternatives to case-control studies to explore recently emerging questions of possible exposure-outcome relationships. Because other states may already be collecting such data as part of routine environmental and outcome surveillance programs, this report, as well as those for the project's first and second phases, may be of special interest to others considering replication of the methods and results presented here.

The first chapter described selected results from some previous studies of environmental pollution and AROs, derived mostly from studies at the individual level because there have been few population-based studies of exposures and outcomes reported for geographic areas. Although our review indicated a lack of uniformity of reported findings, several suggestive relationships provided a rationale for pursuing correlational analyses of linked data as a first step in better understanding associations between exposures and outcome.

Methods and data employed in the analyses were described in the second chapter. After first describing simple (i.e., unadjusted) correlations, the analytic methods used here relied heavily on multiple and partial regression techniques to control for selected background variables before evaluating potential associations between environmental exposures and adverse reproductive outcomes. Considerable emphasis was given to the problem of how to "weight" the data to account for differences among the municipalities with respect to the number of births, which ranged from 6 to 17,439 in the three years covered by this study.

The third chapter presented some results of multiple regression and partial regression analyses of the exposures and outcomes controlling for the sociodemographic characteristics. In addition, complete sets of many intermediate statistical results such as simple (i.e., unadjusted) correlations are described. There are six distinct groupings of information covered in the total of 51 variables included in the analyses, including the twelve sociodemographic characteristics treated as independent variables, three subsets of data on environmental exposures (toxic waste sites, industrial air emissions, and agricultural pesticide applications), and two subsets of data on AROs derived from different reporting sources (vital records and the Birth Defects Registry).

Results are discussed in the fourth chapter, which begins by addressing some important analytic and interpretational issues. Among the four issues addressed are the widely-acknowledged possibility of bias in such ecologic studies, the related limitations and cautions in making causal inferences about individuals from results aggregated at the municipality level (i.e., the "ecologic fallacy"), spatial autocorrelations, and multiple comparisons. In general, controlling for the sociodemographic variables virtually eliminated significant partial correlations between the exposure and outcome variables, so that only a few findings may merit further consideration and investigation. Only six of the 128 partial correlations involving toxic waste site variables and the outcomes derived from vital records were significant, and only three of those associations were positive and consistent with previous results. Similarly, most of the partial correlations between the toxic waste site and birth defects rates were also weak after accounting for the twelve sociodemographic variables. However, after partialling, eight of the nine significant correlations that remain (out of a total of 208) were concentrated within the pairings involving the rates of limb reductions. Very few significant partial correlations were found between the outcomes and the industrial air emission variables (five of 256 for the outcomes derived from vital records and none for the rates of birth defects) or the agricultural pesticide applications variables (seven of 192 for outcomes derived from vital records and none for the rates of birth defects).

Although there are some reliability and stability issues to be dealt with in future work with AROs, the regression results for the outcomes involving the vital records variables are noteworthy, ranging from 2.13% to an exceptionally high 86.68%. In contrast, the regression results for the variables from the Birth Defects Registry were much weaker. The necessity of employing crude exposure surrogates and the use of large geographic areas may have contributed to the failure to detect more statistically significant elevations in birth defects in this ecologic study. Clearly, future work, including the studies dealing with individual cases undertaken as part of the project's fourth phase (Bove et al., 1992a and 1992b), would benefit greatly if the quality of relevant environmental databases were improved.

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APPENDICES

APPENDIX A

Correlations Within The Subset Of Toxic Waste Site Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
NPL-density	Unweighted	1.0000	.4244	.4997	.1763
	Log(10)	1.0000	.3946	.4934	.1711
	Square Root	1.0000	.3245	.4698	.1606
	Fully-wgtd.	1.0000	.2168	.4472	.1469
CERCLIS-density	Unweighted	.4244	1.0000	.2114	.4326
	Log(10)	.3946	1.0000	.2042	.4201
	Square Root	.3245	1.0000	.2336	.3984
	Fully-wgtd.	.2168	1.0000	.3573	.3656
NPL-presence	Unweighted	.4997	.2114	1.0000	.3527
	Log(10)	.4934	.2042	1.0000	.3468
	Square Root	.4698	.2336	1.0000	.3419
	Fully-wgtd.	.4472	.3573	1.0000	.3285
CERCLIS-presence	Unweighted	.1763	.4326	.3527	1.0000
	Log(10)	.1711	.4201	.3468	1.0000
	Square Root	.1606	.3984	.3419	1.0000
	Fully-wgtd.	.1469	.3656	.3285	1.0000

APPENDIX B

Correlations Within The Subset of Industrial Air Emissions Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Air-density	Unweighted	1.0000	.6690	.7167	.0231	.2263	.5303	.3038	.3242
	Log(10)	1.0000	.6267	.6750	.0249	.2319	.4963	.2804	.3015
	Square Root	1.0000	.5596	.6065	.0319	.2410	.4493	.2486	.2731
	Fully-wgtd.	1.0000	.5133	.5575	.0577	.2512	.4286	.2275	.2623
Teratogen-density	Unweighted	.6690	1.0000	.9405	.0167	.2031	.8103	.4127	.4307
	Log(10)	.6267	1.0000	.9372	.0194	.2288	.8024	.4055	.4258
	Square Root	.5596	1.0000	.9356	.0307	.2801	.7974	.3988	.4270
	Fully-wgtd.	.5133	1.0000	.9381	.0720	.3319	.8006	.3847	.4308
Solvent-density	Unweighted	.7167	.9405	1.0000	.0265	.2018	.7325	.3970	.4154
	Log(10)	.6750	.9372	1.0000	.0309	.2261	.7270	.3910	.4115
	Square Root	.6065	.9356	1.0000	.0459	.2773	.7340	.3920	.4217
	Fully-wgtd.	.5575	.9381	1.0000	.0954	.3326	.7662	.3980	.4522
Special-density	Unweighted	.0231	.0167	.0265	1.0000	.0377	.0077	.0819	.0657
	Log(10)	.0249	.0194	.0309	1.0000	.0431	.0115	.0794	.0630
	Square Root	.0319	.0307	.0459	1.0000	.0653	.0236	.0748	.0608
	Fully-wgtd.	.0577	.0720	.0954	1.0000	.1210	.0596	.0753	.0705
Inorganics-density	Unweighted	.2263	.2031	.2018	.0377	1.0000	.2376	.1709	.2858
	Log(10)	.2319	.2288	.2261	.0431	1.0000	.2580	.1860	.2964
	Square Root	.2410	.2801	.2773	.0653	1.0000	.2868	.2187	.3151
	Fully-wgtd.	.2512	.3319	.3326	.1210	1.0000	.3016	.2576	.3330
Hydrocarbon-density	Unweighted	.5303	.8103	.7325	.0077	.2376	1.0000	.2371	.2667
	Log(10)	.4963	.8024	.7270	.0115	.2580	1.0000	.2256	.2587
	Square Root	.4493	.7974	.7340	.0236	.2868	1.0000	.2121	.2526
	Fully-wgtd.	.4286	.8006	.7662	.0596	.3016	1.0000	.2091	.2666
Halogen-density	Unweighted	.3038	.4127	.3970	.0819	.1709	.2371	1.0000	.9120
	Log(10)	.2804	.4055	.3910	.0794	.1860	.2256	1.0000	.9173
	Square Root	.2486	.3988	.3920	.0748	.2187	.2121	1.0000	.9294
	Fully-wgtd.	.2275	.3847	.3980	.0753	.2576	.2091	1.0000	.9435
Carcinogen-density	Unweighted	.3242	.4307	.4154	.0657	.2858	.2667	.9120	1.0000
	Log(10)	.3015	.4258	.4115	.0630	.2964	.2587	.9173	1.0000
	Square Root	.2731	.4270	.4217	.0608	.3151	.2526	.9294	1.0000
	Fully-wgtd.	.2623	.4308	.4522	.0705	.3330	.2666	.9435	1.0000

APPENDIX C

Correlations Within The Subset of Agricultural Pesticide Applications Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Pesticide-density	Unweighted	1.0000	.6838	.9155	.7799	.2779	.7456
	Log(10)	1.0000	.6632	.9210	.8129	.2815	.7817
	Square Root	1.0000	.6603	.9264	.8255	.2880	.7979
	Fully-wgtd.	1.0000	.6762	.9304	.8128	.3233	.7875
Phthalimide-density	Unweighted	.6838	1.0000	.6574	.4284	.0622	.3107
	Log(10)	.6632	1.0000	.6430	.4379	.0788	.3222
	Square Root	.6603	1.0000	.6408	.4372	.1054	.3238
	Fully-wgtd.	.6762	1.0000	.6495	.4295	.1650	.3143
Organophosphates-density	Unweighted	.9155	.6574	1.0000	.8231	.0988	.7564
	Log(10)	.9210	.6430	1.0000	.8330	.1197	.7649
	Square Root	.9264	.6408	1.0000	.8296	.1532	.7540
	Fully-wgtd.	.9304	.6495	1.0000	.8119	.2273	.7163
Carbamate-density	Unweighted	.7799	.4284	.8231	1.0000	.1130	.8988
	Log(10)	.8129	.4379	.8330	1.0000	.1347	.9001
	Square Root	.8255	.4372	.8296	1.0000	.1719	.8967
	Fully-wgtd.	.8128	.4295	.8119	1.0000	.2580	.8817
Herbicide-density	Unweighted	.2779	.0622	.0988	.1130	1.0000	.1036
	Log(10)	.2815	.0788	.1197	.1347	1.0000	.1227
	Square Root	.2880	.1054	.1532	.1719	1.0000	.1544
	Fully-wgtd.	.3233	.1650	.2273	.2580	1.0000	.2248
Halogens-density	Unweighted	.7456	.3107	.7564	.8988	.1036	1.0000
	Log(10)	.7817	.3222	.7649	.9001	.1227	1.0000
	Square Root	.7979	.3238	.7540	.8967	.1544	1.0000
	Fully-wgtd.	.7875	.3143	.7163	.8817	.2248	1.0000

APPENDIX D

Correlations Between The Subsets Of Toxic Waste Site And Industrial Air Emissions Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Air-density	Unweighted	-.0134	.2419	-.0193	.1370
	Log(10)	-.0160	.2540	-.0249	.1310
	Square Root	-.0223	.2739	-.0295	.1303
	Fully-wgtd.	-.0347	.2847	-.0221	.1372
Teratogen-density	Unweighted	-.0100	.1842	-.0103	.1495
	Log(10)	-.0117	.1928	-.0137	.1481
	Square Root	-.0179	.2150	-.0173	.1556
	Fully-wgtd.	-.0367	.2524	-.0176	.1752
Solvent-density	Unweighted	-.0151	.1872	-.0117	.1420
	Log(10)	-.0167	.1976	-.0125	.1397
	Square Root	-.0207	.2366	-.0022	.1498
	Fully-wgtd.	-.0309	.3275	.0415	.1786
Special-density	Unweighted	.0047	.0377	.0367	.0727
	Log(10)	.0024	.0458	.0180	.0698
	Square Root	-.0025	.0721	-.0013	.0695
	Fully-wgtd.	-.0110	.1303	-.0001	.0792
Inorganics-density	Unweighted	.0183	.1958	.0195	.0875
	Log(10)	.0113	.1995	.0019	.0860
	Square Root	-.0070	.1986	-.0302	.0967
	Fully-wgtd.	-.0403	.1772	-.0707	.1172
Hydrocarbon-density	Unweighted	.0062	.1299	.0087	.1222
	Log(10)	.0059	.1353	.0042	.1205
	Square Root	.0005	.1533	-.0028	.1261
	Fully-wgtd.	-.0134	.2044	.0076	.1426
Halogen-density	Unweighted	-.0219	.1300	.0012	.1315
	Log(10)	-.0241	.1371	-.0002	.1298
	Square Root	-.0272	.1494	.0034	.1321
	Fully-wgtd.	-.0294	.1573	.0176	.1341
Carcinogen-density	Unweighted	.0293	.1737	.0379	.1187
	Log(10)	.0287	.1825	.0354	.1181
	Square Root	.0229	.1969	.0357	.1233
	Fully-wgtd.	.0119	.2177	.0523	.1311

APPENDIX E

Correlations Between The Subsets Of Toxic Waste Site And Agricultural Pesticide Applications Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Pesticide-density	Unweighted	-.0096	.0161	.0004	.0427
	Log(10)	-.0050	.0122	.0048	.0484
	Square Root	.0043	-.0085	.0062	.0442
	Fully-wgtd.	.0207	-.0440	-.0002	.0298
Phthalimide-density	Unweighted	-.0204	-.0560	-.0202	.0057
	Log(10)	-.0179	-.0573	-.0189	.0123
	Square Root	-.0113	-.0626	-.0199	.0152
	Fully-wgtd.	.0006	-.0741	-.0247	.0120
Organophosphates-density	Unweighted	-.0003	-.0035	.0226	.0686
	Log(10)	.0057	-.0083	.0255	.0628
	Square Root	.0185	-.0267	.0248	.0461
	Fully-wgtd.	.0409	-.0603	.0127	.0189
Carbamate-density	Unweighted	-.0034	.0051	.0058	.0715
	Log(10)	.0001	.0003	.0046	.0622
	Square Root	.0094	-.0146	.0013	.0453
	Fully-wgtd.	.0289	-.0433	-.0054	.0199
Herbicide-density	Unweighted	-.0139	-.0307	-.0160	-.0267
	Log(10)	-.0128	-.0304	-.0133	-.0219
	Square Root	-.0091	-.0321	-.0091	-.0165
	Fully-wgtd.	.0014	-.0437	-.0028	-.0103
Halogens-density	Unweighted	-.0085	.0217	-.0154	.0461
	Log(10)	-.0078	.0182	-.0158	.0412
	Square Root	-.0048	.0075	-.0154	.0318
	Fully-wgtd.	.0022	-.0115	-.0146	.0182

APPENDIX F

Correlations Between The Subsets Of Industrial Air Emissions
And Agricultural Pesticide Applications Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Air-density	Unweighted	-.0320	-.0281	-.0399	-.0339	-.0173	-.0123
	Log(10)	-.0320	-.0281	-.0408	-.0350	-.0178	-.0125
	Square Root	-.0329	-.0291	-.0433	-.0371	-.0193	-.0123
	Fully-wgtd.	-.0362	-.0325	-.0491	-.0416	-.0253	-.0119
Teratogen-density	Unweighted	-.0319	-.0314	-.0393	-.0314	-.0159	-.0108
	Log(10)	-.0333	-.0331	-.0416	-.0335	-.0169	-.0111
	Square Root	-.0372	-.0372	-.0475	-.0386	-.0198	-.0111
	Fully-wgtd.	-.0452	-.0454	-.0591	-.0486	-.0289	-.0109
Solvent-density	Unweighted	-.0334	-.0278	-.0427	-.0357	-.0178	-.0124
	Log(10)	-.0343	-.0281	-.0449	-.0380	-.0188	-.0127
	Square Root	-.0376	-.0307	-.0507	-.0434	-.0218	-.0128
	Fully-wgtd.	-.0458	-.0390	-.0634	-.0543	-.0319	-.0130
Special-density	Unweighted	.0000	.0283	.0094	.0109	-.0079	-.0015
	Log(10)	.0001	.0343	.0072	.0093	-.0082	-.0023
	Square Root	-.0008	.0400	.0033	.0072	-.0092	-.0035
	Fully-wgtd.	-.0051	.0401	-.0049	.0027	-.0139	-.0059
Inorganics-density	Unweighted	-.0236	-.0313	-.0185	-.0242	-.0150	-.0091
	Log(10)	-.0252	-.0335	-.0216	-.0267	-.0161	-.0102
	Square Root	-.0299	-.0377	-.0300	-.0319	-.0190	-.0124
	Fully-wgtd.	-.0378	-.0430	-.0436	-.0396	-.0267	-.0158
Hydrocarbon-density	Unweighted	-.0261	-.0245	-.0332	-.0271	-.0134	-.0074
	Log(10)	-.0271	-.0253	-.0351	-.0289	-.0140	-.0070
	Square Root	-.0297	-.0278	-.0398	-.0330	-.0157	-.0056
	Fully-wgtd.	-.0357	-.0335	-.0496	-.0410	-.0214	-.0023
Halogen-density	Unweighted	-.0242	-.0216	-.0298	-.0263	-.0142	-.0110
	Log(10)	-.0251	-.0228	-.0317	-.0283	-.0151	-.0117
	Square Root	-.0272	-.0260	-.0356	-.0320	-.0175	-.0125
	Fully-wgtd.	-.0297	-.0304	-.0401	-.0368	-.0236	-.0127
Carcinogen-density	Unweighted	-.0216	-.0119	-.0281	-.0243	-.0135	-.0099
	Log(10)	-.0222	-.0118	-.0300	-.0264	-.0143	-.0106
	Square Root	-.0240	-.0135	-.0340	-.0303	-.0164	-.0113
	Fully-wgtd.	-.0267	-.0174	-.0393	-.0359	-.0223	-.0114

APPENDIX G

Correlations Between The Sociodemographic and Toxic Waste Site Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Mother's age	Unweighted	-.0168	-.2019	-.0346	-.1805
	Log(10)	-.0280	-.2345	-.0438	-.1934
	Square Root	-.0254	-.3446	-.0697	-.2337
	Fully-wgtd.	-.0013	-.5216	-.1150	-.2736
% Mothers > 35	Unweighted	-.0120	-.1563	-.0430	-.1712
	Log(10)	-.0362	-.1867	-.0545	-.1857
	Square Root	-.0470	-.2459	-.0737	-.2156
	Fully-wgtd.	-.0339	-.3541	-.0980	-.2591
% Mothers < H.S.	Unweighted	-.0072	.2094	.0286	.1386
	Log(10)	-.0027	.2649	.0339	.1544
	Square Root	-.0092	.4214	.0640	.1970
	Fully-wgtd.	-.0234	.6235	.1330	.2441
Per capita income	Unweighted	-.0325	-.1578	-.0712	-.2011
	Log(10)	-.0420	-.1902	-.0826	-.2134
	Square Root	-.0402	-.2892	-.1105	-.2459
	Fully-wgtd.	-.0177	-.4864	-.1650	-.2891
Mostly rural	Unweighted	-.0741	-.2008	-.0425	-.0778
	Log(10)	-.0840	-.2071	-.0448	-.0731
	Square Root	-.0848	-.2157	-.0537	-.0798
	Fully-wgtd.	-.0789	-.2177	-.0581	-.0818
Population densidy	Unweighted	.0596	.2569	-.0785	-.0141
	Log(10)	.0543	.2764	-.0883	-.0185
	Square Root	.0338	.3379	-.0834	-.0039
	Fully-wgtd.	.0053	.4184	-.0449	.0112
% Crowded housing	Unweighted	.0338	.2667	.0554	.1366
	Log(10)	.0412	.3286	.0669	.1510
	Square Root	.0328	.4939	.1192	.1887
	Fully-wgtd.	.0211	.6975	.2279	.2288
% Old housing	Unweighted	.1132	.2518	-.1454	-.1001
	Log(10)	.1234	.2891	-.1509	-.0887
	Square Root	.1190	.3657	-.1545	-.0641
	Fully-wgtd.	.0929	.4782	-.1091	-.0037
% Female-headed poverty	Unweighted	-.0267	.2139	-.0114	.0967
	Log(10)	-.0247	.2737	-.0023	.1099
	Square Root	-.0245	.4441	.0474	.1496
	Fully-wgtd.	-.0280	.6594	.1429	.1933

APPENDIX G (continued)

Correlations Between the Sociodemographic and Toxic Waste Site Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
% Primiparous	Unweighted	.0536	.1674	.0077	.0826
	Log(10)	.0743	.1717	.0109	.0786
	Square Root	.0915	.1338	.0146	.0520
	Fully-wgtd.	.1086	.0499	.0395	-.0016
% White	Unweighted	-.0191	-.1743	-.0403	-.1636
	Log(10)	-.0207	-.2044	-.0448	-.1640
	Square Root	-.0163	-.3202	-.0707	-.1692
	Fully-wgtd.	-.0117	-.4985	-.1285	-.1517
% Inadequate prenatal care	Unweighted	-.0208	.0445	.0415	.0638
	Log(10)	-.0125	.0868	.0498	.0951
	Square Root	-.0110	.1969	.0571	.1501
	Fully-wgtd.	-.0253	.3376	.0424	.2099

APPENDIX H

Correlations Between The Sociodemographic and Industrial Air Emissions Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Mother's age	Unweighted	-.0852	-.0700	-.0819	-.0956	-.1449	-.0713	-.0402	-.0568
	Log(10)	-.0866	-.0721	-.0850	-.1035	-.1573	-.0724	-.0407	-.0574
	Square Root	-.0989	-.0941	-.1118	-.1217	-.1939	-.0811	-.0440	-.0611
	Fully-wgtd.	-.1329	-.1702	-.2029	-.1600	-.2462	-.1189	-.0481	-.0735
% Mothers > 35	Unweighted	-.0728	-.0795	-.0926	-.0482	-.1020	-.0731	-.0701	-.0822
	Log(10)	-.0712	-.0846	-.0984	-.0568	-.1123	-.0791	-.0747	-.0878
	Square Root	-.0711	-.1015	-.1183	-.0727	-.1344	-.0932	-.0815	-.0963
	Fully-wgtd.	-.0881	-.1564	-.1842	-.1075	-.1760	-.1316	-.0898	-.1124
% Mothers < H.S.	Unweighted	.1357	.0223	.0458	.1039	.1539	.0195	.0431	.0574
	Log(10)	.1508	.0267	.0509	.1024	.1728	.0208	.0444	.0574
	Square Root	.1768	.0572	.0848	.1102	.2209	.0327	.0461	.0579
	Fully-wgtd.	.2042	.1384	.1810	.1484	.2783	.0768	.0463	.0680
Per capita income	Unweighted	-.0923	-.0636	-.0689	-.0606	-.0905	-.0562	-.0451	-.0524
	Log(10)	-.0997	-.0652	-.0712	-.0646	-.1023	-.0542	-.0453	-.0539
	Square Root	-.1224	-.0820	-.0932	-.0795	-.1385	-.0562	-.0463	-.0588
	Fully-wgtd.	-.1705	-.1532	-.1825	-.1260	-.2060	-.0892	-.0467	-.0735
Mostly rural	Unweighted	-.0870	-.0491	-.0776	-.0074	-.1009	-.0310	-.0917	-.0924
	Log(10)	-.0880	-.0554	-.0824	-.0144	-.0995	-.0409	-.0917	-.0927
	Square Root	-.0927	-.0741	-.0985	-.0263	-.0998	-.0617	-.0944	-.0957
	Fully-wgtd.	-.0981	-.1034	-.1244	-.0441	-.0979	-.0895	-.0943	-.0969
Population densidy	Unweighted	.3231	.0539	.1742	-.0167	.0966	.0233	.0846	.0942
	Log(10)	.3333	.0618	.1759	-.0124	.1053	.0290	.0838	.0917
	Square Root	.3378	.0907	.1819	.0050	.1381	.0445	.0803	.0864
	Fully-wgtd.	.3277	.1538	.2126	.0464	.1798	.0752	.0671	.0783
% Crowded housing	Unweighted	.2081	.0483	.0901	.0675	.1250	.0267	.0541	.0688
	Log(10)	.2268	.0587	.0987	.0767	.1507	.0322	.0571	.0700
	Square Root	.2501	.1073	.1468	.1023	.2162	.0599	.0630	.0748
	Fully-wgtd.	.2760	.2228	.2790	.1624	.2828	.1367	.0728	.0989
% Old housing	Unweighted	.1061	.0704	.0760	-.0105	.1312	.0343	.0628	.0908
	Log(10)	.1227	.0870	.0931	-.0101	.1476	.0436	.0778	.1061
	Square Root	.1532	.1251	.1335	.0034	.1843	.0628	.1059	.1327
	Fully-wgtd.	.1958	.2000	.2141	.0515	.2379	.1051	.1388	.1653
% Female-headed poverty	Unweighted	.1516	.0247	.0393	.0810	.1950	.0212	.0097	.0217
	Log(10)	.1682	.0313	.0467	.0895	.2148	.0218	.0139	.0257
	Square Root	.1978	.0759	.0988	.1074	.2655	.0420	.0290	.0442
	Fully-wgtd.	.2354	.1878	.2373	.1526	.3221	.1129	.0525	.0881

APPENDIX H (continued)

Correlations Between The Sociodemographic and Industrial Air Emissions Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
% Primiparous	Unweighted	.0609	.0607	.0927	.0229	.0357	.0798	.0575	.0597
	Log(10)	.0623	.0736	.1086	.0312	.0328	.0967	.0701	.0701
	Square Root	.0603	.1017	.1382	.0399	.0151	.1293	.0908	.0871
	Fully-wgtd.	.0740	.1637	.2041	.0476	-.0266	.1941	.1260	.1220
% White	Unweighted	-.0664	-.0171	-.0178	-.0802	-.1014	-.0306	-.0175	-.0228
	Log(10)	-.0753	-.0259	-.0269	-.0827	-.1091	-.0402	-.0193	-.0231
	Square Root	-.0931	-.0562	-.0642	-.0904	-.1328	-.0606	-.0265	-.0298
	Fully-wgtd.	-.1179	-.1173	-.1518	-.1184	-.1569	-.1011	-.0349	-.0498
% Inadequate prenatal care	Unweighted	-.0102	-.0391	-.0411	.0389	.1062	-.0114	-.0307	-.0214
	Log(10)	.0053	-.0281	-.0286	.0509	.1338	-.0058	-.0235	-.0144
	Square Root	.0383	.0115	.0121	.0763	.2049	.0103	-.0123	-.0050
	Fully-wgtd.	.0807	.1011	.0949	.1243	.3101	.0402	-.0088	-.0042

APPENDIX I

Correlations Between The Sociodemographic and Agricultural Pesticide Applications Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Mother's age	Unweighted	-.0996	-.1119	-.0878	-.0835	.0061	-.0208
	Log(10)	-.0835	-.0986	-.0733	-.0759	.0072	-.0183
	Square Root	-.0558	-.0728	-.0464	-.0527	.0142	-.0092
	Fully-wgtd.	-.0075	-.0204	.0035	-.0034	.0362	.0109
% Mothers > 35	Unweighted	-.0651	-.0569	-.0550	-.0687	.0053	-.0271
	Log(10)	-.0634	-.0560	-.0528	-.0678	.0071	-.0264
	Square Root	-.0535	-.0487	-.0431	-.0579	.0126	-.0210
	Fully-wgtd.	-.0289	-.0266	-.0181	-.0303	.0288	-.0063
% Mothers < H.S.	Unweighted	.0561	.0627	.0535	.0691	-.0015	.0126
	Log(10)	.0424	.0514	.0393	.0573	-.0056	.0086
	Square Root	.0120	.0207	.0066	.0239	-.0175	-.0029
	Fully-wgtd.	-.0317	-.0285	-.0430	-.0276	-.0440	-.0218
Per capita income	Unweighted	-.0657	-.0573	-.0714	-.0475	-.0116	-.0035
	Log(10)	-.0566	-.0494	-.0610	-.0425	-.0090	-.0007
	Square Root	-.0389	-.0351	-.0403	-.0269	.0002	.0063
	Fully-wgtd.	-.0020	-.0010	.0034	.0109	.0263	.0219
Mostly rural	Unweighted	.0733	.0527	.0575	.0470	.0965	-.0123
	Log(10)	.0611	.0416	.0489	.0480	.0974	-.0106
	Square Root	.0496	.0329	.0429	.0503	.0990	-.0068
	Fully-wgtd.	.0372	.0269	.0390	.0524	.1045	-.0014
Population densidy	Unweighted	-.0698	-.0794	-.0813	-.0580	-.0429	-.0064
	Log(10)	-.0709	-.0818	-.0838	-.0614	-.0447	-.0100
	Square Root	-.0768	-.0879	-.0925	-.0701	-.0490	-.0174
	Fully-wgtd.	-.0889	-.0992	-.1095	-.0869	-.0656	-.0283
% Crowded housing	Unweighted	.0105	.0012	.0240	.0277	-.0061	.0107
	Log(10)	.0067	.0009	.0146	.0180	-.0115	.0064
	Square Root	-.0155	-.0160	-.0171	-.0113	-.0245	-.0065
	Fully-wgtd.	-.0521	-.0499	-.0655	-.0540	-.0503	-.0257
% Old housing	Unweighted	.0224	.0167	.0096	-.0072	.0396	.0135
	Log(10)	.0125	.0040	.0040	-.0058	.0266	.0144
	Square Root	-.0001	-.0146	-.0055	-.0094	.0042	.0128
	Fully-wgtd.	-.0221	-.0433	-.0282	-.0275	-.0371	.0048
% Female-headed poverty	Unweighted	-.0118	-.0133	.0007	.0008	.0093	-.0066
	Log(10)	-.0133	-.0127	-.0044	-.0034	.0007	-.0093
	Square Root	-.0275	-.0266	-.0262	-.0203	-.0163	-.0164
	Fully-wgtd.	-.0533	-.0564	-.0625	-.0514	-.0446	-.0288

APPENDIX I (continued)

Correlations Between The Sociodemographic and Agricultural Pesticide Applications Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
% Primiparous	Unweighted	.0258	.0249	.0200	.0079	-.0439	.0444
	Log(10)	.0224	.0167	.0132	.0057	-.0423	.0480
	Square Root	.0148	.0057	-.0009	-.0026	-.0368	.0467
	Fully-wgtd.	.0035	-.0024	-.0201	-.0149	-.0229	.0391
% White	Unweighted	-.0073	-.0162	-.0073	-.0222	.0177	-.0067
	Log(10)	.0000	-.0112	.0051	-.0078	.0199	-.0012
	Square Root	.0216	.0116	.0338	.0215	.0267	.0111
	Fully-wgtd.	.0519	.0479	.0714	.0595	.0443	.0281
% Inadequate prenatal care	Unweighted	.0560	.0607	.0531	.0653	.0032	.0083
	Log(10)	.0484	.0527	.0468	.0632	.0042	.0077
	Square Root	.0288	.0310	.0291	.0470	-.0001	.0022
	Fully-wgtd.	-.0071	-.0090	-.0065	.0100	-.0169	-.0111

APPENDIX J

Correlations Between The Subsets Of Toxic Waste Site And Vital Records Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Preterm births percent	Unweighted	-.0005	.1489**	.0219	.0618
	Log(10)	.0205	.2102**	.0338	.0879
	Square Root	.0274	.3607**	.0652	.1409**
	Fully-wgtd.	.0168	.5743**	.1348**	.1900**
Small-for-gestational age percent	Unweighted	.0208	.1023*	.0194	.0643
	Log(10)	.0257	.1376**	.0253	.0751
	Square Root	.0276	.2611**	.0667	.1380**
	Fully-wgtd.	.0225	.4978**	.1520**	.2508**
Very low birthweight rate	Unweighted	-.0547	.0603	-.0451	-.0206
	Log(10)	-.0535	.0958*	-.0359	-.0011
	Square Root	-.0506	.2050**	-.0020	.0430
	Fully-wgtd.	-.0420	.4470**	.0830	.1092*
Low birthweight rate	Unweighted	-.0307	.1266**	-.0132	.0137
	Log(10)	-.0157	.1857**	-.0017	.0335
	Square Root	-.0040	.3505**	.0411	.0965*
	Fully-wgtd.	-.0007	.5984**	.1305**	.1712**
Neonatal death rate	Unweighted	.0159	.0281	-.0056	-.0268
	Log(10)	.0271	.0530	.0036	-.0160
	Square Root	.0376	.1244**	.0275	.0190
	Fully-wgtd.	.0415	.3053**	.0864	.0908*
Post-neonatal death rate	Unweighted	-.0009	.0451	.0281	-.0017
	Log(10)	.0041	.0812	.0328	.0179
	Square Root	.0036	.1745**	.0463	.0505
	Fully-wgtd.	-.0029	.4127**	.1159**	.1113*
Total infant death rate	Unweighted	.0125	.0495	.0119	-.0230
	Log(10)	.0247	.0883*	.0209	-.0036
	Square Root	.0323	.1905**	.0462	.0414
	Fully-wgtd.	.0290	.4203**	.1186**	.1196**
Fetal mortality rate	Unweighted	-.0171	.0247	.0045	.0311
	Log(10)	-.0083	.0491	.0122	.0282
	Square Root	.0062	.1177**	.0275	.0482
	Fully-wgtd.	.0262	.2771**	.0574	.0907*

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX K

Correlations Between The Subsets Of Toxic Waste Site And Birth Defects Registry Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Down syndrome	Unweighted	-.0092	-.0317	-.0002	-.0294
	Log(10)	-.0058	-.0361	.0044	-.0251
	Square Root	-.0037	-.0596	.0045	-.0335
	Fully-wgtd.	-.0051	-.1344**	-.0152	-.0520
Neural tube defects	Unweighted	.0069	-.0072	-.0217	-.0667
	Log(10)	.0135	.0031	-.0170	-.0652
	Square Root	.0223	.0382	-.0023	-.0439
	Fully-wgtd.	.0291	.1305**	.0273	.0187
Eye defects	Unweighted	-.0114	.0009	-.0311	-.0002
	Log(10)	-.0117	-.0008	-.0334	-.0053
	Square Root	-.0127	.0001	-.0348	-.0080
	Fully-wgtd.	-.0200	.0115	-.0359	-.0004
Selected severe cardiac defects	Unweighted	-.0186	-.0053	-.0099	-.0580
	Log(10)	-.0141	.0083	-.0060	-.0526
	Square Root	-.0037	.0394	.0103	-.0349
	Fully-wgtd.	.0214	.1132	.0615	.0074
Oral clefts	Unweighted	-.0194	.0239	-.0164	-.0385
	Log(10)	-.0176	.0266	-.0112	-.0361
	Square Root	-.0152	.0226	.0017	-.0228
	Fully-wgtd.	-.0153	.0125	.0240	.0042
Reduction deformities	Unweighted	.1151**	.1138*	.0391	-.0009
	Log(10)	.1260**	.1138*	.0388	-.0087
	Square Root	.1307**	.1027*	.0353	-.0219
	Fully-wgtd.	.1202**	.0944*	.0322	-.0477
Chromosomal anomalies	Unweighted	.0044	-.0172	.0105	-.0289
	Log(10)	.0134	-.0198	.0194	-.0312
	Square Root	.0231	-.0392	.0290	-.0439
	Fully-wgtd.	.0337	-.1020*	.0249	-.0612
Congenital anomalies	Unweighted	.0385	.0570	-.0348	-.0668
	Log(10)	.0469	.0739	-.0257	-.0488
	Square Root	.0591	.0890*	-.0031	-.0217
	Fully-wgtd.	.0732	.1127*	.0384	.0165
Major anomalies	Unweighted	.0121	.0465	-.0324	-.0583
	Log(10)	.0303	.0668	-.0191	-.0384
	Square Root	.0525	.0834	.0047	-.0076
	Fully-wgtd.	.0769	.0962*	.0333	.0378

APPENDIX K (continued)

Correlations Between The Subsets Of Toxic Waste Site And Birth Defects Registry Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Minor anomalies	Unweighted	.0709	.0497	-.0226	-.0508
	Log(10)	.0588	.0523	-.0271	-.0465
	Square Root	.0443	.0574	-.0188	-.0419
	Fully-wgtd.	.0301	.0954*	.0313	-.0387
Central nervous system defects	Unweighted	.0115	-.0107	-.0056	-.0570
	Log(10)	.0191	-.0004	-.0024	-.0571
	Square Root	.0296	.0353	.0066	-.0406
	Fully-wgtd.	.0397	.1266**	.0244	.0105
Heart defects	Unweighted	-.0169	.0495	-.0071	.0235
	Log(10)	-.0131	.0594	-.0003	.0270
	Square Root	-.0075	.0831	.0254	.0458
	Fully-wgtd.	.0000	.1400**	.0811	.0731
Musculoskeletal defects	Unweighted	.0321	.0567	-.0311	-.0181
	Log(10)	.0505	.0810	-.0194	.0048
	Square Root	.0702	.1098*	.0022	.0324
	Fully-wgtd.	.0942*	.1505**	.0347	.0630

* significant at p < .05, two-tailed.

** significant at p < .01, two-tailed.

APPENDIX L

Correlations Between The Subsets of Industrial Air Emissions And Vital Records Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Preterm births percent	Unweighted	.0332	-.0222	-.0089	.1345**	.0712	-.0134	.0012	.0140
	Log(10)	.0522	-.0112	.0037	.1409**	.0899*	.0011	.0028	.0160
	Square Root	.0859	.0267	.0467	.1452**	.1279**	.0339	.0076	.0207
	Fully-wgtd.	.1223**	.1035*	.1424**	.1625**	.1678**	.0871	.0132	.0355
Small-for-gestational age percent	Unweighted	.1014*	.1092*	.1177**	.0643	.0534	.0941*	.0526	.0511
	Log(10)	.1018*	.1086*	.1188**	.0675	.0711	.0910*	.0525	.0497
	Square Root	.1104*	.1184**	.1336**	.0804	.1279**	.0887*	.0568	.0547
	Fully-wgtd.	.1415**	.1767**	.2036**	.1228**	.2302**	.1128*	.0592	.0695
Very low birthweight rate	Unweighted	-.0081	-.0053	-.0157	-.0022	.0190	-.0044	-.0229	-.0201
	Log(10)	.0028	.0060	-.0039	.0093	.0314	.0103	-.0213	-.0189
	Square Root	.0304	.0424	.0385	.0377	.0591	.0466	-.0149	-.0108
	Fully-wgtd.	.0897*	.1424**	.1646**	.1011*	.1037*	.1269**	-.0004	.0196
Low birthweight rate	Unweighted	.0624	.0635	.0571	.0615	.0749	.0706	.0272	.0270
	Log(10)	.0667	.0659	.0603	.0725	.0942*	.0769	.0204	.0209
	Square Root	.0836	.0871	.0901*	.0962*	.1389**	.0902*	.0163	.0204
	Fully-wgtd.	.1249**	.1653**	.1968**	.1435**	.1911**	.1347**	.0234	.0448
Neonatal death rate	Unweighted	.0164	.0171	.0137	-.0116	.0464	.0475	-.0271	-.0179
	Log(10)	.0215	.0221	.0195	-.0060	.0544	.0535	-.0261	-.0162
	Square Root	.0363	.0422	.0431	.0088	.0697	.0706	-.0222	-.0095
	Fully-wgtd.	.0757	.1061*	.1255**	.0494	.0976*	.1212**	-.0150	.0135
Post-neonatal death rate	Unweighted	.0363	.0551	.0524	-.0221	.0461	.0662	-.0182	-.0113
	Log(10)	.0433	.0656	.0658	-.0230	.0615	.0696	-.0176	-.0098
	Square Root	.0508	.0802	.0881*	-.0132	.0926	.0695	-.0164	-.0068
	Fully-wgtd.	.0737	.1193**	.1536**	.0367	.1569**	.0897*	-.0137	.0090
Total infant death rate	Unweighted	.0348	.0462	.0419	-.0225	.0651	.0778	-.0329	-.0213
	Log(10)	.0415	.0541	.0520	-.0175	.0787	.0824	-.0313	-.0188
	Square Root	.0556	.0754	.0802	.0003	.1040*	.0929*	-.0264	-.0112
	Fully-wgtd.	.0905*	.1344**	.1649**	.0536	.1462**	.1313**	-.0176	.0141
Fetal mortality rate	Unweighted	.0153	.0253	.0232	-.0131	.0028	.0613	.0112	.0120
	Log(10)	.0131	.0232	.0213	-.0063	.0113	.0566	.0173	.0189
	Square Root	.0195	.0344	.0344	.0143	.0491	.0532	.0301	.0343
	Fully-wgtd.	.0582	.1031*	.1156**	.0742	.1484**	.0778	.0570	.0709

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX M

Correlations Between The Subsets of Industrial Air Emissions And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Down syndrome	Unweighted	-.0257	-.0276	-.0234	-.0186	.0070	-.0308	-.0263	-.0366
	Log(10)	-.0293	-.0300	-.0239	-.0215	.0099	-.0361	-.0297	-.0438
	Square Root	-.0403	-.0353	-.0299	-.0252	.0126	-.0458	-.0342	-.0521
	Fully-wgtd.	-.0749	-.0621	-.0670	-.0348	.0333	-.0778	-.0455	-.0692
Neural tube defects	Unweighted	-.0089	-.0169	-.0059	-.0279	.0194	-.0169	-.0099	-.0028
	Log(10)	-.0087	-.0145	-.0041	-.0283	.0200	-.0119	-.0079	-.0005
	Square Root	-.0052	-.0040	.0047	-.0236	.0235	.0028	-.0023	.0061
	Fully-wgtd.	.0087	.0295	.0390	.0010	.0409	.0388	.0087	.0240
Eye defects	Unweighted	-.0264	-.0241	-.0257	-.0139	-.0180	-.0264	.0210	.0236
	Log(10)	-.0288	-.0260	-.0286	-.0138	-.0176	-.0287	.0223	.0247
	Square Root	-.0318	-.0293	-.0331	-.0113	-.0092	-.0311	.0233	.0262
	Fully-wgtd.	-.0361	-.0385	-.0393	-.0024	.0185	-.0310	.0237	.0295
Selected severe cardiac defects	Unweighted	.0076	-.0011	.0104	.0590	.0089	-.0319	-.0014	-.0018
	Log(10)	.0095	.0027	.0128	.0424	.0102	-.0293	.0022	.0005
	Square Root	.0163	.0140	.0231	.0179	.0103	-.0190	.0111	.0088
	Fully-wgtd.	.0424	.0490	.0678	-.0034	.0114	.0167	.0358	.0385
Oral clefts	Unweighted	.0189	.0282	.0302	-.0186	.0351	.0057	-.0190	-.0211
	Log(10)	.0194	.0363	.0354	-.0189	.0391	.0157	-.0213	-.0232
	Square Root	.0180	.0476	.0427	-.0157	.0528	.0373	-.0240	-.0239
	Fully-wgtd.	.0146	.0513	.0473	-.0015	.0888*	.0712	-.0218	-.0149
Reduction deformities	Unweighted	.0137	-.0035	.0139	-.0194	-.0417	-.0268	-.0189	-.0425
	Log(10)	.0164	-.0018	.0177	-.0206	-.0472	-.0265	-.0242	-.0481
	Square Root	.0210	.0011	.0229	-.0218	-.0561	-.0214	-.0358	-.0572
	Fully-wgtd.	.0299	.0055	.0308	-.0219	-.0702	-.0059	-.0547	-.0677
Chromosomal anomalies	Unweighted	-.0136	-.0103	-.0004	-.0241	-.0028	-.0326	-.0248	-.0251
	Log(10)	-.0179	-.0084	.0015	-.0277	-.0027	-.0347	-.0264	-.0287
	Square Root	-.0320	-.0084	-.0031	-.0314	-.0015	-.0354	-.0286	-.0337
	Fully-wgtd.	-.0684	-.0255	-.0346	-.0389	.0130	-.0475	-.0383	-.0479
Congenital anomalies	Unweighted	.0300	.0493	.0448	-.0176	.0095	.0340	.0005	-.0042
	Log(10)	.0318	.0536	.0496	-.0239	.0123	.0364	.0027	-.0020
	Square Root	.0310	.0552	.0537	-.0305	.0135	.0389	.0067	.0039
	Fully-wgtd.	.0398	.0671	.0760	-.0268	.0148	.0545	.0210	.0264
Major anomalies	Unweighted	.0248	.0433	.0404	-.0049	.0154	.0216	.0080	.0062
	Log(10)	.0257	.0475	.0450	-.0120	.0187	.0236	.0115	.0092
	Square Root	.0250	.0524	.0511	-.0207	.0245	.0287	.0159	.0145
	Fully-wgtd.	.0345	.0725	.0762	-.0215	.0437	.0503	.0266	.0322

APPENDIX H (continued)

Correlations Between The Subsets of Industrial Air Emissions And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Minor anomalies	Unweighted	.0256	.0369	.0315	-.0336	-.0064	.0414	-.0142	-.0223
	Log(10)	.0288	.0398	.0348	-.0371	-.0073	.0455	-.0171	-.0246
	Square Root	.0287	.0339	.0329	-.0367	-.0175	.0420	-.0170	-.0215
	Fully-wgtd.	.0326	.0231	.0393	-.0257	-.0566	.0378	-.0016	.0008
Central nervous system defects	Unweighted	-.0226	-.0294	-.0212	-.0310	.0193	-.0274	-.0218	-.0141
	Log(10)	-.0239	-.0291	-.0217	-.0320	.0188	-.0243	-.0219	-.0140
	Square Root	-.0233	-.0231	-.0174	-.0290	.0199	-.0136	-.0206	-.0116
	Fully-wgtd.	-.0147	.0013	.0092	-.0096	.0330	.0150	-.0169	-.0006
Heart defects	Unweighted	.0560	.0918*	.0876	.0184	.0347	.0082	.0485	.0421
	Log(10)	.0513	.0955*	.0899*	.0106	.0360	.0078	.0532	.0450
	Square Root	.0433	.1004*	.0952*	.0053	.0436	.0094	.0644	.0550
	Fully-wgtd.	.0495	.1240**	.1302**	.0209	.0702	.0312	.0882*	.0829
Musculoskeletal defects	Unweighted	.0453	.0613	.0498	-.0108	-.0149	.0834	.0129	.0025
	Log(10)	.0505	.0649	.0555	-.0159	-.0130	.0845	.0169	.0065
	Square Root	.0587	.0700	.0668	-.0193	-.0053	.0850	.0259	.0180
	Fully-wgtd.	.0799	.0942*	.1043*	-.0086	.0054	.1010*	.0490	.0487

* significant at p < .05, two-tailed.

** significant at p < .01, two-tailed.

APPENDIX N

Correlations Between The Subsets of Agricultural Pesticide Applications And Vital Records Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Preterm births percent	Unweighted	.0336	.0440	.0125	.0094	.0317	-.0089
	Log(10)	.0207	.0404	.0037	.0072	.0248	-.0110
	Square Root	-.0045	.0214	-.0176	-.0084	.0054	-.0176
	Fully-wgtd.	-.0420	-.0223	-.0549	-.0438	-.0308	-.0312
Small-for-gestational age percent	Unweighted	-.0086	.0139	.0055	-.0078	.0122	.0006
	Log(10)	-.0115	.0178	.0011	-.0108	.0052	-.0020
	Square Root	-.0214	.0140	-.0122	-.0174	-.0091	-.0073
	Fully-wgtd.	-.0469	-.0131	-.0464	-.0373	-.0422	-.0199
Very low birthweight rate	Unweighted	-.0356	-.0367	-.0498	-.0514	.1047*	-.0402
	Log(10)	-.0378	-.0307	-.0497	-.0555	.0984*	-.0458
	Square Root	-.0467	-.0314	-.0570	-.0653	.0716	-.0522
	Fully-wgtd.	-.0654	-.0504	-.0785	-.0868	.0035	-.0580
Low birthweight rate	Unweighted	.0094	-.0427	-.0191	-.0178	.1276**	-.0141
	Log(10)	.0037	-.0384	-.0217	-.0220	.1070*	-.0174
	Square Root	-.0136	-.0378	-.0336	-.0338	.0598	-.0233
	Fully-wgtd.	-.0446	-.0545	-.0614	-.0594	-.0152	-.0336
Neonatal death rate	Unweighted	-.0486	-.0438	-.0492	-.0261	-.0276	-.0346
	Log(10)	-.0463	-.0396	-.0490	-.0296	-.0261	-.0387
	Square Root	-.0471	-.0369	-.0533	-.0388	-.0259	-.0446
	Fully-wgtd.	-.0563	-.0431	-.0691	-.0624	-.0351	-.0534
Post-neonatal death rate	Unweighted	-.0139	-.0204	-.0149	-.0170	-.0315	-.0188
	Log(10)	-.0090	-.0150	-.0092	-.0201	-.0357	-.0225
	Square Root	-.0037	-.0095	-.0038	-.0289	-.0421	-.0282
	Fully-wgtd.	-.0049	-.0173	-.0101	-.0529	-.0599	-.0387
Total infant death rate	Unweighted	-.0481	-.0479	-.0492	-.0315	-.0411	-.0394
	Log(10)	-.0434	-.0411	-.0457	-.0355	-.0411	-.0444
	Square Root	-.0399	-.0347	-.0450	-.0462	-.0426	-.0505
	Fully-wgtd.	-.0435	-.0397	-.0553	-.0708	-.0543	-.0575
Fetal mortality rate	Unweighted	.0344	-.0162	.0272	.0611	.0778	.0309
	Log(10)	.0331	-.0169	.0247	.0550	.0740	.0341
	Square Root	.0255	-.0246	.0186	.0471	.0627	.0357
	Fully-wgtd.	.0013	-.0499	-.0037	.0234	.0286	.0276

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX O

Correlations Between The Subsets of Agricultural Pesticide Applications And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Down syndrome	Unweighted	-.0315	-.0345	-.0287	-.0375	-.0231	-.0195
	Log(10)	-.0293	-.0340	-.0260	-.0419	-.0265	-.0229
	Square Root	-.0183	-.0256	-.0155	-.0433	-.0294	-.0255
	Fully-wgtd.	.0101	-.0024	.0113	-.0389	-.0340	-.0271
Neural tube defects	Unweighted	-.0049	-.0074	.0039	-.0034	-.0256	-.0157
	Log(10)	.0034	.0025	.0122	.0003	-.0240	-.0164
	Square Root	.0158	.0194	.0258	.0088	-.0205	-.0158
	Fully-wgtd.	.0343	.0426	.0461	.0236	-.0142	-.0131
Eye defects	Unweighted	.0140	.0005	.0363	.0273	-.0003	-.0026
	Log(10)	.0226	.0033	.0449	.0310	.0012	-.0031
	Square Root	.0398	.0081	.0616	.0392	.0026	-.0033
	Fully-wgtd.	.0707	.0145	.0891*	.0527	.0011	-.0034
Selected severe cardiac defects	Unweighted	-.0239	-.0239	-.0163	-.0262	-.0198	-.0176
	Log(10)	-.0171	-.0168	-.0088	-.0255	-.0179	-.0178
	Square Root	-.0034	-.0033	.0064	-.0214	-.0140	-.0160
	Fully-wgtd.	.0219	.0176	.0329	-.0123	-.0063	-.0106
Oral clefts	Unweighted	-.0283	-.0127	-.0197	-.0351	-.0134	-.0188
	Log(10)	-.0242	-.0094	-.0135	-.0339	-.0118	-.0195
	Square Root	-.0163	-.0067	-.0006	-.0276	-.0084	-.0184
	Fully-wgtd.	.0004	-.0038	.0251	-.0104	.0011	-.0138
Reduction deformities	Unweighted	.0089	.0337	.0140	-.0131	-.0231	-.0062
	Log(10)	.0033	.0156	.0013	-.0187	-.0241	-.0090
	Square Root	-.0075	-.0087	-.0155	-.0258	-.0258	-.0123
	Fully-wgtd.	-.0244	-.0377	-.0361	-.0356	-.0321	-.0160
Chromosomal anomalies	Unweighted	-.0404	-.0438	-.0335	-.0351	-.0283	-.0239
	Log(10)	-.0377	-.0439	-.0285	-.0354	-.0308	-.0272
	Square Root	-.0247	-.0360	-.0125	-.0289	-.0307	-.0285
	Fully-wgtd.	.0075	-.0139	.0248	-.0087	-.0254	-.0260
Congenital anomalies	Unweighted	-.0250	.0232	.0109	-.0212	-.0523	-.0055
	Log(10)	-.0072	.0384	.0268	-.0145	-.0492	-.0035
	Square Root	.0185	.0537	.0490	-.0018	-.0413	.0003
	Fully-wgtd.	.0555	.0684	.0812	.0186	-.0263	.0063
Major anomalies	Unweighted	-.0292	.0077	.0048	-.0248	-.0493	-.0109
	Log(10)	-.0119	.0213	.0194	-.0177	-.0449	-.0092
	Square Root	.0140	.0384	.0427	-.0027	-.0361	-.0049
	Fully-wgtd.	.0540	.0598	.0801	.0240	-.0193	.0037

APPENDIX O (continued)

Correlations Between The Subsets of Agricultural Pesticide Applications And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Minor anomalies	Unweighted	-.0049	.0419	.0175	-.0040	-.0328	.0076
	Log(10)	.0065	.0555	.0291	-.0007	-.0338	.0103
	Square Root	.0191	.0607	.0387	.0009	-.0324	.0116
	Fully-wgtd.	.0323	.0547	.0449	-.0024	-.0293	.0091
Central nervous system defects	Unweighted	-.0018	.0181	.0223	.0007	-.0281	-.0155
	Log(10)	.0065	.0234	.0294	.0040	-.0263	-.0167
	Square Root	.0196	.0331	.0425	.0125	-.0223	-.0167
	Fully-wgtd.	.0409	.0476	.0643	.0279	-.0151	-.0151
Heart defects	Unweighted	-.0236	.0461	.0123	-.0297	-.0410	-.0308
	Log(10)	-.0136	.0566	.0205	-.0288	-.0390	-.0317
	Square Root	.0041	.0695	.0367	-.0216	-.0342	-.0292
	Fully-wgtd.	.0316	.0820	.0608	-.0058	-.0243	-.0201
Musculoskeletal defects	Unweighted	-.0340	-.0239	-.0145	-.0266	-.0425	-.0191
	Log(10)	-.0285	-.0265	-.0120	-.0261	-.0415	-.0202
	Square Root	-.0241	-.0335	-.0119	-.0257	-.0389	-.0207
	Fully-wgtd.	-.0198	-.0443	-.0124	-.0270	-.0372	-.0201

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX P

Partial Correlations Within The Subset Of Vital Records Variables

VARIABLE	WEIGHTING	S.G.A. percent	Very low B.W.rate	Low B.W.rate	Neonatal Dth.rate	Post-n. Dth.rate	Tot.Inf. Dth.rate	Fetal M. rate
Preterm births	Unweighted	.0492	.1688**	.3666**	.0978*	.0344	.1030*	.0067
percent	Log(10)	.0381	.1736**	.3510**	.1097*	.0233	.1076*	.0097
	Square Root	.0087	.1680**	.3336**	.1145*	.0283	.1139*	.0160
	Fully-wgtd.	.0080	.1520**	.3380**	.1269**	.0531	.1360**	.0171
Small-for-	Unweighted		.1586**	.3830**	.1982**	.0101	.1736**	-.0282
gestational age	Log(10)		.1509**	.3816**	.1650**	.0057	.1455**	-.0335
percent	Square Root		.1124*	.3598**	.1156**	.0018	.1007*	-.0457
	Fully-wgtd.		.0336	.3423**	.0292	-.0018	.0242	-.0998*
Very low	Unweighted			.5064**	.5484**	-.0389	.4411**	.0587
birthweight	Log(10)			.4868**	.5373**	-.0012	.4629**	.0638
rate	Square Root			.4666**	.5088**	.0368	.4588**	.0612
	Fully-wgtd.			.4399**	.4613**	.0961*	.4450**	.0595
Low birthweight	Unweighted				.3714**	-.0839	.2646**	.0381
rate	Log(10)				.3556**	-.0639	.2715**	.0314
	Square Root				.3182**	-.0475	.2493**	.0244
	Fully-wgtd.				.2469**	-.0195	.2021**	.0047
Neonatal death	Unweighted					-.0649	.8077**	.1267**
rate	Log(10)					-.0530	.8335**	.1144*
	Square Root					-.0332	.8454**	.1002*
	Fully-wgtd.					.0052	.8614**	.0875
Post-neonatal	Unweighted						.5359**	.0037
death rate	Log(10)						.5076**	.0107
	Square Root						.5058**	.0080
	Fully-wgtd.						.5123**	.0066
Total infant	Unweighted							.1094*
death rate	Log(10)							.1046*
	Square Root							.0908*
	Fully-wgtd.							.0784
Fetal mortality	Unweighted							
rate	Log(10)							
	Square Root							
	Fully-wgtd.							

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX Q

Partial Correlations Within The Subset Of Birth Defects Registry Variables

VARIABLE	WEIGHTING	NTDs	Eyes	Cardiacs	Clefts	Reductn.	Chromo.	Con. An.	Major D.	Minor D.	CNS	Heart D.	Musculo.
Down syndrome	Unweighted	.0244	-.0059	-.0107	.0095	-.0002	.9339**	.1806**	.2297**	.0034	.0422	.0675	-.0520
	Log(10)	.0346	.0052	.0057	.0343	.0093	.9090**	.1982**	.2347**	.0283	.0573	.1006*	-.0239
	Square Root	.0443	.0269	.0334	.0716	.0264	.8894**	.2369**	.2660**	.0595	.0698	.1431**	.0222
	Fully-wgtd.	.0612	.0720	.0961*	.1407**	.0530	.8650**	.3081**	.3329**	.1082*	.0906*	.2279**	.0939*
Neural tube defects	Unweighted		.0218	.2190**	-.0239	.0216	.0378	.3887**	.4124**	.1614**	.9441**	.3030**	.1769**
	Log(10)		.0280	.2112**	-.0115	.0290	.0471	.3983**	.4127**	.1777**	.9419**	.2804**	.1999**
	Square Root		.0427	.2070**	.0149	.0432	.0556	.3917**	.4046**	.1751**	.9403**	.2588**	.2098**
	Fully-wgtd.		.0700	.2027**	.0611	.0674	.0733	.3631**	.3802**	.1546**	.9387**	.2318**	.1918**
Eye defects	Unweighted			.0595	-.0179	-.0021	.0383	.0994*	.0997*	.0521	.0801	.0786	.0313
	Log(10)			.0590	-.0144	.0002	.0580	.1118*	.1105*	.0607	.0840	.0798	.0387
	Square Root			.0554	-.0016	.0061	.0850	.1293**	.1262**	.0737	.0924*	.0802	.0545
	Fully-wgtd.			.0460	.0282	.0111	.1266**	.1511**	.1445**	.0954*	.1068*	.0740	.0800
Selected severe cardiac defects	Unweighted				.1113*	-.0073	.0064	.3529**	.3938**	.1101*	.2165**	.6099**	.0904*
	Log(10)				.0973*	-.0012	.0246	.3563**	.3868**	.1228**	.2124**	.5965**	.1121*
	Square Root				.0966*	.0098	.0499	.3569**	.3805**	.1337**	.2147**	.5830**	.1368**
	Fully-wgtd.				.1130*	.0300	.0993*	.3560**	.3754**	.1458**	.2230**	.5670**	.1645**
Oral clefts	Unweighted					.1115*	.0562	.2418**	.3090**	.0020	-.0369	.1460**	.1022*
	Log(10)					.1102*	.0855	.2629**	.3177**	.0243	-.0245	.1532**	.1333**
	Square Root					.1049*	.1233**	.2937**	.3358**	.0609	.0032	.1795**	.1696**
	Fully-wgtd.					.0874	.1907**	.3489**	.3716**	.1344**	.0540	.2341**	.2183**
Reduction deformities	Unweighted						.0023	.1914**	.2070**	.0721	.1053*	.0951*	.2731**
	Log(10)						.0128	.1962**	.2126**	.0683	.1014*	.0933*	.2892**
	Square Root						.0314	.1956**	.2164**	.0561	.1000*	.0915*	.2931**
	Fully-wgtd.						.0601	.1946**	.2221**	.0416	.1032*	.0927*	.2832**
Chromosomal anomalies	Unweighted							.2082**	.2648**	.0040	.0559	.1079*	-.0394
	Log(10)							.2331**	.2783**	.0284	.0698	.1441**	-.0032
	Square Root							.2825**	.3210**	.0627	.0811	.1891**	.0563
	Fully-wgtd.							.3708**	.4049**	.1202**	.1020*	.2719**	.1515**
ongenital anomalies	Unweighted								.9206**	.6793**	.4266**	.5670**	.6825**
	Log(10)								.9310**	.6618**	.4404**	.6007**	.6841**
	Square Root								.9373**	.6542**	.4385**	.6308**	.7028**
	Fully-wgtd.								.9431**	.6608**	.4192**	.6723**	.7355**
ajor anomalies	Unweighted									.3388**	.4450**	.6199**	.6129**
	Log(10)									.3424**	.4494**	.6388**	.6282**
	Square Root									.3497**	.4473**	.6614**	.6535**
	Fully-wgtd.									.3737**	.4356**	.6962**	.6929**

APPENDIX Q (continued)

Partial Correlations Within The Subset Of Birth Defects Registry Variables

VARIABLE	WEIGHTING	NTDs	Eyes	Cardiacs	Clefts	Reductn.	Chromo.	Con. An.	Major D.	Minor D.	CNS	Heart D.	Musculo.
Minor anomalies	Unweighted										.1915**	.2010**	.4925**
	Log(10)										.2105**	.2341**	.4707**
	Square Root										.2081**	.2606**	.4710**
	Fully-wgtd.										.1860**	.3039**	.4877**
Central nervous system defects	Unweighted											.3201**	.2205**
	Log(10)											.3012**	.2432**
	Square Root											.2865**	.2509**
	Fully-wgtd.											.2736**	.2333**
Heart defects	Unweighted												.2100**
	Log(10)												.2498**
	Square Root												.2944**
	Fully-wgtd.												.3464**
Musculoskeletal defects	Unweighted												
	Log(10)												
	Square Root												
	Fully-wgtd.												

* significant at p < .05, two-tailed.

** significant at p < .01, two-tailed.

APPENDIX R

Partial Correlations Between The Subsets Of Vital Records And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Preterm percent	S.G.A. percent	Very low B.W.rate	Low B.W.rate	Neonatal Dth.rate	Post-n. Dth.rate	Tot.Inf. Dth.rate	Fetal M. rate
Down syndrome	Unweighted	.0652	.0130	.0269	-.0127	.0506	.5572**	.3720**	-.0182
	Log(10)	.0601	.0156	.0696	.0247	.0775	.4101**	.2938**	-.0074
	Square Root	.0526	.0195	.0961*	.0471	.0968*	.3001**	.2439**	-.0025
	Fully-wgtd.	.0251	.0272	.1105*	.0624	.1194**	.1454**	.1763**	.0047
Neural tube defects	Unweighted	.0362	.0257	.1037*	.1294**	.1248**	-.0302	.0877	.0408
	Log(10)	.0510	.0209	.1003*	.1367**	.1240**	-.0295	.0907*	.0250
	Square Root	.0584	.0169	.0898*	.1360**	.1189**	-.0281	.0876	.0076
	Fully-wgtd.	.0795	.0313	.0660	.1300**	.0985*	-.0188	.0750	-.0101
Eye defects	Unweighted	-.0586	-.0127	-.0064	-.0485	.0046	-.0386	-.0189	.1399**
	Log(10)	-.0597	-.0184	-.0038	-.0545	.0088	-.0362	-.0125	.1487**
	Square Root	-.0570	-.0202	.0003	-.0592	.0164	-.0278	-.0007	.1552**
	Fully-wgtd.	-.0612	-.0204	.0045	-.0698	.0274	-.0058	.0205	.1582**
Selected severe cardiac defects	Unweighted	-.0289	-.0095	.0984*	-.0272	.1762**	-.0371	.1271**	.1051*
	Log(10)	-.0316	-.0203	.0906*	-.0277	.1516**	-.0300	.1142*	.1021*
	Square Root	-.0334	-.0251	.0764	-.0183	.1180**	-.0175	.0925*	.1044*
	Fully-wgtd.	-.0475	-.0263	.0547	.0026	.0593	.0104	.0562	.1179**
Oral clefts	Unweighted	.0176	.0119	-.0401	.0473	-.0163	.0274	.0024	-.0632
	Log(10)	.0247	-.0020	-.0266	.0424	-.0184	.0427	.0078	-.0519
	Square Root	.0332	-.0172	-.0051	.0383	-.0137	.0536	.0169	-.0185
	Fully-wgtd.	.0384	-.0609	.0254	.0210	-.0038	.0728	.0337	.0631
Reduction deformities	Unweighted	.0318	-.0297	-.0272	-.0483	-.0494	.0249	-.0271	-.0115
	Log(10)	.0552	-.0376	-.0249	-.0419	-.0454	.0399	-.0172	-.0030
	Square Root	.0843	-.0372	-.0189	-.0282	-.0364	.0599	.0006	.0113
	Fully-wgtd.	.1285**	-.0239	-.0055	.0004	-.0213	.0914*	.0281	.0324
Chromosomal anomalies	Unweighted	.0706	.0095	.0212	-.0301	.0392	.5216**	.3413**	-.0094
	Log(10)	.0674	.0060	.0589	-.0004	.0617	.3823**	.2647**	.0020
	Square Root	.0687	.0039	.0837	.0210	.0831	.2877**	.2255**	.0100
	Fully-wgtd.	.0620	-.0032	.1014*	.0403	.1181*	.1666**	.1860**	.0232
Congenital anomalies	Unweighted	.0524	.0553	.0634	-.0547	.1261**	.0749	.1509**	.0542
	Log(10)	.0723	.0047	.0878	-.0231	.1306**	.0554	.1434**	.0713
	Square Root	.0790	-.0378	.1088*	-.0012	.1364**	.0490	.1440**	.0924*
	Fully-wgtd.	.0791	-.1001*	.1347**	.0170	.1477**	.0570	.1559**	.1485**
Major anomalies	Unweighted	.0543	.0418	.0765	-.0277	.1399**	.0995*	.1772**	.0495
	Log(10)	.0778	.0043	.1025*	-.0009	.1458**	.0691	.1641**	.0640
	Square Root	.0900*	-.0294	.1262**	.0195	.1556**	.0568	.1647**	.0868
	Fully-wgtd.	.0893*	-.0817	.1572**	.0351	.1696**	.0565	.1743**	.1446*

APPENDIX R (continued)

Partial Correlations Between The Subsets Of Vital Records And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Preterm percent	S.G.A. percent	Very low B.W.rate	Low B.W.rate	Neonatal Dth.rate	Post-n. Dth.rate	Tot.Inf. Dth.rate	Fetal M. rate
Minor anomalies	Unweighted	.0243	.0548	.0089	-.0799	.0408	-.0067	.0306	.0376
	Log(10)	.0261	.0032	.0154	-.0577	.0367	.0007	.0320	.0521
	Square Root	.0171	-.0380	.0186	-.0456	.0290	.0087	.0297	.0600
	Fully-wgtd.	.0190	-.0950	.0208	-.0317	.0295	.0316	.0413	.0879
Central nervous system defects	Unweighted	.0322	.0403	.1145*	.1344**	.1389**	-.0133	.1097*	.0663
	Log(10)	.0509	.0360	.1161**	.1442**	.1399**	-.0080	.1162**	.0520
	Square Root	.0632	.0327	.1104*	.1454**	.1365**	-.0042	.1156**	.0340
	Fully-wgtd.	.0848	.0431	.0903*	.1359**	.1186**	.0042	.1040*	.0122
Heart defects	Unweighted	-.0054	-.0043	.1131*	-.0025	.1169**	-.0260	.0835	.0801
	Log(10)	.0003	-.0202	.1168**	-.0023	.1051*	-.0153	.0822	.0739
	Square Root	.0003	-.0342	.1186**	.0071	.0916*	-.0021	.0780	.0739
	Fully-wgtd.	-.0135	-.0519	.1227**	.0275	.0741	.0211	.0743	.0857
Musculoskeletal defects	Unweighted	.0111	.0387	.0123	-.0361	.0901*	-.0073	.0720	.0056
	Log(10)	.0280	-.0061	.0250	-.0104	.0889*	.0070	.0806	.0313
	Square Root	.0384	-.0431	.0407	.0018	.0935*	.0160	.0892*	.0683
	Fully-wgtd.	.0421	-.1023*	.0712	-.0087	.1052*	.0344	.1078*	.1521*

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX S

Partial Correlations Between The Subsets Of Toxic Waste Site And Vital Records Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Preterm births percent	Unweighted	-.0181	.0235	.0099	-.0599
	Log(10)	.0134	.0532	.0118	-.0573
	Square Root	.0408	.0978*	.0192	-.0537
	Fully-wgtd.	.0686	.1584**	.0333	-.0255
Small-for-gestational age percent	Unweighted	.0093	-.0246	.0041	-.0098
	Log(10)	.0072	-.0268	-.0009	-.0184
	Square Root	.0109	-.0032	.0117	.0034
	Fully-wgtd.	.0241	.0608	.0310	.0702
Very low birthweight rate	Unweighted	-.0643	.0203	-.0364	-.0540
	Log(10)	-.0688	.0196	-.0309	-.0549
	Square Root	-.0722	.0244	-.0151	-.0525
	Fully-wgtd.	-.0744	.0286	-.0004	-.0488
Low birthweight rate	Unweighted	-.0599	-.0183	-.0259	-.0957*
	Log(10)	-.0469	-.0031	-.0225	-.1013*
	Square Root	-.0328	.0348	-.0087	-.0952*
	Fully-wgtd.	-.0161	.1132**	.0030	-.0573
Neonatal death rate	Unweighted	.0040	-.0193	.0067	-.0576
	Log(10)	.0139	-.0128	.0152	-.0542
	Square Root	.0242	-.0036	.0351	-.0449
	Fully-wgtd.	.0375	.0029	.0587	-.0267
Post-neonatal death rate	Unweighted	-.0010	.0157	.0242	-.0300
	Log(10)	-.0005	.0270	.0274	-.0248
	Square Root	.0003	.0395	.0319	-.0246
	Fully-wgtd.	.0042	.0555	.0547	-.0319
Total infant death rate	Unweighted	.0028	-.0071	.0200	-.0664
	Log(10)	.0117	.0039	.0283	-.0605
	Square Root	.0210	.0181	.0475	-.0519
	Fully-wgtd.	.0344	.0309	.0784	-.0391
Fetal mortality rate	Unweighted	-.0129	.0067	.0226	.0277
	Log(10)	-.0063	.0160	.0298	.0200
	Square Root	.0037	.0173	.0372	.0173
	Fully-wgtd.	.0206	-.0135	.0244	.0019

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX T

Partial Correlations Between The Subsets Of Toxic Waste Site And Birth Defects Registry Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Down syndrome	Unweighted	-.0182	-.0339	.0075	-.0020
	Log(10)	-.0192	-.0438	.0110	-.0022
	Square Root	-.0146	-.0549	.0140	-.0119
	Fully-wgtd.	-.0002	-.0740	.0217	-.0185
Neural tube defects	Unweighted	-.0076	-.0653	-.0119	-.0654
	Log(10)	-.0034	-.0624	-.0082	-.0682
	Square Root	.0067	-.0456	.0042	-.0598
	Fully-wgtd.	.0279	-.0048	.0235	-.0310
Eye defects	Unweighted	-.0125	-.0127	-.0338	-.0083
	Log(10)	-.0147	-.0196	-.0353	-.0131
	Square Root	-.0161	-.0301	-.0352	-.0168
	Fully-wgtd.	-.0180	-.0383	-.0290	-.0169
Selected severe cardiac defects	Unweighted	-.0134	-.0202	-.0012	-.0557
	Log(10)	-.0129	-.0100	.0026	-.0503
	Square Root	-.0082	.0165	.0159	-.0349
	Fully-wgtd.	.0097	.0671	.0414	-.0110
Oral clefts	Unweighted	-.0211	.0091	-.0072	-.0308
	Log(10)	-.0240	.0059	-.0060	-.0347
	Square Root	-.0252	.0037	.0016	-.0290
	Fully-wgtd.	-.0225	.0129	.0250	-.0155
Reduction deformities	Unweighted	.1054*	.1111*	.0335	-.0112
	Log(10)	.1170**	.1142*	.0313	-.0209
	Square Root	.1245**	.1138*	.0271	-.0369
	Fully-wgtd.	.1209**	.1164**	.0244	-.0660
Chromosomal anomalies	Unweighted	-.0042	-.0198	.0172	-.0057
	Log(10)	.0010	-.0259	.0255	-.0127
	Square Root	.0135	-.0312	.0367	-.0278
	Fully-wgtd.	.0371	-.0391	.0556	-.0395
Congenital anomalies	Unweighted	.0288	.0210	-.0144	-.0463
	Log(10)	.0314	.0237	-.0125	-.0480
	Square Root	.0414	.0327	.0057	-.0427
	Fully-wgtd.	.0650	.0510	.0441	-.0310
Major anomalies	Unweighted	.0024	.0055	-.0128	-.0433
	Log(10)	.0155	.0142	-.0059	-.0383
	Square Root	.0355	.0253	.0123	-.0265
	Fully-wgtd.	.0703	.0390	.0433	-.0097

APPENDIX T (continued)

Partial Correlations Between The Subsets Of Toxic Waste Site And Birth Defects Registry Variables

VARIABLE	WEIGHTING	NPL-Density	CERCLIS-Density	NPL-Presence	CERCLIS-Presence
Minor anomalies	Unweighted	.0648	.0403	-.0106	-.0302
	Log(10)	.0489	.0320	-.0201	-.0448
	Square Root	.0341	.0332	-.0113	-.0573
	Fully-wgtd.	.0227	.0542	.0251	-.0645
Central nervous system defects	Unweighted	-.0025	-.0602	.0099	-.0465
	Log(10)	.0039	-.0557	.0127	-.0504
	Square Root	.0165	-.0354	.0209	-.0458
	Fully-wgtd.	.0409	.0114	.0293	-.0270
Heart defects	Unweighted	-.0219	.0153	-.0118	.0081
	Log(10)	-.0247	.0180	-.0108	.0060
	Square Root	-.0272	.0248	.0001	.0083
	Fully-wgtd.	-.0281	.0278	.0119	.0007
Musculoskeletal defects	Unweighted	.0276	.0196	-.0278	-.0222
	Log(10)	.0419	.0286	-.0226	-.0197
	Square Root	.0610	.0332	-.0072	-.0139
	Fully-wgtd.	.0929*	.0328	.0282	-.0007

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX U

Partial Correlations Between The Subsets of Industrial Air Emissions And Vital Records Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Preterm births percent	Unweighted	-.0341	-.0558	-.0496	.0830	-.0265	-.0577	-.0029	.0044
	Log(10)	-.0326	-.0516	-.0428	.0881**	-.0331	-.0459	-.0137	-.0051
	Square Root	-.0334	-.0529	-.0421	.0827	-.0549	-.0298	-.0239	-.0145
	Fully-wgtd.	-.0690	-.0580	-.0509	.0842	-.1302	-.0042	-.0630	-.0531
Small-for-gestational age percent	Unweighted	.0412	.0859	.0819	.0191	-.0286	.0750	.0223	.0125
	Log(10)	.0330	.0831	.0804	.0154	-.0258	.0687	.0165	.0049
	Square Root	.0138	.0720	.0692	.0061	-.0077	.0525	.0151	.0023
	Fully-wgtd.	-.0272	.0511	.0394	-.0036	.0019	.0242	-.0019	-.0144
Very low birthweight rate	Unweighted	-.0190	-.0116	-.0150	-.0227	-.0193	-.0124	-.0276	-.0299
	Log(10)	-.0211	-.0093	-.0131	-.0207	-.0243	-.0061	-.0325	-.0360
	Square Root	-.0221	.0054	.0014	-.0137	-.0402	.0157	-.0405	-.0442
	Fully-wgtd.	-.0221	.0529	.0439	-.0015	-.0943	.0651	-.0651	-.0658
Low birthweight rate	Unweighted	-.0007	.0462	.0350	.0021	-.0231	.0519	.0143	.0048
	Log(10)	-.0135	.0430	.0316	.0039	-.0283	.0555	-.0017	-.0116
	Square Root	-.0405	.0329	.0213	.0040	-.0424	.0558	-.0240	-.0334
	Fully-wgtd.	-.0919*	.0311	.0135	.0110	-.1028*	.0615	-.0723	-.0790
Neonatal death rate	Unweighted	.0037	.0023	.0044	-.0324	.0147	.0349	-.0314	-.0264
	Log(10)	.0056	.0054	.0083	-.0290	.0123	.0395	-.0340	-.0292
	Square Root	.0106	.0119	.0160	-.0281	.0029	.0491	-.0394	-.0333
	Fully-wgtd.	.0227	.0357	.0422	-.0288	-.0185	.0769	-.0602	-.0444
Post-neonatal death rate	Unweighted	.0253	.0612	.0583	-.0382	.0205	.0717	-.0292	-.0254
	Log(10)	.0236	.0671	.0679	-.0443	.0215	.0711	-.0316	-.0273
	Square Root	.0113	.0682	.0775	-.0531	.0152	.0629	-.0366	-.0312
	Fully-wgtd.	-.0219	.0583	.0802	-.0660	-.0004	.0534	-.0576	-.0501
Total infant death rate	Unweighted	.0181	.0382	.0382	-.0500	.0245	.0719	-.0438	-.0373
	Log(10)	.0179	.0418	.0447	-.0495	.0225	.0734	-.0469	-.0403
	Square Root	.0153	.0467	.0552	-.0526	.0106	.0760	-.0536	-.0455
	Fully-wgtd.	.0084	.0601	.0769	-.0583	-.0162	.0930*	-.0810	-.0637
Fetal mortality rate	Unweighted	.0148	.0224	.0227	-.0303	-.0176	.0554	.0153	.0123
	Log(10)	.0060	.0199	.0190	-.0237	-.0188	.0506	.0171	.0149
	Square Root	-.0093	.0175	.0148	-.0137	-.0140	.0387	.0194	.0197
	Fully-wgtd.	-.0223	.0191	.0164	.0011	.0083	.0185	.0262	.0323

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX V

Partial Correlations Between The Subsets of Industrial Air Emissions And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Down syndrome	Unweighted	-.0246	-.0212	-.0185	-.0040	.0064	-.0236	-.0269	-.0392
	Log(10)	-.0318	-.0282	-.0242	-.0082	.0065	-.0325	-.0311	-.0469
	Square Root	-.0428	-.0364	-.0308	-.0149	.0079	-.0432	-.0334	-.0518
	Fully-wgtd.	-.0646	-.0487	-.0427	-.0172	.0411	-.0576	-.0272	-.0480
Neural tube defects	Unweighted	-.0319	-.0309	-.0216	-.0335	-.0172	-.0262	-.0150	-.0127
	Log(10)	-.0296	-.0319	-.0214	-.0385	-.0217	-.0231	-.0132	-.0111
	Square Root	-.0251	-.0335	-.0238	-.0445	-.0304	-.0142	-.0097	-.0078
	Fully-wgtd.	-.0231	-.0238	-.0171	-.0380	-.0405	.0131	-.0070	-.0026
Eye defects	Unweighted	-.0331	-.0296	-.0296	-.0212	-.0239	-.0298	.0162	.0176
	Log(10)	-.0339	-.0320	-.0319	-.0205	-.0256	-.0320	.0172	.0181
	Square Root	-.0349	-.0354	-.0366	-.0173	-.0205	-.0332	.0175	.0181
	Fully-wgtd.	-.0352	-.0403	-.0417	-.0072	.0106	-.0284	.0175	.0198
Selected severe cardiac defects	Unweighted	.0033	-.0025	.0108	.0590	-.0121	-.0349	-.0006	-.0027
	Log(10)	.0055	-.0009	.0114	.0421	-.0113	-.0328	.0013	-.0024
	Square Root	.0109	.0023	.0139	.0153	-.0141	-.0263	.0052	-.0002
	Fully-wgtd.	.0275	.0112	.0273	-.0196	-.0151	-.0110	.0169	.0108
Oral clefts	Unweighted	.0126	.0272	.0288	-.0168	.0185	.0036	-.0182	-.0227
	Log(10)	.0139	.0323	.0317	-.0188	.0200	.0119	-.0240	-.0283
	Square Root	.0142	.0386	.0347	-.0182	.0305	.0311	-.0315	-.0335
	Fully-wgtd.	.0122	.0401	.0389	-.0071	.0753	.0658	-.0308	-.0256
Reduction deformities	Unweighted	.0082	-.0089	.0072	-.0187	-.0400	-.0322	-.0226	-.0465
	Log(10)	.0111	-.0071	.0114	-.0225	-.0471	-.0323	-.0272	-.0514
	Square Root	.0169	-.0051	.0172	-.0281	-.0586	-.0275	-.0368	-.0586
	Fully-wgtd.	.0270	.0012	.0282	-.0316	-.0757	-.0091	-.0543	-.0701
Chromosomal anomalies	Unweighted	-.0125	-.0048	.0038	-.0120	-.0012	-.0266	-.0288	-.0305
	Log(10)	-.0183	-.0067	.0021	-.0167	-.0027	-.0320	-.0310	-.0342
	Square Root	-.0290	-.0066	.0006	-.0225	-.0016	-.0324	-.0304	-.0352
	Fully-wgtd.	-.0463	-.0034	-.0013	-.0243	.0255	-.0267	-.0237	-.0293
Congenital anomalies	Unweighted	.0285	.0455	.0450	-.0216	-.0294	.0299	.0068	-.0037
	Log(10)	.0256	.0411	.0411	-.0358	-.0328	.0261	.0025	-.0081
	Square Root	.0248	.0275	.0286	-.0550	-.0362	.0188	.0026	-.0069
	Fully-wgtd.	.0331	.0223	.0303	-.0635	-.0218	.0236	.0131	.0091
Major anomalies	Unweighted	.0221	.0389	.0422	-.0099	-.0282	.0153	.0150	.0075
	Log(10)	.0210	.0356	.0393	-.0239	-.0309	.0128	.0128	.0043
	Square Root	.0208	.0259	.0295	-.0439	-.0332	.0102	.0116	.0031
	Fully-wgtd.	.0293	.0263	.0332	-.0571	-.0147	.0220	.0163	.0124

APPENDIX V (continued)

Partial Correlations Between The Subsets of Industrial Air Emissions And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Air-Density	Terat.-Density	Solvent-Density	Special-Density	Inorgs.-Density	Hydroc.-Density	Halogen-Density	Carcin. Density
Minor anomalies	Unweighted	.0271	.0365	.0293	-.0334	-.0178	.0433	-.0120	-.0228
	Log(10)	.0229	.0326	.0252	-.0431	-.0211	.0408	-.0199	-.0298
	Square Root	.0216	.0179	.0128	-.0524	-.0253	.0284	-.0181	-.0254
	Fully-wgtd.	.0264	.0028	.0096	-.0482	-.0278	.0162	-.0003	-.0025
Central nervous system defects	Unweighted	-.0427	-.0406	-.0332	-.0338	-.0121	-.0346	-.0230	-.0200
	Log(10)	-.0425	-.0433	-.0350	-.0390	-.0176	-.0329	-.0233	-.0204
	Square Root	-.0416	-.0489	-.0414	-.0463	-.0286	-.0272	-.0242	-.0214
	Fully-wgtd.	-.0449	-.0480	-.0424	-.0444	-.0402	-.0072	-.0299	-.0237
Heart defects	Unweighted	.0469	.0798	.0771	.0111	.0080	-.0024	.0399	.0312
	Log(10)	.0424	.0811	.0771	.0005	.0078	-.0048	.0436	.0325
	Square Root	.0316	.0742	.0695	-.0144	.0107	-.0123	.0535	.0393
	Fully-wgtd.	.0223	.0620	.0626	-.0226	.0301	-.0204	.0713	.0573
Musculoskeletal defects	Unweighted	.0524	.0661	.0606	-.0231	-.0579	.0814	.0217	.0070
	Log(10)	.0516	.0612	.0578	-.0369	-.0632	.0759	.0180	.0035
	Square Root	.0533	.0520	.0520	-.0512	-.0675	.0667	.0200	.0081
	Fully-wgtd.	.0698	.0566	.0636	-.0564	-.0599	.0695	.0397	.0332

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX W

Partial Correlations Between The Subsets of Agricultural Pesticide Applications And Vital Records Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Preterm births percent	Unweighted	-.0142	-.0210	-.0355	-.0318	.0554	-.0179
	Log(10)	-.0101	-.0023	-.0276	-.0281	.0514	-.0204
	Square Root	-.0166	.0030	-.0248	-.0215	.0449	-.0193
	Fully-wgtd.	-.0102	.0317	-.0044	-.0056	.0335	-.0170
Small-for-gestational age percent	Unweighted	-.0415	-.0251	-.0256	-.0380	.0295	-.0104
	Log(10)	-.0418	-.0171	-.0282	-.0420	.0251	-.0155
	Square Root	-.0440	-.0122	-.0315	-.0390	.0185	-.0171
	Fully-wgtd.	-.0418	.0037	-.0311	-.0270	.0023	-.0172
Very low birthweight rate	Unweighted	-.0572	-.0568	-.0672	-.0726	.0952*	-.0439
	Log(10)	-.0580	-.0508	-.0659	-.0764	.0950*	-.0509
	Square Root	-.0600	-.0446	-.0644	-.0804	.0839	-.0572
	Fully-wgtd.	-.0601	-.0381	-.0600	-.0845	.0506	-.0618
Low birthweight rate	Unweighted	-.0241	-.0970*	-.0581	-.0475	.1541**	-.0211
	Log(10)	-.0226	-.0886*	-.0535	-.0513	.1432**	-.0263
	Square Root	-.0252	-.0801	-.0471	-.0507	.1199**	-.0283
	Fully-wgtd.	-.0172	-.0493	-.0237	-.0388	.0715	-.0274
Neonatal death rate	Unweighted	-.0744	-.0715	-.0714	-.0389	-.0412	-.0350
	Log(10)	-.0676	-.0625	-.0676	-.0429	-.0374	-.0407
	Square Root	-.0651	-.0576	-.0680	-.0508	-.0311	-.0468
	Fully-wgtd.	-.0616	-.0477	-.0680	-.0611	-.0206	-.0533
Post-neonatal death rate	Unweighted	-.0259	-.0315	-.0238	-.0378	-.0370	-.0234
	Log(10)	-.0183	-.0251	-.0155	-.0382	-.0392	-.0255
	Square Root	-.0042	-.0128	-.0011	-.0381	-.0409	-.0270
	Fully-wgtd.	.0251	.0079	.0275	-.0375	-.0421	-.0280
Total infant death rate	Unweighted	-.0782	-.0791	-.0745	-.0552	-.0567	-.0434
	Log(10)	-.0684	-.0678	-.0669	-.0581	-.0540	-.0492
	Square Root	-.0584	-.0564	-.0592	-.0642	-.0487	-.0549
	Fully-wgtd.	-.0401	-.0369	-.0444	-.0715	-.0390	-.0600
Fetal mortality rate	Unweighted	.0139	-.0406	.0133	.0456	.0700	.0277
	Log(10)	.0187	-.0342	.0155	.0408	.0680	.0303
	Square Root	.0201	-.0328	.0176	.0391	.0640	.0334
	Fully-wgtd.	.0179	-.0395	.0212	.0404	.0535	.0362

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.

APPENDIX X

Partial Correlations Between The Subsets of Agricultural Pesticide Applications And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Pest.- Density	Phthal.- Density	Organo.- Density	Carbam.- Density	Herb.- Density	Halo.- Density
Down syndrome	Unweighted	-.0300	-.0305	-.0272	-.0370	-.0260	-.0215
	Log(10)	-.0267	-.0290	-.0246	-.0394	-.0266	-.0248
	Square Root	-.0154	-.0209	-.0152	-.0406	-.0288	-.0265
	Fully-wgtd.	.0112	-.0018	.0071	-.0408	-.0374	-.0271
Neural tube defects	Unweighted	-.0094	-.0141	-.0023	-.0026	-.0258	-.0191
	Log(10)	-.0034	-.0064	.0035	-.0018	-.0250	-.0203
	Square Root	.0050	.0052	.0136	.0024	-.0221	-.0190
	Fully-wgtd.	.0263	.0330	.0373	.0173	-.0125	-.0136
Eye defects	Unweighted	.0059	-.0067	.0281	.0205	-.0053	-.0050
	Log(10)	.0136	-.0050	.0359	.0233	-.0044	-.0059
	Square Root	.0303	-.0014	.0523	.0304	-.0031	-.0062
	Fully-wgtd.	.0611	.0034	.0792	.0429	-.0025	-.0061
Selected severe cardiac defects	Unweighted	-.0242	-.0219	-.0177	-.0263	-.0250	-.0196
	Log(10)	-.0182	-.0148	-.0111	-.0267	-.0228	-.0202
	Square Root	-.0064	-.0023	.0023	-.0246	-.0188	-.0189
	Fully-wgtd.	.0161	.0131	.0271	-.0165	-.0092	-.0125
Oral clefts	Unweighted	-.0319	-.0132	-.0234	-.0365	-.0191	-.0210
	Log(10)	-.0284	-.0099	-.0185	-.0371	-.0158	-.0228
	Square Root	-.0208	-.0072	-.0065	-.0323	-.0099	-.0223
	Fully-wgtd.	-.0052	-.0079	.0179	-.0155	.0029	-.0166
Reduction deformities	Unweighted	.0070	.0331	.0105	-.0107	-.0210	-.0071
	Log(10)	.0009	.0136	-.0027	-.0167	-.0220	-.0100
	Square Root	-.0106	-.0136	-.0198	-.0237	-.0248	-.0123
	Fully-wgtd.	-.0263	-.0418	-.0382	-.0313	-.0332	-.0139
Chromosomal anomalies	Unweighted	-.0396	-.0406	-.0324	-.0354	-.0303	-.0270
	Log(10)	-.0365	-.0407	-.0281	-.0343	-.0306	-.0303
	Square Root	-.0235	-.0332	-.0133	-.0278	-.0303	-.0308
	Fully-wgtd.	.0054	-.0167	.0186	-.0123	-.0293	-.0275
Congenital anomalies	Unweighted	-.0356	.0124	.0007	-.0214	-.0602	-.0084
	Log(10)	-.0191	.0260	.0138	-.0184	-.0544	-.0076
	Square Root	.0034	.0343	.0337	-.0090	-.0428	-.0027
	Fully-wgtd.	.0444	.0498	.0717	.0155	-.0206	.0076
Major anomalies	Unweighted	-.0442	-.0049	-.0107	-.0273	-.0632	-.0147
	Log(10)	-.0275	.0077	.0021	-.0242	-.0552	-.0146
	Square Root	-.0037	.0198	.0231	-.0135	-.0421	-.0100
	Fully-wgtd.	.0385	.0411	.0635	.0136	-.0190	.0012

APPENDIX X (continued)

Partial Correlations Between The Subsets of Agricultural Pesticide Applications And Birth Defects Registry Variables

VARIABLE	WEIGHTING	Pest.-Density	Phthal.-Density	Organo.-Density	Carbam.-Density	Herb.-Density	Halo.-Density
Minor anomalies	Unweighted	-.0028	.0391	.0218	-.0001	-.0262	.0074
	Log(10)	.0072	.0511	.0314	.0022	-.0267	.0102
	Square Root	.0173	.0493	.0403	.0052	-.0236	.0145
	Fully-wgtd.	.0369	.0460	.0567	.0125	-.0146	.0186
Central nervous system defects	Unweighted	-.0065	.0132	.0167	.0029	-.0326	-.0177
	Log(10)	-.0002	.0165	.0216	.0031	-.0313	-.0194
	Square Root	.0096	.0211	.0316	.0071	-.0274	-.0190
	Fully-wgtd.	.0340	.0394	.0572	.0225	-.0161	-.0152
Heart defects	Unweighted	-.0246	.0465	.0092	-.0305	-.0371	-.0342
	Log(10)	-.0176	.0538	.0144	-.0317	-.0344	-.0358
	Square Root	-.0045	.0599	.0270	-.0268	-.0286	-.0326
	Fully-wgtd.	.0257	.0728	.0571	-.0066	-.0150	-.0196
Musculoskeletal defects	Unweighted	-.0473	-.0382	-.0291	-.0336	-.0477	-.0254
	Log(10)	-.0432	-.0420	-.0277	-.0362	-.0457	-.0269
	Square Root	-.0363	-.0480	-.0228	-.0343	-.0398	-.0250
	Fully-wgtd.	-.0226	-.0520	-.0095	-.0244	-.0300	-.0180

* significant at $p < .05$, two-tailed.

** significant at $p < .01$, two-tailed.