50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	PB90-142605

4. Title and Subtitle A Retrospective Study of Inferred Fertility of Married Men Occupationally Exposed to Ethylene Dibromide (EDB). Final Report	5. Report Date 77/11/22 6.
7. Author(s) Anonymous	8. Performing Organization Rept. No.
9. Performing Organization Name and Address Equitable Environmental Health, Inc, Rockville, Maryland	10. Project/Task/Work Unit No. 11. Contract (C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address	13. Type of Report & Period Covered 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words) A retrospective study of reproductive effects of exposure to ethylene-dibromide (106934) (EDB) in a group of exposed male workers was conducted. Reproductive histories of the wives of EDB exposed workers were examined. Data on the date of birth of each wife, the date of birth of the worker husband, race, dates of birth of all live born natural children, details on adopted children and children by previous marriages of wives, dates of marriages, and other pertinent factors were collected for workers at four firms in the United States. Less complete data was also obtained from one facility in the United Kingdom. A negative result was obtained for all facilities studies except the Houston facility cohort. Examining high and low exposure categories gave no consistent evidence of any dose response relationship. In the Houston cohort, the observed/expected births ratio was consistently and significantly low, suggesting a possible antifertility effect. Relative exposure categories were not available, so any dose response relationship which might exist could not be found. The prevalence of vasectomy among the EDB workers at this site was particularly high. Other cases of sterility of either husband or wife from preexisting causes gave a total of 22/67 couples or 33 percent of the study group at this site who did not offer a valid test of the potential antifertility effect of exposure to EDB. It appeared that a negative finding was also the outcome of the British study.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms Chemical-industry-workers, Chemical-manufacturing-industry, Halogenated-hydrocarbons, Reproductive-system-disorders, Spermatogenesis, Laboratory-animals, Spermatozoa, Fumigants, Reproductive-hazards

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages 24
	22. Security Class (This Page)	22. Price

R0493

A RETROSPECTIVE STUDY OF INFERRED FERTILITY OF MARRIED MEN OCCUPATIONALLY EXPOSED TO ETHYLENE DIBROMIDE (EDB).

FINAL REPORT

Submitted to:

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November 22, 1977

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TABLE OF CONTENTS

INTRODUCTION

Following the recent disclosures that certain industrial workers have been rendered oligospermic or in some cases azoospermic and sterile following occupational exposure to dibromochloropropane or DBCP, some suspicion of potential similar effects has fallen upon the structurally similar compound, ethylene dibromide (EDB) or dibromoethane. Moreover, in the case of ethylene dibromide itself, there is some supporting evidence of a potential human reproductive hazard, from animal studies. Thus, induction of reversible spermatozoic abnormalities has been reported in bulls, and of reduced fertility in male rats. As several groups of male workers have been engaged in the manufacture of EDB during the past two decades (some as early as in 1952) in the U.S. and Europe, an attempt has been made to examine retrospectively any such antifertility influence by studying the reproductive performance of these men exclusively on the basis of their reproductive histories in terms of live-births to their wives, subsequent to their occupational exposure to EDB. To this end, basic marital reproductive histories have been collected from five gorups of male workers, from four EDB manufacturing units in the United States, and from one in Gt. Britain.

METHODOLOGICAL DISCUSSION

Because male, as opposed to female, fertility rates and reproductive performance have been little studied, and no corresponding data have evidently been published, the fertility of married EDB workers has been indirectly inferred from that of their respective wives. This is making the primary assumption that the male subjects of the study are the exclusive sexual consorts of their designated wives. Single men have been excluded from the study because it was felt that reliable data on their fathering of offspring would not be readily available, and it would be similarly difficult to obtain data on their reproductive partners. Therefore the date of birth of each wife, in addition to the date of birth of the worker-husband, his race (W/NW), the dates of birth of all live-born natural children, details on adopted children and children by previous marriages of wives, dates of marriages, divorces, remarriages etc. together with the date of onset of exposure to EDB have been collected from all four U.S. plants in the study. The data received from the one plant in the U.K. included ab-

solutely no information about the workers' wives. Within the very tight time frame initially imposed upon this study it was felt that it would not be possible to collect such information from the U.K. In view of the fact that this group alone included as many unexposed (control) subjects as the total of the three exposure categories (41), it was decided to perform, on this data set alone, a simple internal comparison study of reproduction in exposed versus unexposed men, adjusting separately for age and parity.

The definitive calculation performed on each of the four U.S. plant cohorts in turn, was the computation of the standardized fertility ratio between the observed number of children born to each couple, subsequent to the date of onset of exposure to EDB of the husband (this date being deferred by 9 months for purposes of this calculation, to accommodate the normal period of gestation) and the expected number derived from national fertility tables published for successive birth cohorts of U.S. women, by the National Center for Health Statistics. These tables are published in book form covering the years 1917 through 1973 and supplemental tables were available on special request from NCHS for the years 1974 and 1975.

The precise method of applying these tables, of which a sample page is attached in Appendix I, together with a worked example (Appendix II), is described under the heading of Analysis and Results (American Data).

SPECIAL ISSUES AND THEIR TREATMENT

Many problems arose in logical handling of the available data, for which scientifically ideal solutions may not be available, given the limitations of this type of inferential study. In such cases arbitrary decisions have been made, but consistently applied to all data sets.

(i) Surgical sterilization: vasectomy/hysterectomy/tubal ligation

For some of the U.S. data sets, volunteered information on permanent sterilization of either sex, mainly vasectomies, some female sterilizations, and one case of male sterility following mumps orchitis, was available. After some discussion, it was decided to effectively ignore such information, and leave the affected subjects in the analysis of "couple-years at risk," largely on the grounds that such phenomena must also impact the national female fertility rates, which are the basis for our comparison. The prevalence of vasectomy was significantly high at one plant, the Houston Chemical Company, where there were 18 vasectomies among 67 subjects

included in the analysis (plus 4 other cases of known sterility of either party - see Houston C.C. Results). Keeping all these cases of known sterility independent of EDB exposure in the analysis of the Houston C.C. data had a major impact on their final ratios. For comparison, the Houston data were recalculated removing the vasectomy subjects from further analysis following the date of vasectomy.

(ii) Adopted Children and Step-children of Workers

On the theory that the major mechanism whereby parity influences fertility is socio-economic rather than biological, both adopted and step-children who are part of the worker's household were counted as contributing to parity, but not as "births" counting towards reproductive performance of the worker. Where a worker had children by a previous marriage, prior to the onset of EDB exposure, they were treated in the same way, on the assumption that the worker would be economically supporting them.

(iii) Marital Status

As already defined, the study was confined to men who have been married for at least some part of the study period. Where a man has been divorced or separated for a period and then remarried, only the years and months within marriage have been counted in the "couple-years at risk".

(iv) Ethnic Group

The standard tables are broken down only by white/non-white distinction. Mexicans are included as white. Data on the ethnic group of wives was not obtained. The assumption was made that it would correspond to that of the worker-husband, which was available.

(v) Current Pregnancies and Miscarriages

A few of the wives are known to be currently pregnant. These pregnancies have been ignored, since the corresponding national female fertility rates are based on live-births only. Known miscarriages have also been discounted for the same reason.

(vi) Puerperal Infertility

Although it is recognized that most women are relatively infertile for a variable period after child-birth, somewhat influenced by duration of lactation, the arbitrary assumption was made that potential fertility is fully restored immediately following childbrith, in the calculation of "couple-years at risk".

(vii) Imprecise Dates

Every effort has been made to obtain all relevant dates with the greatest precision possible. Wherever it has not been possible to obtain precision greater than one year however, the mid-point of the year, i.e. the month of July, has been

arbitrarily assigned. Those dates where precision is most critical are the date of onset of exposure to EDB and the date of birth of offspring.

(viii) Prematurity

Although the exact length of gestation could be critical in certain borderline cases in deciding whether conception took place just before or just after the onset of paternal exposure to EDB, it is assumed that all gestations were in fact of 9 months, i.e. the possibility of premature live-birth has been discounted.

(ix) Cut-Off Period for Study

The general cut-off period is September 1977, determined by the currency of the available data at the time of completing the calculations (mid-November 1977). For the Dow Company cohort, an earlier cut-off date was imposed at the end of 1975. At that time concomitant exposures to dibromochloropane (DBCP) commenced, which constitute a confounding exposure variable, as DBCP has been associated with impaired fertility in certain groups of exposed male workers.

(x) Fertility Rates after 1975

For 1976 and the first 9 months of 1977, the 1975 tables, the most recent available from NCHS were applied. It is not known how great an error this might introduce, as in the changing socio-economic climate of the past 5 years, it is probable that effective fertility rates have been changing quite rapidly, due to inflationary pressures coupled with the increasing use of several methods of female contraception, and the increasing popularity of vasectomy in males. Thus, the expected births might have been slighly over-estimated, resulting in a slightly lower fertility ratio.

(xi) Unmarried Women in U.S. Cohorts

On the other hand, since the national female fertility rates are based on both married and unmarried women, the expected births might have been slightly underestimated.

LIMITATIONS OF THIS STUDY

The foregoing eleven (11) issues indicate some of the constraints and limitations, some of which are generic to this type of study and a few due to deficiencies in the data which were not remediable within the given time-frame. In addition, because of the necessarily indirect or inferential method used for studying male fertility through female reproductive performance, a number of sweeping assumptions and/or approximations have been made. To start with, we are accepting the demographic and reproductive data, some of which is in rather sensitive areas, as elicited from the study subjects, at face value. Secondly, we are employing female fertility tables, based upon the national decennial census, and applying them to different regional populations. Such tables have the statistical strength of being based upon very large numbers, but the concomitant weakness of not recognizing the possibly very influential variables of regional variations, socio-economic status, religious preference, other cultural variables, marital status and contraceptive practices, including permanent sterilization. In fact the national fertility tables reflect only the impact of maternal age, calendar year, parity (number of children already born) and race in the very crude dichotomy of white/non-white (Mexican women are included explicitly in the white category).

Perhaps the biggest imponderable of all however, stems from the fact that effective human fertility or reproduction performance is determined by a complex interaction of volitional and biological variables of which nationally observed fertility rates are a gross resultant, from which specific regional, occupational, socio-economic and cultural subgroups may deviate markedly. Such deviation from "national average behavior" may be particularly significant in such areas as contraceptive practices. One way to address these influential variables, so difficult to assess directly, would be to study the reproductive performance of in-plant control groups, unexposed to DBE, but presumably comparable for many of the concomitant variables.

ANALYSIS AND RESULTS

I. American Data

For each company and each calendar year, the number of woman-years 9 months after the onset of the husbands' DBE exposure, or date of marriage, to the end of September, 1977 (end of 1975 for Dow since in 1976 DBCP was introduced), was computed by maternal age, by parity and by race. The time interval between divorce and remarriage has been excluded, since the couple was not "at risk" during this period. In the computation, parity was adjusted after each birth. The indirect method of standardization was used to adjust for the confounding effects of maternal age, parity, race and calendar year on birth rates. To obtain the expected births, age-parity-year-race-specific birth probabilities for successive U.S. birth cohorts published by the National Center for Health Statistics (Fertility Tables for Birth Cohorts by Color: United States, 1917-1973 and Supplementary Tables, 1974-1975) were applied to the woman-years. For the years 1976, and 1977 standard rates are not available, and the 1975 rates were used. An illustrative example has been included in Appendix II. By this methodology, the expected births are adjusted for age, parity, year and race. The ratios of observed births to expected births were computed as an index of fertility. A standardized fertility ratio larger (smaller) than one indicates higher (lower) fertility of the study group than the U.S. cohorts. A statistical test based on the Poisson distribution was employed to detect any significant departure from unity at the 0.05 level. When the number of observed births is less than 5, caution must be exercised in interpreting the ratio.

Results

A. Great Lakes

Original number of married subjects = 81

Race-Exposure groups	Number of Subjects	Observed Births	Expected Births	Observed/Expected
White; (< 0.5 ppm)	9	4	2.832	1.412 not significant
White; (0.5 - 5.0 ppm)	65	15	16.559	0.906 not significant
All Whites	74	19	19.391	0.980 not significant
All Nonwhites	7	0	1.415	- -
Both Races & Exposure Groups	81	19	20.806	0.913 not significant

Results

B. Ethyl

Original number of married subjects = 105

Race-Exposure groups	Number of Subjects	Observed Births	Expected Births	Observed/Expected
White; (< 0.5 ppm)	71	7	10.063	0.696 not significant
White; (0.5 - 5.0 ppm)	29	5	3.379	1.480 not significant
All Whites	100	12	13.442	0.893 not significant
All Nonwhites	5	1	0.198	5.050 not significant
Both Races & Exposure Groups	105	13	13.640	0.953 not signicicant

NOTE: One birth occurred 8 months after exposure.
One birth occurred 7 months after exposure.
Both of these were counted as "before-exposure" births.

Results

C. DOW

Original number of married subjects = 56

12 were excluded from analysis, because their exposure dates were after January 1976 (DBCP was introduced that time).

Race-Exposure groups	Number of Subjects	Observed Births	Expected Births	Observed/Expected
White; (< 0.5 ppm)	22	9	9.373	0.960 not significant
White; (0.5 - 5.0 ppm)	15	8	7.422	1.078 not significant
All Whites	37	17	16.795	1.012 not significant
All Nonwhites	7	0	0.422	- -
Both Races & Exposure Groups	44	17	17.217	0.987 not significant

Results

D. Houston

Original number of married subjects = 70

3 were excluded from analysis, because the dates of birth of their former wives were not recorded. In two of these three, their former wives gave 3 births after exposure.

Race-Exposure groups	Number of Subjects	Observed Births	Expected Births	Observed/Expected
White	52	11	22.197	0.496 significant at 0.05
Nonwhite	15	2	3.317	0.603 not significant
Both	67	13	25.514	.510 significant at 0.05

It should also be pointed out that among the 67 included in the analysis, there are:

18	vasectomies
1	sterility due to mumps
1	hysterectomy
1	sterility due to x-ray treatment in childhood
1	low sperm count sine age 21.
22	

It seems there is an unusually high ($\frac{22}{67}$ or 33%) proportion of sterility known to be unrelated to occupational exposure. Among the 3 excluded from analysis, 2 had vasectomy.

Excluding the 18 vasectomy and the one hysterectomy subjects from analysis following date of vasectomy or hysterectomy, the results are as follows:

Race-Exposure groups	Number of Subjects	Observed Births	Expected Births	Observed/Expected
White	34	11	18.108	.607 Not significant
Nonwhites	15	2	3.317	0.603 not significant
Both	49	13	21.425	0.607 not significant

Results

All Four U.S. Plants

Race-Exposure groups	Number of Subjects	Observed Births	Expected Births	Observed/Expected
White; < 0.5 ppm; (excluding Houston)	102	20	22.268	0.898 not significant
White; 0.5 - 5.0 ppm; (excluding Houston)	109	28	27.360	1.023 not significant
White; all exposures;	263	59	71.825	0.821 not significant
Nonwhite; all exposures	34	3	5.352	0.560 not significant
Both races; all exposures	297	62	77.177	0.803 not significant

II. British Data

The 82 married male employees were divided into four exposure groups:

(1) non-exposure to DBE (N=41)
(2) occasional exposure (N=17)
(3) regular exposure (N=13), and
(4) irregular exposure (N=11).

For each exposure group, the number of person-years of observation since joining the company (onset of exposure) was computed by age of father and by parity at the time of joining the company. The indirect method of standardization was employed to adjust for the confounding effects of paternal age and parity on birth rates. The age- or parity-specific birth rates per person-year for the non-exposed group were used as the standard. The indirect method of standardization was chosen, because, among the four, the non-exposed group is the largest, and, accordingly, its rates would be more stable than those in the other groups. The standard birth rates from the non-exposed group were applied to the age- or parity-specific person-years in each of the three exposed groups to obtain the expected births. The expected births are the number of births one would expect to observe in the exposed group, had the latter been experiencing the same fertility rates as the non-exposed group. As an index, the ratio of the actually observed births in each exposed group to the expected births was formed. These indirectly standardized fertility ratios are adjusted for age or parity. A ratio larger (smaller) than one indicates higher (lower) fertility of the exposed group than the non-exposed group. Because of the extremely small numbers in the exposed groups, it was not feasible to carry out the analysis adjusting for both paternal age and parity simultaneously.

Results

(1) Adjusting for age

Exposure	Observed Births	Expected Births	Observed/Expected
Occasional	14	17.19	0.81
regular	8	7.16	1.12
irregular	13	15.43	0.84
combined	35	39.78	0.88

(2) Adjusted for parity

Exposure	Observed Births	Expected Births	Observed/Expected
occasional	14	9.71	1.44
regular	8	7.74	1.03
irregular	13	9.56	1.36
combined	35	27.01	1.30

Treating the number of observed births as a Poisson random variable, none of the ratios is significantly different from one at the 0.05 level. This statistical test is only an approximate one, since the standard rates are based on a fairly small sample (N=41).

DISCUSSION OF RESULTS

With the exception of the Houston plant cohort, the results of all the remaining three U.S. plants are extremely close to unity, i.e. a negative result for any postulated anti-fertility effect of EDB exposures at these levels. Where high and low exposure categories (0.5 - 5.0 ppm vs. <0.5 ppm) are looked at separately there is no consistent evidence of a dose-response relationship. None of the small deviations from unity seen, in either direction, have statistical significance at the 0.05 level, largely due to the extremely small numbers in the sub-group cells, and the even smaller numbers of "events" i.e. births, upon which our analysis is based.

In the Houston cohort alone, the observed/expected births ratio is consistently and significantly low, suggesting a possible anti-fertility effect. Relative exposure categories were not available from the Houston Chemical Company, so it is impossible to address a possible dose-response relationship. It should be pointed out that the prevalence of vasectomy among the EDB workers at this plant was extremely high (18 out of 67 married workers eligible for inclusion in the study). To this must be added four other cases of sterility of either husband or wife from pre-existing causes, giving a total of 22/67 couples or 33% of the study group who do not offer a valid test of the potential antifertility effect of exposure to EDB. Although the prevalence of permanent sterility from all causes, including vasectomy, in the general population, from a section of which our expected fertility rates are derived, is not known, it is extremely unlikely that it could be as high as 33%. The Houston cohort results therefor would appear to be somewhat anomalous. At the same time it would be of interest to know what their EDB exposure levels were, at least in terms relative to the other plants.

The results of the British plant studied, having been derived by a totally different approach, are not comparable with the American cohorts. Such as they are, however, they would appear to be negative, though lacking statistical significance at the 0.05 level.

TABLE 98. BIRTH PROBABILITIES FOR WHITE WOMEN FOR EACH YEAR 1917-73 BY AGE AND PARITY FOR GROUPS OF COHORTS FROM 1868-72 TO 1954-58--CON.

(PROBABILITIES ARE THE NUMBER OF BIRTHS PER 1,000 WOMEN IN SPECIFIED PARITY AND EXACT AGE GROUP. FIGURES IN THE "0 PARITY" COLUMN SHOW THE PROBABILITY OF FIRST BIRTHS TO "0 PARITY" WOMEN, THOSE IN THE "1 PARITY" COLUMN SHOW THE PROBABILITY OF SECOND BIRTHS TO "1 PARITY" WOMEN, ETC. BASED ON CENTRAL BIRTH RATES AND PARITY DISTRIBUTIONS FOR GROUPS OF COHORTS)

EXACT AGE AND COHORT	AS OF JANUARY 1	PARITY							
		0	1	2	3	4	5	6	7 AND HIGHER
20-24 YEARS									
1893-1897	1917	115.6	264.5	277.9	277.9	302.8	*	*	*
1894-1898	1918	117.7	253.9	270.2	276.9	298.1	*	*	*
1895-1899	1919	90.2	236.9	255.0	270.8	288.5	*	*	*
1896-1900	1920	118.4	245.1	253.8	276.0	303.9	*	*	*
1897-1901	1921	123.4	232.1	259.0	290.5	326.7	*	*	*
1898-1902	1922	110.7	229.6	239.8	272.2	297.0	*	*	*
1899-1903	1923	107.9	235.4	243.1	286.1	*	*	*	*
1900-1904	1924	112.6	231.3	249.8	288.8	*	*	*	*
1901-1905	1925	108.8	218.3	242.7	278.6	*	*	*	*
1902-1906	1926	105.4	213.1	233.1	276.7	*	*	*	*
1903-1907	1927	103.5	208.6	228.9	281.1	*	*	*	*
1904-1908	1928	98.4	200.2	222.1	266.1	*	*	*	*
1905-1909	1929	93.4	196.8	215.8	257.9	*	*	*	*
1906-1910	1930	94.8	197.8	216.0	259.7	*	*	*	*
1907-1911	1931	88.6	191.6	207.5	250.8	*	*	*	*
1908-1912	1932	83.7	188.6	203.6	248.3	*	*	*	*
1909-1913	1933	77.7	181.6	197.2	241.8	*	*	*	*
1910-1914	1934	83.0	188.9	204.1	252.9	*	*	*	*
1911-1915	1935	86.3	181.9	198.5	250.0	*	*	*	*
1912-1916	1936	87.0	183.0	196.4	249.0	*	*	*	*
1913-1917	1937	90.0	186.8	198.4	253.3	*	*	*	*
1914-1918	1938	93.3	192.8	204.1	253.3	*	*	*	*
1915-1919	1939	90.4	187.4	195.2	242.3	*	*	*	*
1916-1920	1940	92.2	194.2	206.0	262.0	*	*	*	*
1917-1921	1941	104.5	201.1	204.0	254.2	*	*	*	*
1918-1922	1942	127.6	214.9	207.5	250.0	*	*	*	*
1919-1923	1943	119.0	217.3	218.0	264.8	*	*	*	*
1920-1924	1944	107.6	192.1	205.1	255.6	*	*	*	*
1921-1925	1945	102.4	168.6	177.3	225.9	*	*	*	*
1922-1926	1946	142.4	234.8	207.1	248.0	*	*	*	*
1923-1927	1947	179.7	246.4	206.8	239.0	*	*	*	*
1924-1928	1948	159.6	236.9	208.0	239.5	*	*	*	*
1925-1929	1949	151.3	247.3	211.4	250.9	*	*	*	*
1926-1930	1950	142.9	252.6	213.9	246.0	*	*	*	*
1927-1931	1951	156.6	272.7	223.8	253.5	*	*	*	*
1928-1932	1952	160.3	283.0	226.3	251.9	*	*	*	*
1929-1933	1953	162.4	297.4	230.6	253.4	283.2	*	*	*
1930-1934	1954	170.7	310.2	238.7	257.4	285.7	*	*	*
1931-1935	1955	174.7	316.7	243.0	256.9	287.8	*	*	*
1932-1936	1956	183.4	328.7	252.2	262.0	288.6	*	*	*
1933-1937	1957	187.9	336.4	258.1	263.1	285.7	*	*	*
1934-1938	1958	183.9	334.4	256.6	260.7	286.5	*	*	*
1935-1939	1959	181.6	339.7	260.7	264.0	284.9	*	*	*
1936-1940	1960	179.0	340.4	263.1	266.6	288.8	*	*	*
1937-1941	1961	175.6	335.8	261.2	264.2	285.7	*	*	*
1938-1942	1962	166.4	325.6	255.0	255.5	278.0	*	*	*
1939-1943	1963	159.2	317.0	243.2	237.7	254.9	*	*	*
1940-1944	1964	153.8	301.9	226.6	219.3	241.0	*	*	*
1941-1945	1965	141.2	271.7	194.3	190.0	209.0	*	*	*
1942-1946	1966	140.6	253.0	171.9	168.5	183.0	*	*	*
1943-1947	1967	132.4	243.4	164.3	168.5	187.5	*	*	*
1944-1948	1968	130.1	231.8	155.5	163.4	175.9	*	*	*
1945-1949	1969	127.9	229.1	159.3	176.1	*	*	*	*
1946-1950	1970	127.9	227.9	161.4	176.7	*	*	*	*
1947-1951	1971	114.5	209.9	148.5	162.2	*	*	*	*
1948-1952	1972	97.9	187.1	123.3	138.2	*	*	*	*
1949-1953	1973	88.3	181.5	115.3	127.6	*	*	*	*
	1974	86.2	188.0	114.9	124.4	*	*	*	*
	1975	82.0	184.6	115.0	130.7	*	*	*	*
	1976	82.0	184.6	115.0	130.7	*	*	*	*
	1977	82.0	184.6	115.0	130.7	*	*	*	*

APPENDIX I

TABLE 98. BIRTH PROBABILITIES FOR WHITE WOMEN FOR EACH YEAR 1917-73 BY AGE AND PARITY FOR GROUPS OF COHORTS FROM 1868-72 TO 1954-58--CON.

ROBABILITIES ARE THE NUMBER OF BIRTHS PER 1,000 WOMEN IN SPECIFIED PARITY AND EXACT AGE GROUP. FIGURES IN THE "0 PARITY" COLUMN SHOW THE PROBABILITY OF FIRST BIRTHS TO "0 PARITY" WOMEN, THOSE IN THE "1 PARITY" COLUMN SHOW THE PROBABILITY OF SECOND BIRTHS TO "1 PARITY" WOMEN, ETC. BASED ON CENTRAL BIRTH RATES AND PARITY DISTRIBUTIONS FOR GROUPS OF COHORTS]

EXACT AGE AND COHORT	AS OF JANUARY 1	PARITY							
		0	1	2	3	4	5	6	7 AND HIGHER
29 YEARS									
1888-1892	1917	94.1	195.0	211.1	247.5	277.1	307.7	314.0	*
1889-1893	1918	98.8	190.6	203.8	242.9	273.0	302.4	302.5	*
1890-1894	1919	79.3	178.7	188.9	230.0	264.6	289.2	299.1	*
1891-1895	1920	101.0	179.2	187.6	230.6	268.5	295.4	312.5	*
1892-1896	1921	106.9	171.2	187.1	232.2	278.1	316.5	333.3	*
1893-1897	1922	98.7	168.0	171.9	214.4	255.5	293.0	309.1	*
1894-1898	1923	96.7	168.8	170.0	213.9	264.8	306.8	327.1	*
1895-1899	1924	97.9	164.8	169.5	211.9	261.6	305.0	320.8	*
1896-1900	1925	94.4	158.0	163.5	204.4	252.3	292.5	301.9	*
1897-1901	1926	90.9	150.7	155.5	200.4	244.8	292.7	310.7	*
1898-1902	1927	89.5	144.7	150.9	202.1	247.6	294.1	*	*
1899-1903	1928	87.1	137.6	143.2	189.6	236.5	280.9	*	*
1900-1904	1929	84.9	131.5	136.5	180.7	227.9	265.2	*	*
1901-1905	1930	87.2	130.5	135.4	180.2	226.7	267.9	*	*
1902-1906	1931	83.5	125.0	129.0	174.2	217.1	256.9	*	*
1903-1907	1932	77.4	120.6	126.7	172.8	215.2	258.4	*	*
1904-1908	1933	70.9	116.0	121.4	168.5	205.4	237.4	*	*
1905-1909	1934	73.7	121.8	125.3	173.5	214.1	252.7	*	*
1906-1910	1935	75.3	119.5	119.5	165.9	207.8	252.8	*	*
1907-1911	1936	76.4	119.8	117.2	163.1	202.0	254.4	*	*
1908-1912	1937	80.6	122.8	116.4	162.8	205.3	259.5	*	*
1909-1913	1938	85.7	128.3	120.0	166.7	206.1	260.0	*	*
1910-1914	1939	86.9	126.8	116.9	160.3	198.8	250.0	*	*
1911-1915	1940	92.4	132.6	120.7	161.9	202.4	262.8	*	*
1912-1916	1941	105.1	137.9	121.5	164.4	204.3	263.2	*	*
1913-1917	1942	128.6	154.8	127.8	165.8	203.1	250.0	*	*
1914-1918	1943	119.2	169.9	142.2	179.9	220.2	272.7	*	*
1915-1919	1944	101.7	156.8	135.1	171.9	216.6	264.7	*	*
1916-1920	1945	98.5	155.6	126.4	158.5	198.8	250.0	*	*
1917-1921	1946	145.4	190.7	136.0	163.9	201.1	248.2	*	*
1918-1922	1947	176.1	202.9	140.3	158.1	193.4	237.8	*	*
1919-1923	1948	153.5	188.3	135.5	150.4	187.5	237.8	*	*
1920-1924	1949	147.9	192.5	137.5	154.6	191.9	244.8	*	*
1921-1925	1950	141.6	197.9	140.6	156.4	188.5	241.1	*	*
1922-1926	1951	150.3	209.8	147.7	165.1	198.5	253.5	*	*
1923-1927	1952	151.8	219.3	155.2	169.9	203.7	253.3	*	*
1924-1928	1953	148.1	225.9	157.2	170.0	202.2	250.0	*	*
1925-1929	1954	146.3	235.6	163.3	173.1	205.9	255.6	*	*
1926-1930	1955	144.4	241.1	167.0	173.5	201.4	251.3	*	*
1927-1931	1956	145.7	250.4	172.1	175.0	198.7	248.9	*	*
1928-1932	1957	150.0	260.7	177.9	178.2	198.8	242.8	*	*
1929-1933	1958	148.1	260.5	177.0	176.0	195.9	239.7	*	*
1930-1934	1959	146.7	261.5	179.8	179.4	195.4	237.1	278.8	*
1931-1935	1960	145.5	261.7	181.1	179.4	192.6	237.2	283.2	*
1932-1936	1961	142.2	257.4	180.0	177.4	193.7	232.6	272.7	*
1933-1937	1962	136.8	247.9	173.2	170.3	184.9	224.4	257.8	*
1934-1938	1963	132.3	242.7	167.6	162.6	174.5	212.1	246.3	*
1935-1939	1964	136.0	238.7	161.6	153.6	163.8	192.9	222.2	*
1936-1940	1965	128.5	222.6	144.5	132.4	138.9	164.8	194.0	*
1937-1941	1966	129.8	211.8	129.0	113.8	120.0	142.9	168.0	*
1938-1942	1967	126.2	206.3	121.6	105.8	111.1	132.3	162.2	*
1939-1943	1968	132.0	204.4	116.4	101.2	105.3	127.7	*	*
1940-1944	1969	127.0	206.4	119.1	106.7	113.3	136.2	*	*
1941-1945	1970	125.6	206.8	119.7	109.1	116.7	137.3	*	*
1942-1946	1971	117.0	191.5	107.7	101.5	110.5	129.9	*	*
1943-1947	1972	105.1	176.1	89.6	84.4	92.8	111.1	*	*
1944-1948	1973	100.2	176.8	80.5	75.9	82.9	100.8	*	*
	1974	100.1	171.5	78.1	73.5	82.6	94.3	*	*
	1975	95.9	165.3	76.6	73.5	83.3	*	*	*
	1976	95.9	165.3	76.6	73.5	83.3	*	*	*
	1977	95.9	165.3	76.6	73.5	83.3	*	*	*

TABLE 98. BIRTH PROBABILITIES FOR WHITE WOMEN FOR EACH YEAR 1917-73 BY AGE AND PARITY FOR GROUPS OF COHORTS FROM 1868-72 TO 1954-58--CON.

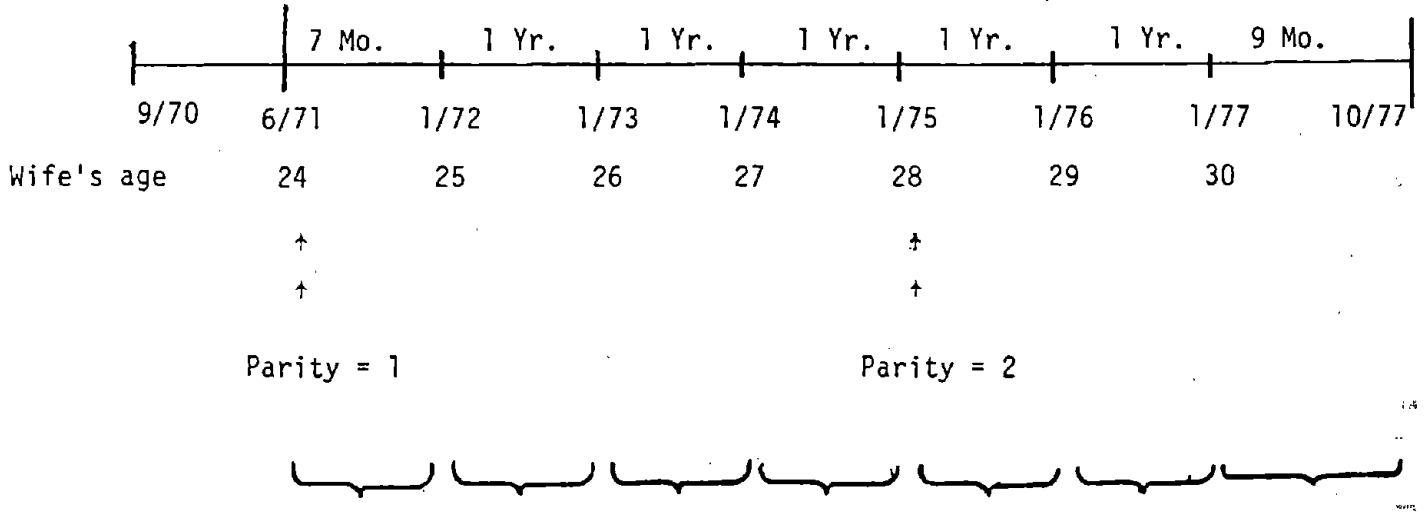
(PROBABILITIES ARE THE NUMBER OF BIRTHS PER 1,000 WOMEN IN SPECIFIED PARITY AND EXACT AGE GROUP. FIGURES IN THE "0 PARITY" COLUMN SHOW THE PROBABILITY OF FIRST BIRTHS TO "0 PARITY" WOMEN, THOSE IN THE "1 PARITY" COLUMN SHOW THE PROBABILITY OF SECOND BIRTHS TO "1 PARITY" WOMEN, ETC. BASED ON CENTRAL BIRTH RATES AND PARITY DISTRIBUTIONS FOR GROUPS OF COHORTS)

EXACT AGE AND COHORT	AS OF JANUARY 1	PARITY							
		0	1	2	3	4	5	6	7 AND HIGHER
30-34 YEARS									
1883-1887	1917	43.6	110.3	123.2	156.7	194.4	235.6	249.4	272.3
1884-1888	1918	46.3	107.8	119.8	152.6	192.3	233.8	256.5	281.7
1885-1889	1919	41.3	105.3	115.8	145.7	182.4	227.3	245.8	284.3
1886-1890	1920	47.9	106.9	115.3	143.8	181.3	226.1	245.8	293.5
1887-1891	1921	49.4	107.0	114.8	146.9	180.9	232.1	258.0	317.1
1888-1892	1922	48.9	104.9	107.1	131.9	167.7	217.7	240.6	296.1
1889-1893	1923	47.9	101.8	104.0	130.4	169.0	220.8	244.8	312.8
1890-1894	1924	49.2	99.1	103.9	128.5	167.9	219.2	246.7	308.7
1891-1895	1925	49.2	93.7	98.2	122.9	161.7	211.1	240.4	303.6
1892-1896	1926	47.3	88.7	93.6	117.9	154.3	205.4	236.6	291.4
1893-1897	1927	47.7	84.8	88.5	114.6	153.8	208.2	236.2	297.1
1894-1898	1928	46.5	80.9	82.8	107.3	146.5	199.2	222.9	280.1
1895-1899	1929	45.8	77.8	78.5	101.8	141.7	192.0	211.8	271.9
1896-1900	1930	47.6	77.5	77.5	102.4	143.0	196.3	213.6	274.5
1897-1901	1931	45.5	73.2	74.0	98.0	138.0	189.8	206.7	267.1
1898-1902	1932	42.9	69.4	70.6	95.8	136.4	189.0	207.6	269.8
1899-1903	1933	40.4	64.4	66.8	92.1	129.9	179.1	200.7	255.6
1900-1904	1934	42.9	67.1	67.5	94.4	131.5	180.8	203.8	265.9
1901-1905	1935	44.9	65.0	64.7	90.1	124.8	172.3	202.4	276.2
1902-1906	1936	46.2	64.9	63.0	86.5	119.6	166.7	196.7	269.9
1903-1907	1937	48.5	66.9	62.2	85.9	117.6	165.8	200.9	274.4
1904-1908	1938	50.9	71.0	63.3	85.4	117.3	166.2	202.8	275.9
1905-1909	1939	52.3	73.5	63.3	84.4	114.1	160.3	195.0	264.2
1906-1910	1940	54.0	79.0	65.4	85.8	113.1	163.1	195.8	280.2
1907-1911	1941	59.3	83.3	66.9	86.8	114.7	161.8	194.4	271.7
1908-1912	1942	70.2	93.8	71.8	91.1	119.1	161.6	197.7	268.3
1909-1913	1943	68.2	105.3	83.4	102.2	131.2	176.5	207.3	286.6
1910-1914	1944	60.3	103.1	85.4	103.7	133.7	181.8	218.8	289.5
1911-1915	1945	61.2	112.2	87.9	101.4	128.7	176.1	208.9	288.6
1912-1916	1946	83.6	124.9	91.9	102.7	127.6	175.4	205.1	260.8
1913-1917	1947	98.4	129.0	91.5	100.0	121.9	162.6	192.3	272.7
1914-1918	1948	82.1	119.0	85.6	93.5	114.8	155.9	187.1	269.5
1915-1919	1949	78.1	119.4	84.0	94.3	114.6	153.3	194.8	285.7
1916-1920	1950	75.4	121.6	85.7	95.3	113.8	154.6	187.1	273.4
1917-1921	1951	80.1	125.2	90.2	98.8	118.0	154.8	194.8	271.4
1918-1922	1952	83.7	128.3	95.2	105.2	123.6	160.4	193.5	269.5
1919-1923	1953	83.1	126.9	97.6	106.8	125.3	160.6	195.0	265.7
1920-1924	1954	85.5	129.4	99.1	109.8	126.5	166.2	195.1	277.8
1921-1925	1955	83.1	126.4	98.9	109.5	128.4	167.6	203.5	272.1
1922-1926	1956	80.8	126.6	99.2	109.6	129.1	166.7	202.2	276.3
1923-1927	1957	80.8	128.0	100.8	110.2	129.0	166.3	203.0	275.0
1924-1928	1958	76.0	124.8	98.4	107.2	124.8	159.8	194.3	269.0
1925-1929	1959	72.1	124.4	97.3	106.3	123.6	160.6	193.0	273.2
1926-1930	1960	68.2	125.4	96.2	104.6	120.7	156.4	191.1	269.0
1927-1931	1961	66.1	126.3	95.8	103.5	119.2	154.2	187.3	266.4
1928-1932	1962	63.0	123.1	91.6	97.0	112.6	145.6	177.7	253.2
1929-1933	1963	63.4	121.8	89.0	94.0	107.3	138.7	172.6	239.0
1930-1934	1964	70.5	121.4	86.9	90.0	99.7	129.5	156.9	222.6
1931-1935	1965	68.9	115.0	80.3	80.0	87.8	112.5	136.9	189.1
1932-1936	1966	68.2	108.2	72.9	69.8	76.1	95.7	117.3	169.1
1933-1937	1967	62.7	104.5	68.5	64.5	68.9	85.2	104.8	148.9
1934-1938	1968	68.0	103.8	64.7	58.9	62.2	76.0	93.5	139.9
1935-1939	1969	63.1	103.8	65.4	58.5	62.4	77.8	93.6	135.7
1936-1940	1970	64.0	104.6	64.6	57.7	62.3	76.2	90.3	136.4
1937-1941	1971	59.3	99.3	57.5	52.6	57.5	71.4	87.0	125.7
1938-1942	1972	55.8	96.6	49.2	44.4	49.0	61.3	75.2	111.8
1939-1943	1973	54.0	93.8	44.6	39.5	43.3	55.9	71.4	101.6
	1974	53.7	95.2	42.5	37.3	40.8	52.0	65.9	104.8
	1975	52.9	93.6	40.8	36.2	40.0	51.8	71.4	*
	1976	52.9	93.6	40.8	36.2	40.0	51.8	71.4	*
	1977	52.9	93.6	40.8	36.2	40.0	51.8	71.4	*

APPENDIX B

Example

Race = White
Wife's date of birth = 9/1946
Date of marriage = 5/1968
Date of birth of first child = 8/1970
Date of exposure to EDB = 9/1970
Date of birth of second child = 12/1974



Expected Births Σ $.2099 \times \frac{7}{12} = .1224$ + .1761 + .1708 + .1715 + .0766 + .0766 $.0408 \times \frac{9}{12} = .0306$

Sum of expected births from 6/1971 to 9/1977 = .8246

During the same time interval, one birth was observed.

Explanation:

The starting point on the birth probability table (see Appendix I) is established from the woman's age, the calendar year and her parity at the point of entry into the study period. The subsequent annual birth probabilities are read from appropriate age cohort-section of the table for each successive calendar year (i.e. descending the vertical column), until the birth of her next child, when one moves horizontally to

the next parity column and starts to descend again for each successive year. Thus, one makes a stepwise progression down and across the tables. Birth probabilities for the partial calendar years at the beginning and end of the study period are proportionated to the nearest month. Finally, all these probabilities are summed to give the cumulative probability of births for the whole study period (i.e. the duration of exposure of the husband to EDB, excluding the initial 9 months).

[Note: the probabilities as printed in the tables are expressed per 1,000 women and have therefore been divided by 1000 to obtain individual probabilities.]