

Work With Video Display Terminals and the Risk of Reduced Birthweight and Preterm Birth

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To determine whether the use of video display terminals (VDTs) is associated with an increased risk of reduced birthweight (RBW) and preterm birth, a cohort of telephone operators who used VDTs at work was compared to a cohort of non-VDT-users. Among 2,430 women interviewed, 713 eligible singleton live births were reported. Exposure was estimated from company records and a representative sample of electromagnetic fields was measured at the VDT workstations. For RBW ($\leq 2,800$ g), we found no excess risk associated with any VDT use during pregnancy (odds ratio [OR] = 0.9; 95% confidence interval [CI] = 0.5–1.7). For preterm birth (≤ 37 weeks), we similarly found no excess risk (OR = 0.7; 95%CI = 0.4–1.1). The risks estimated did not change substantially when hours working with VDTs were used as exposure variables. By contrast, increased risks were found for several known risk factors for LBW and preterm birth. We conclude that occupational VDT use does not increase the risk of RBW and preterm birth. Am. J. Ind. Med. 32:681–688, 1997. © 1997 Wiley-Liss, Inc.[†]

KEY WORDS: computer terminals; electromagnetic fields; pregnancy; pregnancy outcome; birthweight; infant, premature

INTRODUCTION

The potential effects of working with video display terminals (VDTs) on perinatal outcomes have been of continuing interest since the first clusters of adverse pregnancy outcomes were reported in 1980. Most studies, however, have reported only equivocal associations of VDTs with low birthweight (LBW), preterm birth, and birth defects [Delpizzo, 1994].

Since 1986, eight studies have been published in which the association between VDTs and LBW was investigated [Ericson et al., 1986a,b; McDonald et al., 1988; Nurminen

et al., 1988; Windham et al., 1990; Nielsen et al., 1992; Parazzini et al., 1993; Bracken et al., 1995]. In these studies, exposure to VDTs was estimated by using either job titles or self-reported interview data. Most odds ratios (ORs) for delivering a low-birthweight infant were within the range of 0.5–1.1 and did not suggest an LBW-VDT association. The study by Windham et al. [1990] reported an OR of 1.6 (95%CI = 0.9–2.9) for intrauterine growth retardation (IUGR), suggesting an effect of VDT exposure on fetal growth. A decreased risk of LBW was suggested for the offspring of women who used VDTs at home or at work for 1–20 hr/week [Bracken et al., 1995].

Birthweight has long been considered the perinatal outcome of primary interest because of its effect on infant survival. Recently, however, Wilcox et al. [1995] concluded that although most preterm infants are LBW, prematurity rather than LBW has the predominant effect on infant survival. Relatively little is known about the effect of VDTs on preterm birth. Two studies on VDTs and preterm birth reported crude ORs of 1.2 [Nurminen et al., 1988; Windham et al., 1990]. Two other studies, by McDonald et al. [1988] and Nielsen and Brandt [1992], reported adjusted ORs of 1.1 (90%CI = 1.0–1.2) and 1.1 (95%CI = 0.9–1.5), respectively.

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Ericson and Källén [1986b] reported an OR of 2.3 (95%CI = 1.4–3.9) for the combined category of birth defects, very low birthweight (VLBW) and perinatal mortality among women who worked with VDTs of more than 20 hr/week. Other studies did not suggest an association between VDT use and birth defects [McDonald et al., 1988; Goldhaber et al., 1988; Brandt et al., 1990].

This paper describes the second part of a study in which we examined the association between working with VDTs and adverse perinatal outcomes in two groups of female telephone operators with similar work situations. We obtained data on VDT use from the employers' records and measured electric and magnetic fields (EMFs) at a sample of the operators' workstations. In the first part of this study, the use of VDTs and exposure to VDT characteristic EMFs were found not to be associated with an increased risk of spontaneous abortion [Schnorr et al., 1991].

MATERIALS AND METHODS

Study Population

The study population consisted of 2,430 married women aged 18–33 years who were employed as either directory-assistance operators or general telephone operators (reached by dialing 0) at two companies in eight southeastern states. The directory assistance (VDT-exposed) operators used VDTs to provide telephone numbers to customers. The comparison group of general (unexposed) operators primarily assisted customers in placing long-distance calls. Two VDT models were used by the VDT-exposed operators during the study period: International Business Machines (IBM) model 4978 and Computer Consoles Inc. (CCI) model 4500. The unexposed operators used units containing a light-emitting diode (LED) or neon glow tube (NGT) to display the numbers, rather than a VDT. Typically, both VDT-exposed and unexposed operators worked 7 hr/day in front of the equipment. Both groups of operators were monitored by a supervisor and by a computer that recorded the number and length of calls. Education and salary levels were similar for both VDT-exposed and -unexposed operator positions. We did not observe any differences in work practices between the two groups other than the presence or absence of VDTs.

Data Collection

A telephone interview was used to collect lifetime reproductive histories, including the outcome of all pregnancies inside and outside the study period, defined as the period from January 1, 1983 through December 31, 1986. Birthweight and gestational age questions were asked as follows: "How much did he/she weigh at birth?" and "Did

the doctor say your baby was born early, late or on time? If early or late, how many weeks?" Use of VDTs at home was obtained by self-report during the interview. Data were also collected on potential confounders or effect modifiers including race, age, smoking habits, pregnancy complications, medical history, and interpregnancy interval. Interpregnancy interval was defined as the time between the end date of the previous pregnancy and the estimated start date of the last menstrual period before the index pregnancy. For validation purposes, birth certificates were collected for live births and medical records were requested for infants with a reported birth defect.

VDT-exposed operators used VDTs exclusively whereas unexposed operators only used units containing a LED or NGT. Neither group of operators had any other duties. Thus, company records of dates of employment as a VDT-exposed or unexposed operator and interview data on dates of pregnancy were used to ascertain the women's use of VDTs for each trimester of pregnancy. For VDT-exposed operators, we also used weekly payroll records to calculate the hours of VDT use during each study pregnancy.

In 1990, the EMFs emitted by the two models of VDTs and the LED/NGT equipment in use during the study period were measured [Schnorr et al., 1991; Tell, 1990]. Both VDT operators and LED/NGT operators were exposed to extremely low-frequency electric and magnetic fields (ELF, 45–60 Hz) in the same range as reported average home exposures. The abdominal ELF geometric means were with the range of 0.4–0.8 V/m for the electric field and 32.4–62.4 mA/m for the magnetic field. VDT-exposed operators were exposed to above-background levels of very low-frequency electric and magnetic fields (VLF, approximately 15 kHz). Their measured abdominal VLF geometric means were with the range of 0.1–0.5 V/m for the electric field and 4.0–17.4 mA/m for the magnetic field.

Outcome Definitions

Pregnancies that met the following criteria were included in the analyses: the pregnancy resulted in a singleton live birth during the study period, and the mother was employed for at least 1 day as a VDT-exposed operator or -unexposed operator during the first 28 weeks of pregnancy. The estimated date of the last menstrual period was considered the start date of each pregnancy. Gestational age was calculated as the number of weeks between the estimated last menstrual period and the date of birth. Reduced birthweight (RBW) was defined as $\leq 2,800$ g. We chose this cutpoint for RBW due to small numbers of live births that met the traditional LBW definition of $< 2,500$ g. Preterm birth was defined as a live birth of 21–37 weeks gestation. The criteria identified by Erickson et al. [1984] were used to define and identify infants with major birth defects. These

birth defects are included in codes 740.0–759.9 of the International Classification of Disease (ICD), Ninth Revision, and are considered to affect survival, require substantial medical care, result in marked physical or psychological handicaps, or interfere with a baby's prospect for life.

Definition of VDT Use

VDT use was initially defined as a dichotomous variable for the entire pregnancy and for each trimester separately. Pregnancies or trimesters in which the mother worked as a VDT-exposed operator at any time were classified as exposed. If the mother worked as a unexposed operator only, the pregnancy or trimester was classified as unexposed. From payroll records, we calculated the actual hours of VDT work for each study pregnancy of a VDT-exposed operator by trimester and for the total pregnancy. Analysis of actual hours worked was crucial because work hours might have varied depending on the stage of pregnancy when hired, the timing of vacations, the amount of leave used, and the number of hours worked on a given day. We generated a trimester-specific index of weekly hours of VDT use by dividing the days of VDT use in each trimester by the days pregnant in each trimester. Similarly, we calculated hours of VDT use per week for the entire pregnancy. Pregnancies in which the mother worked as a unexposed operator only were assigned 0 hr of VDT use.

Statistical Analysis

Frequency distributions and stratified analyses were used to assess evidence of confounding and interaction by demographic, medical, and lifestyle variables. Of these variables, age, race, parity, gravidity, alcohol consumption, smoking, infant gender, gestational age (RBW analysis only), previous RBW or preterm live birth prior to the study period, other adverse pregnancy outcomes prior to the study period, diabetes, maternal weight gain during pregnancy, thyroid condition, hypertension medication during pregnancy, pre-eclampsia or toxemia, and interpregnancy interval were included as potential confounders in initial multivariable analyses. All these variables were also examined for interaction with VDT exposure. We used multiple logistic regression analysis to determine the relative odds of RBW and the relative odds of preterm birth. Multiple linear regression analysis was used to assess the effect of VDT use on continuous birthweight. To address the issue of correlated outcomes (multiple pregnancies per woman), we analyzed our linear and logistic regression models with the quasi-likelihood generalized estimating equations of Zeger and Liang [1986]. The effect of VDT exposure on risk of preterm birth was also analyzed in a proportional hazards model, and the marginal analysis approach of Wei et al. [1989] was used to account for multiple pregnancies per woman. For these

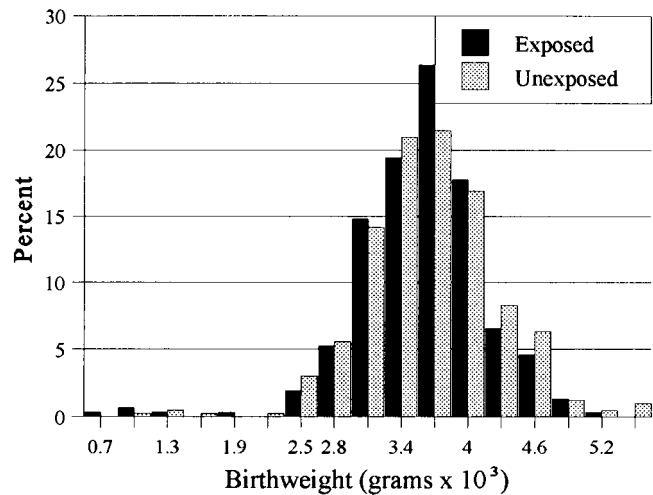


FIGURE 1. Crude distribution of birthweight in percentages by VDT use. Low birthweight and reduced birthweight cutoffs are at 2.5 (2,500 g) and 2.8 (2,800 g), respectively.

survival analyses, all pregnancies that ended after 20 weeks gestation during the study period were included, regardless of outcome. Analyses of residuals, multicollinearity, and goodness-of-fit were conducted to confirm that the final models did not violate analytic assumptions. Multivariable analyses of major birth defects and perinatal death were not conducted due to small sample sizes. PC-SAS® software was used for all statistical procedures [SAS Institute, 1989, 1994].

RESULTS

Details about response rates and demographic characteristics of the study population were reported previously [Schnorr et al., 1991]. Of the initial 5,544 employees found in company records, 94.9% of the 4,475 women we contacted agreed to participate. Among the 2,430 married women interviewed, 713 pregnancies from 647 women met our criteria of ending in a singleton live birth during the study period and employment of at least 1 day as a telephone operator. Of the 707 eligible pregnancies, there were 304 pregnancies in which the woman was exposed to VDTs at work at any time during pregnancy and 403 unexposed pregnancies. The 284 VDT-exposed operators and 363 unexposed operators were similar in age, lifetime number of pregnancies, and percentage employed at the study company at the time of the interview. VDT-exposed operators had worked slightly longer than unexposed operators at the study company (8.2 vs 7.6 years). The proportion with more than a high school education was higher among unexposed operators (36.2% vs 27.1%), as was the proportion of Hispanic women (9.1% vs 2.5%).

Figure 1 shows the crude distribution of birthweight in the study population. The percentage of RBW infants was

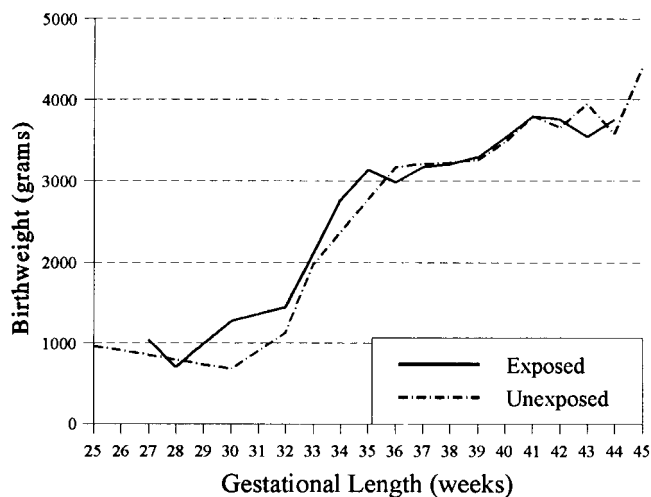


FIGURE 2. Birthweight and gestational length by VDT use.

8.9% ($n = 27$) in the exposed and 9.7% ($n = 39$) in the unexposed pregnancies. The distribution of mean birthweight by gestational age for exposed and unexposed pregnancies is depicted in Figure 2. No substantial differences appear to be present between the exposure groups. The logistic regression model for RBW included the dichotomous VDT exposure variable and independent risk factors, i.e., prematurity, race, smoking, use of diuretics, RBW infant prior to the study period, and interpregnancy interval (Table I). None of these risk factors appeared to be a confounder of exposure; crude and adjusted odds ratios for VDT use are equal. No significant interactions with exposure were found. No association was found between VDT use and reduced birthweight ($OR = 0.9$; $95\%CI = 0.5-1.7$). When the average number of hours per week (categorized as 0, 1-25, and >25 hr/week) of VDT use in the total pregnancy was substituted in the model, the coefficients for the other risk factors did not vary substantially. In this analysis, reduced birthweight did not appear to have a consistent relationship with hours of VDT use during pregnancy. The point estimates suggest the possibility of a decreased risk of RBW for women working with VDTs no more than an average of 25 hr/week, and a slightly increased risk ($OR = 1.4$, $95\%CI = 0.7-3.1$) for women working more than 25 hr/week. A similar pattern was found when trimester-specific hours worked per week (i.e., hr/week in first, second, or third trimester) were substituted into the model.

Two restricted analyses were performed to investigate the slightly increased risk of RBW for women working with VDTs for more than 25 hr/week. First, to determine whether degree of employment contributed to the increased estimate, we performed an analysis restricted to the pregnancies of study participants who had worked an average of 4 or more days/week (4 or more working days/week is roughly comparable to the 25+ hr/week category for continuous VDT

TABLE I. Crude and Adjusted Odds Ratios (OR) With 95% Confidence Intervals (CIs) for Reduced Birthweight (≤ 2800 g) Associated with Occupational VDT Use and Other Variables in the Logistic Model

Variable	No. of pregnancies	Crude OR	Adjusted		
			95%CI	OR ^a	95%CI
VDT use during pregnancy					
None	392	1.0		1.0	
Any	303	0.9	(0.5-1.5)	0.9	(0.5-1.7)
VDT use (hr/wk), total pregnancy ^b					
0	394	1.0		1.0	
1-25	116	0.5	(0.2-1.1)	0.4	(0.1-1.0)
>25	120	1.4	(0.7-2.6)	1.4	(0.7-3.1)
Born premature (≤ 37 weeks)					
No	627	1.0		1.0	
Yes	68	9.9	(5.5-17.8)	12.9	(6.6-25.3)
Race					
White	499	1.0		1.0	
Other	196	3.5	(2.1-5.9)	4.4	(2.3-8.4)
Cigarettes smoked per day					
0	540	1.0		1.0	
1-9	77	1.3	(0.6-2.7)	1.5	(0.6-3.6)
10+	78	2.1	(1.1-4.1)	5.0	(2.3-11.3)
Use of diuretics during pregnancy					
No	675	1.0		1.0	
Yes	20	2.5	(0.8-7.6)	4.3	(1.1-16.4)
Reduced birthweight infant prior to study period					
No	623	1.0		1.0	
Yes	72	3.6	(2.0-6.7)	3.3	(1.5-7.3)
Interpregnancy interval					
First pregnancy	210	1.0	(0.6-1.7)	4.3	(1.8-10.3)
0-12 mo	128	1.9	(1.1-3.4)	3.4	(1.5-8.1)
12-48 mo	217	1.0		1.0	
49+ mo	140	1.2	(0.6-2.2)	1.6	(0.6-4.0)

^aAdjusted for all covariates.

^bWhen these VDT exposure variables were substituted in the model, covariate coefficients did not vary substantially. Because of missing data, the total number of pregnancies varied between the two analyses.

exposure, in which exact hours of VDT-exposed operator work were available). Restricting the analysis to those women working 4 or more days/week showed no increased risk of RBW among women using VDTs ($OR = 0.7$, $95\%CI = 0.4-1.4$). A second analysis was restricted to

third-trimester unexposed operators. The point estimates for unexposed RBW risk were similar to those generated in the presence of VDT exposure (OR = 0.8, 95%CI = 0.3–2.3 for 4 or more days/week; OR = 0.2, 95%CI = 0.01–2.5 for 1–4 days/week).

The covariates in the linear regression model for birthweight were similar, but not identical, to those found in the logistic regression model. The model contained all logistic model covariates except for use of diuretics. Additionally, the linear model contained the covariates infant gender, hypertension medication during pregnancy, diabetes, and thyroid disorder. Again, none of these additional risk factors changed the relationship between VDT use and birthweight substantially. Adjusted least-squares mean birthweights and standard errors were $3,440 \pm 27$ and $3,475 \pm 24$ g for exposed and unexposed pregnancies, respectively.

The distribution of gestational age is shown in Figure 3. The percentages of preterm infants were 7.9% ($n = 24$) and 11.2% ($n = 45$) for exposed and unexposed pregnancies, respectively. The logistic regression analysis for preterm birth resulted in an exposure odds ratio identical to the crude estimate (OR = 0.7) for women who worked with VDTs (95%CI = 0.4–1.1). The following risk factors, however, were associated with preterm birth: pre-eclampsia or toxemia, diabetes, and a previous preterm infant prior to the study period (Table II). No significant interactions with exposure were found. The substitution of continuous exposure variables in the preterm model did not have a substantial effect on the relationship between exposure and outcome, nor did it change the coefficients of the other risk factors. Proportional hazards analysis of preterm birth resulted in the same model as for logistic regression. The risk ratio (RR) for VDT use during pregnancy was 0.7 (95%CI = 0.4–1.1), which is identical to the logistic regression odds ratio (Table II).

Of the 652 women in the study population, 60 (9.2%) had more than one live birth during the study period, 59 had two births, and one woman had three. Since these multiple births are not independent events, we adjusted for correlation between births by using the quasi-likelihood generalized estimating equations derived by Zeger and Liang [1986]. The coefficients and standard errors from these analyses did not differ from those of the logistic regression models for RBW and preterm birth. Also, the birthweight linear regression coefficients and standard errors did not differ substantially after adjustment for correlated outcomes. When we examined the effect of correlated outcomes on the proportional hazards analysis of preterm birth with the marginal analysis approach of Wei et al. [1989] the data were only sufficient to analyze the unadjusted RR for VDT use. The exposure coefficient from this analysis ($\beta = -0.33$, standard error [SE] = 0.25) was very similar to the analogous coefficient from the proportional hazards model ($\beta = -0.36$, SE = 0.25), which ignores correlation effects.

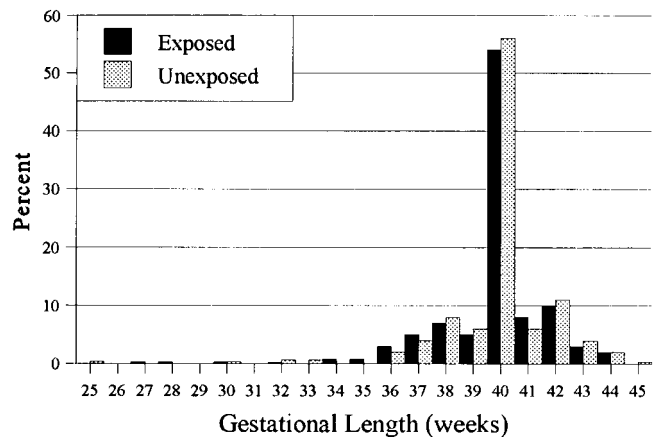


FIGURE 3. Crude distribution of gestational length in percentages by VDT use.

Because the mean values for VLF and ELF emissions at the CCI terminals were higher than the values at the IBM terminals, we conducted analyses for RBW and preterm birth with separate exposure variables for IBM and CCI users. These analyses indicated no differences in risk of RBW or preterm birth between women using an IBM or a CCI unit.

Major birth defect rates, defined as the total number of major birth defects divided by the total number of live births, are generally estimated at 2–3% in the US [Bloom, 1981]. In this study, the rate of self-reported major birth defects was 2.3% ($n = 7$) in the exposed group and 1.0% ($n = 4$) in the unexposed group. For the 11 birth defects reported, medical records were obtained for, and confirmed, only three of the self-reported major birth defects. One additional major birth defect was discovered in the review of these records (Table III). Birth certificates were available for 93% ($n = 663$) of the eligible study pregnancies. However, only one of the eleven major birth defects reported was confirmed by birth certificate. No additional major birth defects were discovered in reviewing the birth certificates.

The perinatal death rate, defined as

$$\frac{(\text{Total number of fetal deaths after 28 or more weeks gestation} + \text{infant deaths within 7 days after birth})}{(\text{Total number of live births plus still births during the study period})}$$

$$= \frac{(\text{Total number of fetal deaths after 28 or more weeks gestation} + \text{infant deaths within 7 days after birth})}{(\text{Total number of live births plus still births during the study period})}$$

was 1.0% in the exposed group (two stillbirths and one infant death) and 0.5% in the unexposed group (one stillbirth and one infant death).

DISCUSSION

We did not find an increased risk of RBW and preterm birth among women who worked with VDTs. The risk of delivering an RBW infant was not increased for women who used VDTs during pregnancy, nor was the mean birthweight

TABLE II. Crude and Adjusted ORs^a and Adjusted RRs^b With 95% Confidence Intervals (CI) for Preterm Birth (≤ 37 weeks) Associated With Occupational VDT Use and Other Variables

Variable	No. of pregnancies	Crude OR	95%CI	Logistic ^a		Proportional hazards ^b	
				Adjusted OR	95%CI	Adjusted RR	95%CI
VDT use during pregnancy							
None	400	1.0		1.0		1.0	
Any	304	0.7	(0.4–1.1)	0.7	(0.4–1.1)	0.7	(0.4–1.1)
VDT use (hr/wk), total pregnancy ^c							
0	403	1.0		1.0		1.0	
1–25	116	0.9	(0.5–1.8)	0.8	(0.4–1.7)	0.8	(0.4–1.5)
>25	120	0.7	(0.3–1.4)	0.6	(0.3–1.3)	0.7	(0.3–1.3)
Pre-eclampsia or toxemia							
No	654	1.0		1.0		1.0	
Yes	50	2.2	(1.0–4.7)	2.4	(1.1–5.3)	2.2	(1.1–4.5)
Diabetes (diagnosed before or during the study period)							
No	687	1.0		1.0		1.0	
Yes	17	9.1	(3.4–24.5)	9.0	(3.3–24.9)	6.1	(2.8–13.1)
Preterm infant prior to study period							
No	657	1.0		1.0		1.0	
Yes	47	3.2	(1.5–6.5)	2.9	(1.3–6.1)	2.3	(1.2–4.4)

^aOR, odds ratio from logistic regression analysis.^bRR, risk ratio from proportional hazards analysis.^cWhen these VDT exposure variables were substituted in the model, covariate coefficients did not vary substantially. Because of missing data, the total number of pregnancies varied between the two analyses.**TABLE III.** Distribution of Self-Reported Major Birth Defects

Birth defect (ICD 9 code)	VDT user (n = 304)	Non-VDT user (n = 403)
Cleft palate (749.0)	2	0
Club foot (745.7)	1	0
Congenital cataract (743.3)	0	2
Congenital multiple exostosis (756.4)	1	0
Hypospadias (752.6)	1	2
Anomaly of epiglottis or trachea (748.3) ^a	2	0
Total number of major birth defects ^b	7	4

^aDetermination of major vs. minor status not conclusive due to incomplete records.^bMultiple heart defects (ventricular septal defect and interruption of aortic arch, ICD 9 745.4 and 747.11) were identified after studying the medical record of one child for a self-reported minor birth defect. These defects are not included in self-reported major birth defect totals and rates in Results.

meaningfully decreased. These results did not change when analyses were performed with continuous or trimester-specific measures of VDT exposure, when monitor type was considered, or when adjustments were made for multiple pregnancies per woman. Although we did not find an association between VDT use and RBW, we confirmed

associations with RBW in our logistic or linear models for a number of previously reported risk factors: prematurity, infant gender, nonwhite (primarily African-American) race, smoking more than 9 cigarettes per day, hypertension medication during pregnancy, diabetes, thyroid disorders, RBW infant before the study period, first pregnancy, and short interval between pregnancies (≤ 12 months).

For prematurity, we did not find an increased risk for women working with VDTs for any measure of exposure we evaluated. Again, previously reported risk factors affected prematurity in our study: pre-eclampsia or toxemia, diabetes diagnosed before or during pregnancy, and a preterm infant prior to the study period. Diabetes and pre-eclampsia/toxemia are risk factors for preterm birth, as labor is often induced early in these women. The number of children with birth defects and the number of perinatal deaths were too small to analyze in multivariable analyses, but the data do not suggest an unusual or specific excess in either the exposed or unexposed groups.

Selection bias seems to be an unlikely explanation for these results. The participation rate was high and minimizes the impact of nonparticipant demographic differences on our results. The demographic characteristics of study participants did not differ greatly by exposure status. All the

women worked for the same company for comparable salaries in similar work situations.

Information on birthweight and gestational age was collected from questionnaires and birth certificates. We were able to obtain birth certificates for 663 (93%) of the births included in the study. Birthweight data were available from all these birth certificates, and gestational age from 633 (89%) of the study births. Because birth certificates were not available for all reported births, and maternal reports of birthweight and gestational age are considered of good quality [Selevan, 1980], we decided to use self-reported data in our analyses. Agreement between self-reports and birth certificates was good for birthweight: 81% of the exposed and 83% of the unexposed mothers' reports differed by <100 g from birth certificate data. For gestational age, reports from 83% of the exposed and 81% of the unexposed participants differed by ≤ 2 weeks from the birth certificate records.

Differential misclassification of exposure status is also unlikely, since VDT use was ascertained and calculated from company records. Home VDT use was infrequent during the study period: only 0.9% of the exposed women and 2.2% of the unexposed women reported VDT use at home.

With the exception of possible confounding based on employment level, in the multivariable analyses, neither interaction nor confounding of the association between VDT use and RBW or preterm birth occurred. Factors that increased risk for RBW or preterm birth in these models were unrelated to VDT exposure. Weinberg [1993, 1995] and Nurminen [1995] have suggested that previous pregnancy outcomes should not be treated as confounders because of their potential association with previous exposure. It is possible that risk factors such as hypertension medication during pregnancy, preterm birth before the study period, or an RBW infant before the study period may be associated with exposure, although inclusion or exclusion of these factors from our models did not meaningfully affect the exposure risk estimates, and multicollinearity between these factors and VDT exposure was not detected.

Our study design did not allow us to address the possible confounding effects of physical and psychological stress, prepregnancy weight and height, and passive smoking. However, we consider the work-related physical and psychological stress of VDT-exposed and -unexposed telephone operators to be similar, based on work practices and responsibilities.

Although we chose a 2,800-g cutpoint for RBW due to small numbers of live births that met the traditional LBW definition of <2,500 g, we reanalyzed our data with the 2,500-g cutpoint and compared these results to national LBW rates. The 2,500-g LBW analysis resulted in an exposure OR of 1.0 and a broader 95%CI (0.4–2.4). Birthweights of <2,500 g were reported by 3.6% of the exposed women and by 4.3% of the unexposed women in our study, while the U.S. population rate is 7.1% [Centers for

Disease Control, 1994]. The relatively low LBW rates in this study may have resulted from the demographic characteristics of the study population (primarily middle class, married, age 18–33 years).

We found a decreased point estimate for the risk of delivering a RBW infant among women working with a VDT of 1–25 hr/week, consistent with the findings of Bracken et al. [1995], who found a decreased risk for women working with a VDT of 1–20 hr/week. On the other hand, we found a slightly elevated point estimate for women who used a VDT more than 25 hr/week. In an analysis restricted to those women who worked 3 or more days/week, however, there was actually a decreased risk among VDT users compared to nonusers. In a second analysis, restricted to third-trimester unexposed operators, point estimates for RBW were similar to those generated for RBW in the presence of VDT exposure. This finding suggests that the apparent increased risk among women who used VDTs more than 25 hr/week compared to all non-VDT users may actually reflect other differences between women who work full-time during pregnancy as compared with those who do not and that these differences are not necessarily related to VDT exposure.

In our study, use of diuretics during pregnancy was associated with RBW, which has not been previously reported. Of the 20 women in our study who used diuretics, nine reported the use of hypertension medication during pregnancy. Hypertension has been associated with LBW in previous studies [Velentgas et al., 1994] and hypertension medication use was determined to be a risk factor for RBW in our linear analysis. Thus, in our data, use of diuretics and hypertension medication may represent surrogate measures for hypertensive disorders.

The strengths of this study include the use of payroll records to assess the number of hours worked with VDTs during pregnancy, as opposed to using job titles or self-reported exposure; the measurement of EMFs at the workplace; and the similarity of the two study groups for factors other than VDT use.

Our findings are similar to those reported in previous studies [Ericson et al., 1986a,b; McDonald et al., 1988; Nurminen et al., 1988; Windham et al., 1990; Nielsen et al., 1992; Parazzini et al., 1993; Bracken et al., 1995]. Exposure to ELF (45–60-Hz) and VLF (15-kHz) electromagnetic fields produced by VDTs was not associated with low birthweight, preterm birth, birth defects, and perinatal death. The lack of an association suggests that exposure to EMFs produced by VDTs was too low to cause the outcomes studied but does not imply a lack of association between all EMF exposures and adverse reproductive outcomes. We conclude that in this study, the occupational use of VDTs was not associated with reduced birthweight or preterm birth.

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