Reproductive Toxicology, Vol. 4, pp. 61–65, 1990
Printed in the U.S.A.

0890-6238/90 $3.00 + .00

THE NIOSH STUDY OF REPRODUCTIVE OUTCOMES AMONG VIDEO DISPLAY TERMINAL OPERATORS

Teresa M. Schnorr
National Institute for Occupational Safety and Health, Cincinnati, Ohio 45226

In late 1981, investigators at the National Institute for Occupational Safety and Health (NIOSH) began investigating whether we could study the effects of video display terminals (VDTs) on reproductive outcomes. At that time, 4 of the 12 well-known case clusters had been reported. The outcomes reported in those four clusters were primarily miscarriages, but also included birth defects, stillbirths, and neonatal deaths.

In addition to chance, there were three suggested explanations for the clusters. They were, and still are, ergonomic factors, stress, and nonionizing radiation. Our goal was to design a study that both would be comprehensive and would provide a clearcut answer to the question, "Do VDTs cause adverse reproductive outcomes?" It was not a particularly easy task, especially since some of these factors, such as stress, are very complex issues in and of themselves. We therefore decided to simplify the question. If we could come up with a study design that would eliminate stress, and perhaps ergonomics, as factors in the study, then we could possibly obtain a clearer answer to the radiation question.

We chose to conduct an occupational cohort study for three reasons. First, a cohort study would allow us to examine all outcomes. Based upon the pregnancy outcomes reported in the clusters, it became clear to us that we should examine all adverse pregnancy outcomes rather than focus on a single one. Second, we could use objective, company personnel records to define VDT use. Third, the cohort design might allow us to identify a reference group that would be very similar to VDT users, with respect to socioeconomic status, but also possibly with respect to ergonomic and stress factors as well.

Our first step was to survey those industries in the country that were heavy VDT users. We made a number of site visits and telephone calls to companies that employed large numbers of women (Table 1). Our greatest problem was the difficulty in identifying a population of non-VDT users who were also similar to the VDT users in socioeconomic status. In our search, we identified a population in the communications industry which fit our criteria very well. That population was telephone operators.

Study population

There are two types of telephone operators: directory assistance operators, who use VDTs, and long distance operators, who do not. The directory assistance operator, who is the operator you speak to when you dial 411 or 555-1212, sits in front of a VDT for her 7 hour work day. She receives calls from the public requesting assistance in obtaining telephone numbers. She types in the name of the person requested, and a screen showing the telephone directory is illuminated in front of her. She provides that information to the customer, and then a fraction of a second later she receives another call. She performs this task 7 hours a day with a 30-minute lunch break and two 15 minute rest breaks. The computer automatically routes calls to the next available operator so the time between calls is brief. Operators are monitored by their supervisors, and also by the computer, which records the number of calls they receive per day and how long they spend on each call.

The long distance operator's duties are similar to those of the directory assistance operator. Long distance operators (reached by dialing 0) receive calls for assistance in placing long distance calls, among other duties. Long distance operators do not use a VDT, they use a light emitting diode (LED) screen. It is a very low, direct current line which has an estimated 1 volt of power. When a call comes in to the operator, the telephone number is illuminated in a pattern of small, electric red lights in front of her. She then punches a keyboard to connect the call. The long distance operators are also monitored by a computer and by their supervisors. Like the directory assistance operators, the time between calls is a fraction of a second.

The populations I have described are ergonomically the same. Both sit for 7 hours a day in front of their

Address correspondence to Teresa M. Schnorr, Ph.D., Industry-wide Studies Branch, NIOSH, Mail Stop R-15, 4676 Columbia Parkway, Cincinnati, OH 45226.

Table 1. Industries considered for study

Insurance
Communications
Airlines
Computer manufacturing
Airplane manufacturing
Federal government
State government

Table 2. Definition of major congenital malformation

Defect present at birth (ICD9 codes 740–759) includes only those which
- affect survival
- require substantial medical care
- result in marked physical or psychological handicaps
- interfere with a baby's prospects for a productive life

Source: Reference 2.

respective equipment. With respect to stress, they are similar but not identical. The jobs I have described to you are both stressful. However, one would think the directory assistance operator's job would be somewhat more stressful, since the job is more routine with less variety than the long distance operator's job. The primary difference between these two populations is the presence or absence of the VDT. Therefore, the study focuses more on the question of whether physical emissions from that equipment affect reproductive outcome.

We had some general criteria that we applied to both telephone operator groups. The women had to be employed in one of these two jobs at any time between January 1, 1983, and August 1, 1986 (the date when we obtained the records from the companies). A potential participant had to work full time in one of these jobs at one of the two companies that cover an eight southeastern state area. She had to be female, between the ages of 18 and 35, and married during the study period.

Our study objectives are to determine whether VDT use increases the risk of adverse reproductive outcomes. We are specifically interested in spontaneous abortions and major congenital malformations.

Data collection

We had four sources of data for the study, the first being the employment records that we obtained from the telephone companies. We used these records to identify potential study participants and to obtain work history data including job titles and dates of employment in those job titles. Because the employment records did not have marital status, our first question when we called a woman to conduct the telephone interview was whether she had been married for any portion of the study period. If so, we then conducted the interview and collected a complete reproductive history. I want to point out that the employment data for our study are objective and independent, but outcome data are self-reported. This is the opposite situation of Dr. Goldhaber's study (1). To deal with the issue of possible differential recall in self-reported outcome data, we decided to collect some records to confirm reported outcomes. For each fetal loss or birth defect reported in the interview, we are obtaining medical records. To address the question of underreporting of adverse outcomes, we are obtaining vital records. Vital records can be of some help in measuring underreporting of adverse outcomes, since they do report birth defects. Also, we plan to use vital records to look at birth weight, since birth weight data collected at the time of birth may be more accurate than those recalled by women. As I have said, we will be analyzing all adverse outcomes of pregnancies. However, based upon what was reported in the original case clusters, we are focusing on spontaneous abortions and major congenital malformations as a priori interests. We selected these two outcomes because we wanted to avoid a multiple comparison problem at the end of the study.

We have defined a major congenital malformation by adapting a definition that was used before in a major study by the Centers for Disease Control (2) (Table 2). This definition categorizes birth defects into two groups. The first group included birth defects that are always considered major, such as spina bifida. The second group includes birth defects from codes (in the International Classification of Diseases [ICD]) in which we cannot determine the severity. The records of birth defects in this second category will be reviewed by two physicians and categorized as major if they fit the severity criteria shown in the table.

Some of the other outcomes that we will examine are prematurity, low birth weight, and neonatal mortality, all of which have been reported in one or more clusters by VDT users.

VDT exposure definitions

Since both the dose and the timing of exposure are important in these types of studies, and since one single definition of exposure might not be adequate for all outcomes of interest, we decided to define exposure in several ways. The first and simplest method will be to

Table 3. Continuous exposure index

Example 1
Period of interest = first trimester

$$\frac{\#\text{ person-days at VDT during trimester 1}}{\#\text{ person-days of pregnancy during trimester 1}}$$

Example 2
Period of interest = entire pregnancy

$$\frac{\#\text{ person-days at VDT during pregnancy}}{\#\text{ person-days of pregnancy}}$$

Table 4. Power estimates

Spontaneous Abortions

Relative risk	# Pregnancies per group	
	400	500
1.3	.52	.60
1.4	.72	.80
1.5	.86	.92

Spontaneous abortion prevalence = 0.15; alpha = 0.05 (two-sided).

Major Malformations

Relative risk	# Pregnancies per group	
	350	450
2.0	.54	.64
2.5	.81	.90
3.0	.95	.98

Major malformation prevalence = 0.025; alpha = 0.05 (two-sided).

determine whether or not the woman had been employed as a directory assistance operator at anytime during her pregnancy. Then, because we want to focus on the most susceptible trimester for the outcome of interest, we will define exposure as a yes/no, did she work as a directory assistance operator during the susceptible trimester. For spontaneous abortion, this might be the first trimester. Finally, we plan to construct a continuous exposure index, ranging from 0 to 1. This is because even within a single trimester, the actual hours worked might vary depending upon when during the pregnancy she was hired, when she took vacation, or whether she took sick leave during the trimester. In this index, we want to calculate the number of hours of VDT use during that trimester or trimesters of interest, and correct for that by dividing by the full length of the individual's trimester(s) of interest.

Table 3 gives some examples of how this index would work. In the first example, where the period of interest is the first trimester, one would calculate the number of person-days that the woman worked as a directory assistance operator during the first trimester and then divide that by the length of that trimester. So, if her pregnancy ended at eight weeks, then she would have only eight weeks in the denominator, whereas if it continued to the second trimester, she would have 13 weeks in the denominator. For outcomes in which the entire pregnancy would be of interest, such as low birth weight, one would calculate the number of person-days that she worked for the entire pregnancy divided by the number of person-days of her entire pregnancy; if the pregnancy ended at 37 weeks, 37 weeks of pregnancy would be in the denominator.

Some of the other reproductive risk factors that we will be considering include age, parity, prior reproductive history, medications during pregnancy, smoking, and medical conditions.

Table 4 shows the power estimates we calculated when we began the study. We have just completed the study interviews, and do not have accurate numbers yet, but it looks as though the data will be in the range of the initial power estimates. We have estimated approximately 500 pregnancies in each group. With these estimates we will be able to detect a 1.4-fold increased risk for spontaneous abortion with at least 80% power. For major malformations, we should have power to detect a 2.5-fold increase. The initial data analysis will consist of a preliminary stratified analysis. The major analysis will be regression analysis which incorporates all of the covariates.

I will conclude by informing you of the current status of the study. At this point, we have just completed the interviews. There are approximately 2500 women in the final dataset. Our overall response rate was about 78%. Only 3% of the women actually refused to participate. We were unable to locate 19% of the study population. We are still processing medical, vital, and interview data and expect some preliminary results in early 1990.

REFERENCES

1. Goldhaber MK, Polen MR, Hiatt RA. The risk of miscarriage and birth defects among women who use visual display terminals during pregnancy. Amer J Ind Med. 1988; 13:695–706.
2. Erickson JD, Mulinare J, McClain PW: Vietnam veterans' risks for fathering babies with birth defects. U.S. DHHS, CDC, Center for Environmental Health, Atlanta, GA. August, 1984.

QUESTIONS

Q: Do the two operator groups have the same educational requirements and same salaries?

A: Yes. The demographics and job selection factors are the same. The population used to be employed by one telephone company. Divestiture occurred and now the workers are employed by two different companies, but the hiring practices and the management styles are similar.

Q: It would be useful to at least characterize the radiation exposure, not just to say VDT and non-VDT users. I am sure the radiation exposure of the controls is not zero.

A: Certainly no one has zero exposure because we are surrounded by electrical equipment. The VDT operators would have that as well but in addition, they have the VDT. So yes, there is probably some exposure, but is should not be more than other office workers or other persons in the general office environment.

Q: Will you obtain finer information on VDT exposure, such as the density of VDTs in the workplace?

A: We have not done that. This particular population is scattered over about 200 different work locations in 8 states. Telephone operators generally work in small buildings distributed across the countryside. These buildings house about 20 operators per shift and they run three shifts a day. The sites we visited were fairly similar with respect to layout, but I did not visit all of the sites. It would be possible to do that, but at additional expense.

Q: In an earlier design of your study, you had planned to study stress, and you dropped that at the insistence of the Office of Management and Budget (OMB). I assume that meant you wanted to clarify whether the stress levels were identical in both groups.

A: That is right. We had tried to design a study to reduce the possible effect of stress as much as possible, since the study of stress is so complex. However, we wanted to obtain a measure of the women's perceived stress in the two occupations so that we had some data upon which to base the assumption that they were similar. We included a series of standard work stress questions in the questionnaire, but those were deleted by the OMB. At this point, we will not be able to quantify any differences in workplace stress between the two groups.

The OMB required us to make other changes in the questionnaire. A question at the very end of the interview which asked the question, "Do you think VDTs cause pregnancy problems?" was deleted. This question was an attempt to get a measure of possible biases that the population might have. In addition, questions which addressed whether fertility might be affected by VDT use were deleted from the questionnaire. The study design itself was not changed. The methods of our data collection, the study population, and the methods of analysis were left unchanged. The effect of the OMB revisions was to possibly limit our ability to interpret some of our findings and also to eliminate one outcome, reduced fertility, from our analysis.

Q: Why did the OMB make you delete the questions on stress?

A: The OMB felt there was not enough evidence to link stress, VDT use, and pregnancy outcomes so that stress questions were superfluous, and an excess burden to the public.

Q: Was there any movement of people between these two jobs, maybe before divestiture?

A: Yes, there was.

Q: Did it go preferentially one way or the other?

A: I do not know that yet. However, we have obtained all the personnel records from the two companies in the study. We will be linking the dates the women spent in an operator job with the date of pregnancy. Therefore, a woman might have an exposed pregnancy and an unexposed pregnancy.

Q: If the volume of transfers between these two jobs was equal in both directions, or minimal, that would mean that the employees did not know of big differences in stress. When people perceive big differences in stress they "speak with their legs," and change jobs.

A: That is a good point. We could examine transfer patterns to determine if one job was preferred over the other.

Q: Why did you limit the study to women age 35 or less?

A: Because the age group is the age group that is producing the most pregnancies. We could have included women up to age 40. We looked at the population data and birth rates in different age groups to decide where to make the cut-off, to both increase the efficiency of obtaining pregnancies from an interview, and also to obtain enough pregnancies detect a relatively low effect. When we visited the companies, we obtained their maternity leave data which gave us an indication of the number of the live births that were occurring in the population. We then looked at the ages at which women were taking maternity leave. There were so few women taking maternity leave after age 35, that by including older women in our population, we would have drastically increased the number of interviews, but very marginally increased the number of pregnancies we would have captured. That is why we decided for a maximum age of 35 years.

Q: If the results of your study show no difference between the two occupational groups, could it be argued that because your measure of miscarriage is limited, you are going to miss some of those early miscarriages that could have affected the results?

A: There definitely will be some limitations to what we can say when the study is completed. Obviously, our conclusions will be limited to outcomes of recognized pregnancies, so we will not be able to look at the question of whether women had difficulty conceiving or whether they had early fetal loss.

Q: How much suspicion is there among these telephone operators that VDTs might cause spontaneous abortions? Thinking back to the study of Axelson and his colleagues, in nurses who were exposed to anesthetic gases, I think literally none of them forgot miscarriages, but in the comparison group, roughly a third of the miscarriages were forgotten. That might be something kind of analogous to recall bias in this retrospective cohort study. Would you comment on those two?

A: I do not know the attitude toward VDTs in this population. Originally, we had included a question to assess the participants' attitude toward VDTs, but it was disallowed by the OMB. Therefore, we have no direct measure of their opinion. Nevertheless, I think every woman who is VDT user is aware of this issue. As I said, our study is the opposite of Ms. Goldhaber's study in that our outcome data are based upon the recall of the study participants. It is very difficult to do these types of studies and have good, objective data on both outcome

and exposure. We decided to go with an objective measure of exposure because we wanted to identify a population of full-time users who would be most likely to show any potential effect of exposure. We tried to address potential recall bias of outcome data by getting medical and vital records.

Q: Are you getting medical records only on people who said they had a spontaneous abortion or are you also getting the records of people who said they had not had one, but might in fact have a miscarriage documented on medical charts?

A: If the woman does not remember that she had an abortion, she cannot tell you her doctor's name for you to request the record. It is a problem, and there is really no way to deal with that directly. The birth certificate in a number of states indicates the date of prior fetal death. We can compare a woman's report of her reproductive history with what is recorded on the certificate; it gives you a way of determining whether she has had a pregnancy loss. We plan to do this whenever possible.

Q: How are you going to interpret the grouping together of all congenital malformations? You cannot address birth defects in the study realistically, unless this population had the most unique heritage ever identified. I think the birth defects findings here, if they are negative, provide false reassurance; if they are positive, they could no be attributed to VDTs.

COMMENT BY ANOTHER PARTICIPANT: Usually I would completely agree with the objection to grouping congenital malformations, but in this case, I would qualify my objections. Looking at all malformations together will usually make it difficult to detect a higher incidence of a particular type of malformation. A point exposure at a specific stage of gestation may produce a single organ system defect, but exposure to a less specific agent, throughout pregnancy, may cause malformations in multiple organ systems. For example, with radiation, you preferentially get central nervous system defects, but then you get a whole host of other malformations, and you do not tend to get the patterns of anomalies that you get with exposure to a drug, such as with hydantoin. Since in VDT users one would postulate an exposure throughout organogenesis, this is one of the rare situations in which it probably does make some sense to look at multiple outcomes, as long as you have excluded the genetic conditions which you would not logically expect (single Mendelian traits or chromosomal abnormalities, for example).

A: The study's power to examine specific malformations is very low. We tried to think of a malformation which we could specify a priori as being of interest. The case clusters were our only source of this information and we saw no pattern. So we decided to use major malformations as the a priori hypothesis, for the simple reason that the clusters were showing a variety of birth defects and that we had no evidence to specify a specific malformation ahead of time.