Fetal Loss and Work in a Waste Water Treatment Plant

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Abstract: We investigated pregnancy outcomes in 101 wives of workers employed in a waste water treatment plant (WWTP), and verified fetal losses by hospital records. Paternal work histories were compiled and each of the 210 pregnancies was assigned a paternal exposure category. The relative risk of fetal loss was increased when paternal exposure to the WWTP occurred around the time of conception. (*Am J Public Health* 1984; 74:499–501.)

Introduction

In 1976, a major oil company opened a waste water treatment plant (WWTP) to process contaminated water by settling, aeration, pH adjustment, biologic digestion by rotifers, and drying.

In 1980, responding to worker concern that their wives seemed to be experiencing an excess of miscarriages, the company first assigned a staff person with epidemiologic skills and a nurse to investigate the problem. They interviewed all men thought to have worked more than 30 days in WWTP since 1976, the process start-up date. Their interview responses indicated an excess of fetal loss for pregnancies following fathers' assignment to the WWTP. The company then retained the authors to investigate the question further.

Although about 15 per cent of recognized pregnancies end in spontaneous abortion, little is known of the paternal influence on this outcome. The maternal factors of age, smoking, alcohol use, and prior abortion have all been suggested as risk factors.[1] Presumably, a paternal exposure could alter the genetic material of the sperm,[2] leading to an anomaly in the conceptus with resulting increased risk of fetal loss. Previous studies[3–12] concerning mutagenic and reproductive effects have generally been inconclusive or severely flawed, especially in regard to response bias and lack of exposure data. Processes used in waste water treatment have not previously been associated with reproductive hazards.

Methods

We questioned the wives of the WWTP workers originally interviewed. Ninety-five of the 100 current wives agreed to be interviewed. We also attempted to contact 20 former wives of WWTP workers, but were able to interview only six, bringing the total of women interviewed to 101. Of the 101 women, nine had never been pregnant and three had husbands with no WWTP exposure, thus reducing the effective study population to 89.

Trained interviewers administered a fairly rigid standardized questionnaire which we pre-tested and modified before interviews began. The respondent was asked to sign a consent form allowing doctors and hospitals to release to us records of each unsuccessful reproductive event reported in the interview. We assumed that for successful pregnancies, no validation was needed.

Paternal WWTP employment histories were collected from company records. For each man, we reconstructed his WWTP work history after June 1, 1976, and sent it to him for verification. In each instance where he disagreed with the summary, we resolved the difference to the satisfaction of both the worker and his supervisor. Each pregnancy was classified by three paternal WWTP exposure categories: E_1 exposure any time prior to conception; E_2 exposure within four months prior to conception; E_3 exposure three months after conception. Categories were not exclusive; a man working consecutively for six months prior to conception as well as two months after would be considered to have E_1, E_2, and E_3 exposure.

For each category of pregnancy (exposed and unexposed), we calculated fetal loss rates (i.e., the proportion of pregnancies ending in miscarriage or stillbirth). Rates were also calculated for miscarriages (fetal loss before end of fifth month) only, with little change from those derived from total fetal loss. We calculated relative risk by dividing the fetal loss rates of exposed by the unexposed. Unexposed pregnancies, the reference point, have a relative risk of one.

In analyzing the data, all pregnancies were treated as independent events, although this was not strictly true. It should also be remembered that although we report p-values, we have tested the hypothesis, in part, on the data which generated it. Therefore, conventional notions of statistical significance are somewhat violated. We provide p-values only for interest.

Results

The population studied ranged in age from 18 to 38 years, 70 per cent were White, and 51 per cent had at least some college experience. Table 1 summarizes the number of pregnancies, according to pre- and post-WWTP status, with no reference to time limitation (variable E_1). Number of pregnancies ranged from 1 to 8, with a median of 2.

Only verified miscarriages or stillbirths were included in the analysis. No elective abortions were reported. For some women, reports of miscarriages erred by many months, an important feature when trying to relate husband's exposure of date of conception.

Table 2 is a sample of pregnancy outcome data by any WWTP exposure prior to conception. Similar tables were prepared for exposure within four months prior to conception, and for three months after conception. Table 3 summarizes these tables. Exposure around the time of conception produced the highest relative risks. Since most (35/45) husbands exposed within four months prior were also exposed after, and a meager seven had exposure only after conception, the numbers do not allow us to distinguish immediate pre-conception exposure from post-conception experience.

We employed a multiple logistic analysis to control for the possible confounding variables of race, age, education,

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TABLE 1—Frequency Distribution of Women with Pregnancies Before and After Husband's Start at WWTP

		Number of Pregnancies After Husband's Start in WWTP					
		0	1	2	3	4	TOTAL
Number of Pregnancies Before Husband's Start in WWTP	0	0	7	3	0	1	11
	1	8	16	3	0	1	28
	2	24	8	0	0	0	32
	3	11	2	0	0	0	13
	4	2	0	0	0	0	2
	5	2	0	0	0	0	2
	6	0	0	0	0	0	0
	7	0	0	0	0	0	0
	8	1	0	0	0	0	1
	TOTAL	48	33	6	0	2	89

TABLE 2—Pregnancy Outcome of Women Whose Husbands Had Any Exposure to the WWTP Prior to Conception (E_1)

	Pregnancy Outcome		
Work Status	Miscarriage or Stillbirth	Live Birth	Total
Any prior WWTP work	9	44	53
No prior WWTP work	13	144	157
TOTAL	22	188	210

$\chi^2 = 3.20$
$p = 0.07$

$RR = \frac{9/53}{13/157} = 2.05$

95% C.I. = [0.93–4.52]

smoking, and alcohol intake. That analysis showed a slight effect from education, but uncovered no confounding. It confirmed the 2 × 2 tables summarized by Table 3.*

Different job categories in the WWTP have very different risks of spontaneous abortion, ranging from 0.65 for one job up to 8.0 for another. Because sample sizes for each job category are small, the confidence limits of the relative risk tend to be wide. Although small numbers limit conclusions, crafts (electrical, mechanical, and instrument) experienced higher risk than production workers (Table 4).

To consider the trend over time, we compared the rates of fetal loss for the two halves of the 1976–1981 period. Because of a zero value, we could not calculate properly the relative risk for 1976–1978. The risk of 1.28 for 1979–1980 is less than that reported for the total experience (Table 2), but is based on numbers too small to be conclusive.

*Data available on request to author.

Discussion

Previous authors have suggested the monitoring of spontaneous abortion as an early warning system for environmental mutagens and teratogens.[13] Presumably, because of the differing biology of sperm and ovum production, such events would more likely reflect male exposure if the effect was mutagenic, while female exposure would be expressed as a teratogenic effect. The results of this study are compatible with a male exposure producing a defective conceptus, resulting in a spontaneous abortion. The adverse outcomes do not appear to have lowered fertility rates for the group, nor does the WWTP population have an inordinately high rate of fetal loss, when compared to other published studies.[14–17] However, the fetal loss rate of the exposed pregnancies is significantly greater than the rate for the unexposed.

One needs to use extreme caution in interpreting these results. Although we restricted our analysis to only confirmed instances of fetal loss, there is still potential for underreporting, especially of much earlier events, perhaps those prior to the start of the WWTP. Underreporting would tend to increase the relative risk associated with more recent WWTP experience. However, the lack of association for production workers, who identify themselves as exposed but have no marked increase in relative risk, argues against a possible underreporting bias.

The WWTP workers are potentially exposed to many substances, most at low concentrations. Although we tried, we were not able to assign each worker a useful type of exposure category. Thus, we cannot speculate on either an agent or mode of exposure.

The data do not answer the question of whether or not increased risk continues.

There is still considerable question whether the data represent statistical artifact, reporting bias, or biologic reality. That question and the nature of the cause, should the problem be real, will require more research using larger numbers and better exposure data, preferably with an unexposed referent group for comparison. In the meantime, there is reason to suspect that paternal exposure to an environmental mutagen may have resulted in an increased risk of fetal loss. We anticipate that future studies will use the retrospective method described here or will modify the approach for prospective surveillance of suspect groups. We would emphasize that great care should be paid to verification of exposure and outcome variables as both are subject to considerable error.

TABLE 3—Summary of Probabilities, Relative Risks, and Confidence Intervals

	210 Pregnancies		
Exposure Time Frame	p	Relative Risk	95% Confidence Limits
Any exposure prior to conception (E_1)	0.07	2.05	0.93–4.52
Exposure within 4 months prior to conception (E_2)	0.008	2.86	1.30–6.29
Exposure within 3 months after conception (E_3)	0.006	2.94	1.35–6.40

TABLE 4—Risk of Fetal Loss, by Occupation and WWTP Exposure Any Time Prior to Conception

Occupation and WWTP Exposure	No. Pregnancies	Rate of Fetal Loss	Relative Risk (RR)	95% Confidence Limits of RR
1a) Exposed Process Operators	10	.100	.85	.11–6.77
b) Un-exposed Process Operators	34	.118		
2a) Exposed Mechanical, Instrument, Electrical	35	.200	4.85	1.51–15.57
b) Un-exposed Mechanical, Instrument, Electrical	97	.041		

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Diet Policies of PKU Clinics in the United States

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Abstract: About two-thirds of 90 clinics treating phenylketonuria (PKU) now recommend indefinite continuation of a low phenylalanine diet as compared to 1978 when fewer than one-fourth had this policy. The percentage of children maintained on diet has increased markedly for six to eight year-olds. Greater conservatism in clinic diet recommendations likely reflects reports of adverse consequences following diet discontinuation and negative individual clinic experiences. (*Am J Public Health* 1984; 74:501–503.)

Introduction

Since 1953, phenylketonuria (PKU) has been treated with a diet restricted in phenylalanine.[1] Although well-treated children have IQs comparable to those of their non-PKU siblings,[2] the age at which the restricted diet can be safely stopped is still unknown.

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Reviews of diet discontinuation showed IQ losses[3,4] in about half of the reports. Brown and Warner[3] suggested reasons why real losses in IQ might be obscured in those studies indicating no significant intellectual changes following diet discontinuation.

After four to seven years of follow-up, Seashore[5] reported modest to very significant declines in intellectual performance, attentional and academic problems in school, and electroencephalogram (EEG) changes after diet discontinuation. Pueschel[6] found no changes in eight children six months after discontinuation of diet at age five, in physical, neurological, and psychological assessments, or in somatosensory and visual evoked potentials. The PKU Collaborative Study found lowered school performance after diet discontinuation.[7,8]

This paper describes diet policies of PKU treatment programs in 1982 and compares them with policies found in 1978–79.[9]

Methods

In 1982, a questionnaire was sent to all identified programs involved in the treatment of PKU in the United States.[10,11] Policies for discontinuation or continuation of the phenylalanine-restricted diet were described by each program. We have grouped the policies into three general categories: