

**AN INVESTIGATION OF
SPONTANEOUS ABORTIONS
FOLLOWING A METAM SODIUM SPILL
INTO THE SACRAMENTO RIVER**

California Department of Health Services,
Environmental Health Investigations Branch



March 1993

Molly J. Coye, M.D., M.P.H.
Director, California Department
of Health Services

EXECUTIVE SUMMARY

On July 14, 1991, shortly before 10 p.m., a tank car derailed and released 19,000 gallons of the herbicide metam sodium into the Sacramento River six miles north of the town of Dunsmuir in Northern California. Local residents were exposed to the toxic by-products, mainly methylisothiocyanate. A community-based health survey focusing on chronic effects including pregnancy outcomes was conducted in April 1992 in the Dunsmuir area. A total of 969 households (81%) participated.

Since metam sodium has been associated with increased incidence of fetal loss in animals and there had been anecdotal reports of spontaneous abortions following the spill, the relationship between spontaneous abortion (fetal loss before 20 weeks gestation) and possibility of exposure was examined. Seventy-four pregnancies were reported during the study period (7/90-2/92). A follow-up interview was conducted (October 1992) to confirm pregnancy information and obtain permission to review the medical records of women who reported a spontaneous abortion.

A woman was considered exposed if she resided in or visited the spill area during the time of greatest potential exposure (July 15 to July 16, 1991). Based upon this exposure definition and the date of the last menstrual period, four groups were defined: fetus exposed in the first trimester, fetus unexposed in the first trimester, post-spill conception in an exposed woman, and post-spill conception in an unexposed woman.

Five spontaneous abortions were reported during the April 1992 survey among fetuses exposed in the first trimester. One spontaneous abortion has been confirmed to date giving a confirmed spontaneous abortion rate of 14% (1/7). If all five were confirmed the rate would be 45% (5/11). The rates of reported and confirmed spontaneous abortion in the unexposed group (26%, 21%), in the exposed post-spill conception group (26%, 23%) and in the unexposed post-spill conception group (20%, 20%) were similar.

Using only confirmed spontaneous abortions, this study does not show a higher rate of spontaneous abortion among fetuses exposed in the first trimester. Including the four unconfirmed spontaneous abortions exposed in the first trimester increases the rate above the unexposed, but the statistical confidence interval around this rate is very wide. The higher than usual rates of confirmed spontaneous abortion even in unexposed groups and a review of birth certificates suggests that women whose pregnancies ended in live births did not all participate in our study.

Due to the inherent limitations of epidemiological studies, we cannot determine whether the elevated rate of reported spontaneous abortion among fetuses exposed in the first trimester was due to exposure to the by-products of metam sodium. Other factors such as imprecise reporting of exposure and pregnancy ending date, chance, differential recall of missed menstrual periods in the unconfirmed spontaneous abortions, under-ascertainment of live births and spontaneous abortions, and stress generated by the spill could have influenced the rate.

DHS will make another attempt to confirm the reported but unconfirmed spontaneous abortions.

ACKNOWLEDGMENTS

This report was prepared by Amy Casey and Laura Fenster under the direction of Raymond Neutra, Acting Chief of the Environmental Health Investigations Branch of the California Department of Health Services. Staffing and leadership were also contributed by Shanna Swan, Daniel Smith, Rachel Broadwin, David Epstein, Margot Smith and Suzanne Teran.

Table of Contents

EXECUTIVE SUMMARY	i
ACKNOWLEDGMENTS	ii
BACKGROUND	1
<i>Description of the Incident and Initial DHS Response</i>	1
<i>Reproductive Toxicology of Metam Sodium and By-Products</i>	1
<i>DHS Health Investigations</i>	3
<i>Birth Defects</i>	3
<i>Community-Based Health Survey</i>	3
<i>Objectives of the Current Study</i>	4
METHODS	4
<i>Data Collection</i>	4
<i>Community-Based Health Survey - Reproductive Component</i>	4
<i>Follow-Up Interview</i>	5
<i>Data Analysis</i>	5
<i>1991 California Birth Certificates</i>	6
<i>Assessment of Information Provided by a Proxy</i>	7
RESULTS	7
<i>Data Collection</i>	7
<i>Community-Based Health Survey</i>	7
<i>Follow-Up Interview</i>	7
<i>Data Analysis</i>	8
<i>Demographics</i>	10
<i>Spontaneous Abortion Rate</i>	10
<i>1991 California Birth Certificates</i>	12
<i>Assessment of Information Provided by a Proxy</i>	12
DISCUSSION	12
CONCLUSIONS	13
RECOMMENDATIONS	14
REFERENCES	14

List of Figures

1. MAP OF THE AFFECTED AREA2
 2. STATUS OF PREGNANCIES REPORTED IN APRIL 1992.....9
-

List of Tables

1. FOUR EXPOSURE GROUPS FOR ANALYSIS.....6
 2. ANALYSIS OF CONFIRMED SPONTANEOUS ABORTIONS CATEGORIZED BY
EXPOSURE IN THE FIRST TRIMESTER 11
 3. ANALYSIS OF ALL REPORTED SPONTANEOUS ABORTIONS CATEGORIZED BY
EXPOSURE IN THE FIRST TRIMESTER 11
-

AN INVESTIGATION OF SPONTANEOUS ABORTIONS FOLLOWING A METAM SODIUM SPILL INTO THE SACRAMENTO RIVER

On July 14, 1991, shortly before 10 p.m., several cars of a Southern Pacific train derailed at the Cantara Loop on the Upper Sacramento River, six miles north of the town of Dunsmuir in Northern California. In all, 19,000 gallons of the herbicide metam sodium were spilled into the Sacramento River. The chemical plume traveled 45 miles downstream, killing nearly all aquatic life and exposing residents to the chemical and its volatile by-products. The California Department of Health Services (DHS) has previously reported on the acute health effects of the chemical spill.¹ The purpose of this report is to describe the investigation of pregnancy outcomes among women who participated in a community-based health survey in April 1992 and in a follow-up interview in October 1992.

BACKGROUND

Description of the Incident and Initial DHS Response

Dunsmuir, with a population of 2,129,² is the largest town on the affected segment of the river and is the nearest to the spill site (Figure 1). It is believed that the plume of metam sodium passed through Dunsmuir in the early morning hours of July 15.

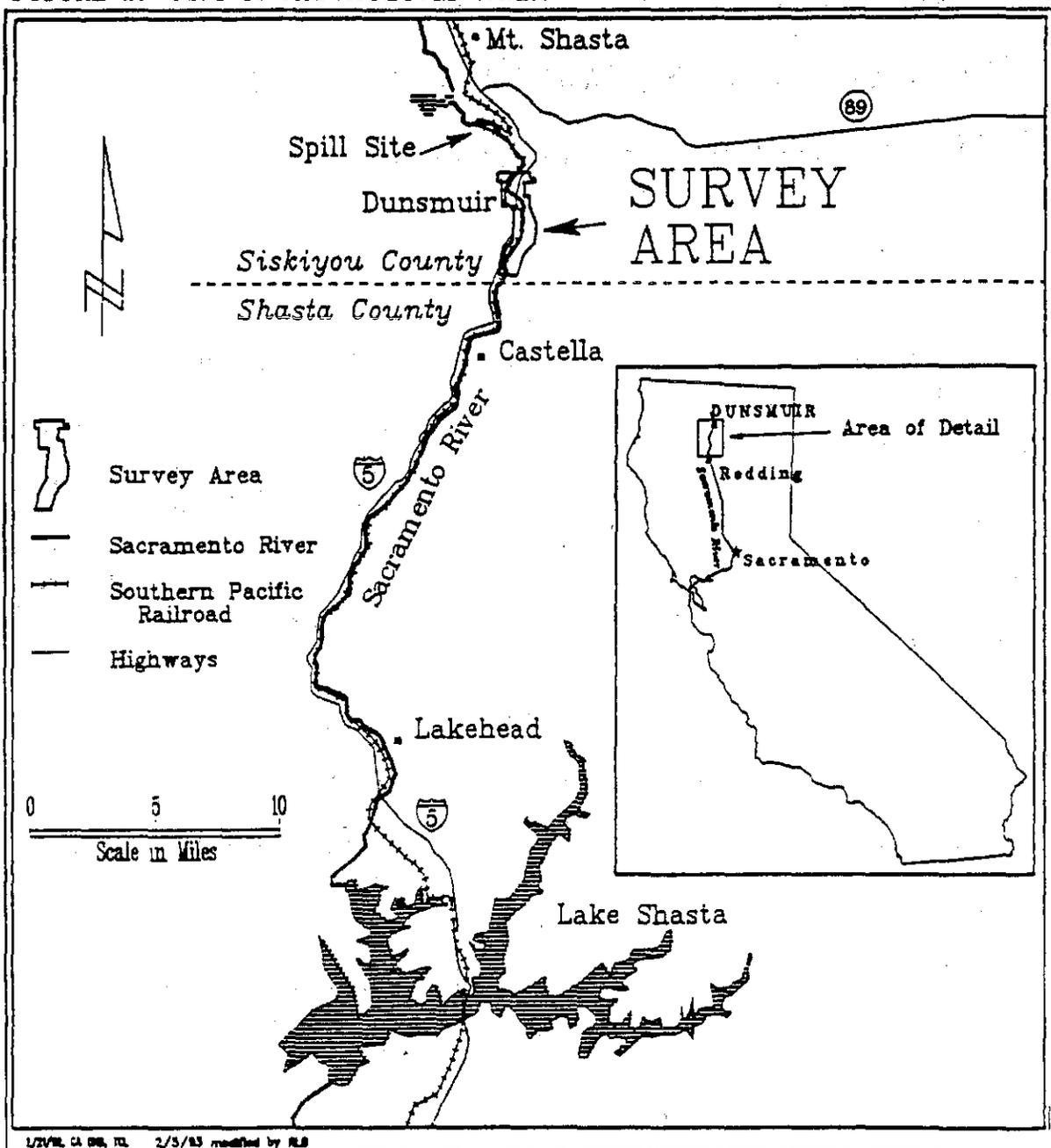
The DHS investigation of acute health effects showed that 14% of Dunsmuir city residents sought medical care in the month following the spill.³ Symptoms were consistent with exposure to irritant gases and included eye, respiratory, gastrointestinal, and skin irritation.

Reproductive Toxicology of Metam Sodium and By-Products

Metam sodium when mixed with water is believed to rapidly decompose to methylisothiocyanate (MITC) and hydrogen sulfide. Other less common by-products include methylamine and carbon disulfide. A review of the toxicological literature on metam sodium found an increased number of fetal losses and birth defects (neural tube defects) occurring in pregnant rats and rabbits exposed to

metam sodium at concentrations of 10-120 mg/kg-day.⁴ No specific birth defects have been related to MITC but developmental toxicity studies in the rat and rabbit are being repeated.⁵

FIGURE 1. MAP OF THE AFFECTED AREA



The Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency prepared developmental toxicity action levels for exposure to MITC in air. The one-hour action level is 720 parts per billion (ppb) and the 24-hour action level is 30 ppb. Action levels are considered to be health protective and provide a guideline for mitigation or avoidance of contact.

Air monitoring for MITC began on July 17th, the third day following the spill. The highest measured amount of MITC in Dunsmuir for a 12-hour period was taken on July 18 and was 4 to 5 ppb. This measurement was well below the one-hour (720 ppb) and 24-hour (30 ppb) action levels for developmental toxicity.⁶

Since air measurements for MITC in Dunsmuir were not available, OEHHA estimated MITC levels for the first two days, July 15 and 16, for different exposure situations. For the first 12 hours after the spill, a short term exposure of a few minutes to one hour for individuals within 300 feet of the river would have produced a maximum exposure estimate of 140 to 1600 ppb of MITC. For a longer exposure of several hours and possibly for up to one day, levels could have ranged from 15 to 200 ppb during the first day after the spill in the Dunsmuir area.⁷ These estimated exposure levels apply to individuals living near the river and the actual exposures for Dunsmuir residents who lived as far as 1,500 feet from the river are likely to have been much lower.⁸

Thus, the estimated maximum one-hour exposure level (140 to 1600 ppb) contained the one-hour developmental toxicity action level of 720 ppb. In addition, anecdotal reports of spontaneous abortions following the spill were received by DHS staff.

DHS Health Investigations

In the months following the spill, residents continued to report health problems they felt were related to the spill. These included reports of new and/or continuing respiratory problems, skin rashes, joint pain, diarrhea, sensitivity to chemicals, mood changes, fatigue, and vision problems. Residents also continued to express concern about the occurrence of spontaneous abortions and possible birth defects.

Birth Defects

The DHS's Birth Defects Monitoring Program conducted an investigation to determine whether any excesses in birth defects occurred among children born to women potentially exposed to the spill during their pregnancy. Among 100 deliveries, one baby was identified with a structural birth defect which affected the gastrointestinal system. In California, three of every 100 babies have a reportable birth defect. Thus, one baby with a birth defect out of 100 deliveries is lower than expected.⁹

Community-Based Health Survey

To address concerns regarding continuing health problems and pregnancy outcomes, DHS's Environmental Health Investigation Branch conducted a health survey in the Dunsmuir area in April 1992. The survey collected information from one adult who responded for all other household members. The survey collected demographic information for each household, asked where each individual was during the first three days following the spill, and asked about the occurrence of certain health problems and pregnancy outcomes.

Objectives of the Current Study

The initial DHS investigation of acute health effects was limited to individuals who sought medical care in the month following the spill. That investigation could not fully document pregnancy outcomes. Therefore the main objective of this study was to examine the relationship between spontaneous abortion (unintentional fetal loss before 20 weeks gestation) and possibility of exposure.

METHODS

Pregnancy information was gathered during the community-based health survey in April 1992. The survey area included the city of Dunsmuir and the area south of the city limits to just north of the Siskiyou/Shasta County line (Figure 1). Additional information was collected through a subsequent follow-up interview in October 1992. Study subjects included past and current residents as well as visitors. Pregnancies eligible for inclusion in the study were those with a last menstrual period (LMP) between July 1, 1990 and February 29, 1992. This time period included pregnancies which began before and after the spill. Pregnancies which ended in a therapeutic abortion or which were reported to be less than 20 weeks gestation and with an unknown outcome were excluded. Exposure was based upon self-reported dates of residence or visits and calculated LMP date.

Each pregnancy outcome was classified as a spontaneous abortion (SAB) or a non-spontaneous abortion (non-SAB). A SAB is an unintentional fetal loss occurring before 20 weeks gestation.¹⁰ A non-SAB is any pregnancy which ended in a live or still birth, or which was continuing and was at least 20 weeks gestation or greater at the time of interview. Each SAB was further classified as either confirmed or reported. A confirmed SAB has been verified either through a review of the medical records or physician review of the October 1992 follow-up interview information. A reported SAB was identified during the April 1992 survey but could not be verified.

Data Collection

Community-Based Health Survey - Reproductive Component

In April 1992, an in-person interview was conducted with one adult in each household in the study area, who provided information for all household members. The respondent was asked to provide the name of all members in the household but some individuals, on the advice of their lawyers or for other reasons, withheld their names. Survey information on these "anonymous" individuals was collected, but could not be confirmed in the subsequent follow-up interview.

For each woman age 12 to 50 years, information on the pregnancy outcome, gestational age, and ending date for each pregnancy was provided by the woman herself or by a proxy (family member or friend). Date of birth or age, location from 10 p.m. on July 14 to 8 p.m. on July 17, 1991, residence, and smoking history were asked for each individual. Ethnicity, health insurance status

and income were asked for each household. Questions on both acute and long-term health problems were also asked but are not part of this report.

Follow-Up Interview

In October 1992, trained interviewers made an effort to conduct a follow-up interview with each woman who had a reported pregnancy. During the interview, each woman was asked to either confirm or clarify where she had been from 10 p.m. on July 14 to 8 p.m. on July 25, 1991. She was then asked her total number of pregnancies, number of SABs, and how many times she had been pregnant with an LMP beginning on or after July 1, 1990. For each pregnancy in the time period, she was asked for the date of her LMP, pregnancy outcome, number of weeks the pregnancy lasted, the date the pregnancy ended, and if and how much she smoked during the pregnancy.

If the pregnancy ended in a live birth, the name of the child, place of delivery and birthweight were asked. If the pregnancy ended in a SAB, the woman was asked whether she had a positive pregnancy test, had seen a doctor to confirm the pregnancy, had an ultrasound, had passed tissue during the SAB and had seen a doctor following the SAB. These women were also asked to allow DHS to examine their medical records regarding the pregnancy which ended in a SAB.

Data Analysis

All reported pregnancies with a known outcome were included in these analyses whether or not a follow-up interview was conducted. Twin pregnancies were included as two pregnancies. Information provided by the woman in the interview took precedence over information provided in the survey since the survey response was sometimes given by a family member or friend and was of a less detailed nature.

A woman was considered exposed if she resided in or visited Dunsmuir, Mt. Shasta, Castella, or Lakehead (spill area) on July 15 and/or July 16, 1991 for any amount of time. Based upon existing and estimated air levels of MITC, July 15 to 16 represented the period of greatest potential exposure. The woman's presence in the spill area was determined from information provided in the follow-up interview or if not available, from the survey.

The exposure information and the calculated LMP date were used to place each pregnancy into one of four groups for analysis. The date of the woman's LMP was calculated by subtracting the number of weeks the pregnancy lasted from the date the pregnancy ended. The four groups are: fetus exposed in the first trimester, fetus unexposed in the first trimester, post-spill conception in an exposed woman, and post-spill conception in an unexposed woman (Table 1). While most SABs occur during the first trimester, a SAB can occur up to 20 weeks gestation thus, exposure during the first 20 weeks was also examined. The rate of SAB (proportion of pregnancies ending in a SAB) was calculated for confirmed and reported SABs in each of the four groups. Exact 95% binomial confidence intervals (CI) were obtained for each rate.¹¹ However, since the exposed

pregnancies which ended in a SAB were all exposed in the first trimester, results are presented only for this time period.

TABLE 1. FOUR EXPOSURE GROUPS FOR ANALYSIS

Date of Last Menstrual Period	Woman in Dunsmuir Area July 15 or 16, 1991	Exposure Groups
		1st Trimester of Pregnancy
4/15/91 → 7/16/91	Yes	Fetus Exposed
7/1/90 → 4/14/91	Yes (but not during 1st trimester)	
7/1/90 → 4/14/91	No	Fetus Unexposed
4/15/91 → 7/16/91	No	
		Post-Spill Conception
7/17/91 → 2/29/92	Yes	in Exposed Woman
7/17/91 → 2/29/92	No	in Unexposed Woman

Demographic variables (age at LMP, income, insurance, ethnicity) were examined for association with the risk of SAB. For those women who participated in the follow-up interview the following variables were also examined: a prior history of SAB, gravidity (number of pregnancies), and smoking during the pregnancy. In order to explore the possibility of confounding, these variables were also examined in relation to exposure.

1991 California Birth Certificates

In order to determine how completely the April 1992 survey ascertained live births, the 1991 State birth certificate tape was searched for all live births for which the residence of the mother was indicated as Dunsmuir (zip code 96025 or census place 805) and with an LMP of July 1, 1990 or later. Children listed on the 1991 California tape were compared to the children identified in the April 1992 survey. Records were matched by child's name, date of birth and sex. For those survey children whose name was withheld, child's date of birth and sex as well as parent's date of birth were used to identify possible matches. The addresses of children listed on the 1991 California tape but who were not identified in the survey were examined to determine whether the family did not participate in the survey (refused, never home) or were no longer at that address.

Assessment of Information Provided by a Proxy

The pregnancy information collected in the survey was provided either by the woman herself or by a proxy (family member or friend). Information provided by a proxy may be less reliable. In particular the proxy may have been unaware of a pregnancy during the study period. Therefore, a sample (10%) of the women whose names were provided and who were reported by a proxy to have no pregnancies during the study period (n=145) were interviewed to verify their non-pregnancy status.

For women with a reported pregnancy who participated in the follow-up interview, the following information was compared with that provided in the survey by a proxy: exposure, calculated LMP and ending date, and pregnancy outcome.

RESULTS

Data Collection

Community-Based Health Survey

A total of 1,192 households were contacted, and 969 (81%) completed the April 1992 survey; of these 969 households, 111 (11%) participated anonymously. Among the non-respondents, 94 (8%) refused, and 129 (11%) were never at home when contacted.

Initial analysis of the survey data identified 79 possible pregnancies reported for 68 women. This included two sets of twins (three non-SABs, one SAB) and four pregnancies which were reported to have ended in therapeutic abortions. Two therapeutic abortions took place prior to the spill and two following the spill. All therapeutic abortions were excluded from the follow-up interview and subsequent analyses.

Of the remaining 75 pregnancies, the name of the woman was withheld for 11 pregnancies (9 women). These 11 anonymous pregnancies resulted in seven non-SABs and four SABs. These four SABs could not be confirmed but were included in some of the analyses.

Follow-Up Interview

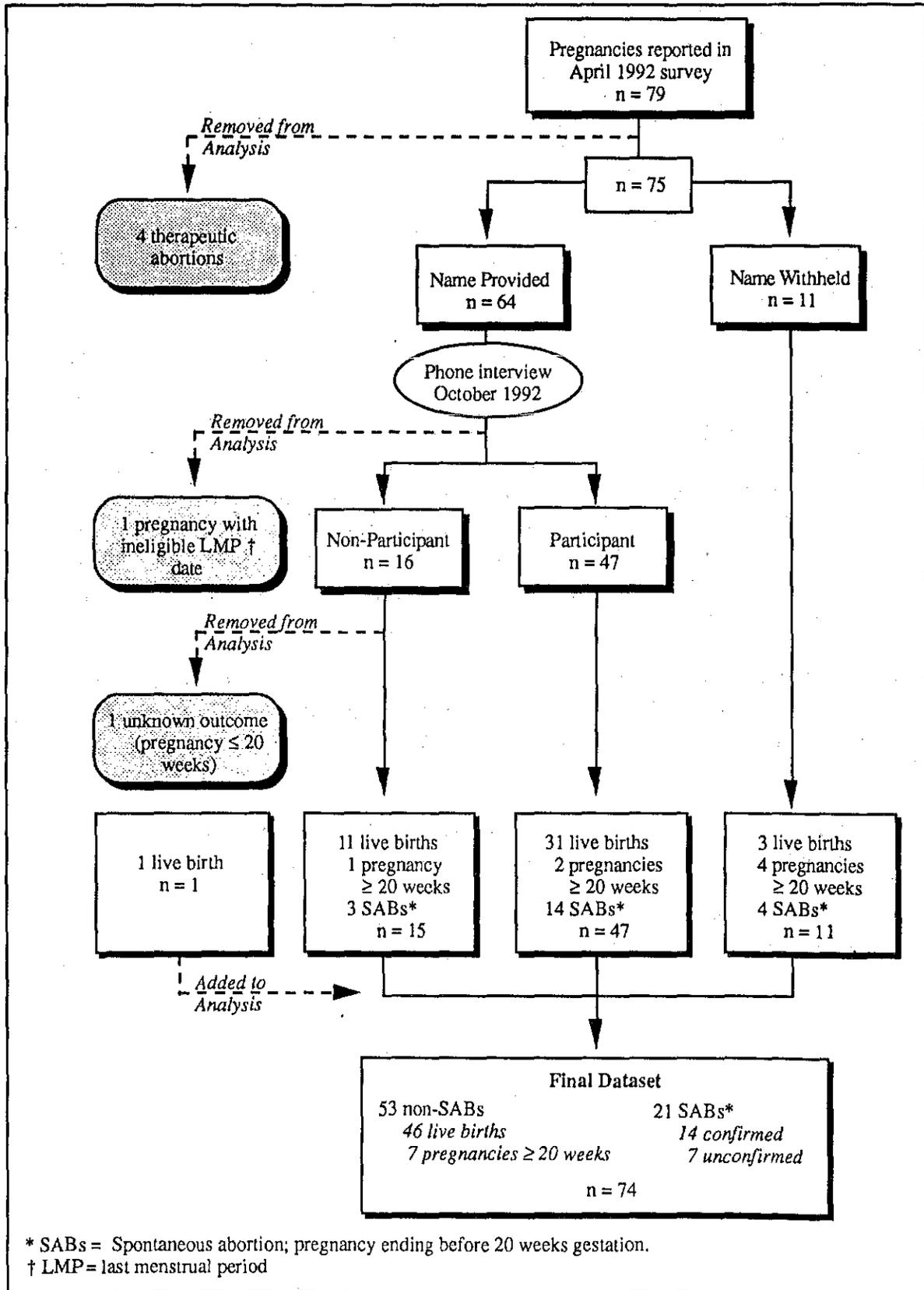
The follow-up interview attempted to collect information on all 64 pregnancies for which the name of the mother was provided. One reported pregnancy resulting in a live birth was found to have begun prior to the study period and was excluded. Interviews were completed for 47 of the remaining 63 pregnancies (73%); 33 non-SABs and 14 confirmed SABs. Five women refused to participate (five non-SABs); nine women could not be reached by telephone or letter (11 pregnancies: seven non-SABs, three SABs, and one unknown outcome). Since the outcome for one pregnancy remained unknown following the interview, this pregnancy was then excluded from the analyses (Figure 2). Among women reporting live births, the participation rate in the follow-up

interview appeared related to exposure. For women with a live birth whose pregnancy was not exposed in the first trimester, 50% (11/22) participated in the follow-up interview compared to 100% (6/6) of women whose pregnancy was exposed in the first trimester.

Data Analysis

A total of 74 pregnancies reported for 64 women were included in the analyses (Figure 2). These included 11 anonymous pregnancies, 47 pregnancies where the woman completed the follow-up interview, 15 pregnancies where the woman did not participate in the follow-up interview, and one additional pregnancy (live birth) which was identified after the interview period ended. Fifty-three pregnancies were non-SABs which included 46 live births and 7 pregnancies which lasted for at least 20 weeks. Of the 21 reported SABs, 14 (67%) were confirmed; eight through a review of medical records and six by physician review of the interview information. Seven SABs remain unconfirmed; three women were not reached for follow-up and four women had participated anonymously. Of these, five were reported by proxy.

FIGURE 2. STATUS OF PREGNANCIES REPORTED IN APRIL 1992



Demographics

Women reporting a pregnancy were mostly white, non-Hispanic (83%). The age at LMP ranged from 14 to 42 years with a mean age of 25.7 years. At the time of the survey, approximately 71% had health insurance. Household income was provided for 60 of the 64 women, with 63% reporting incomes less than \$20,000 per year. For SABs, the gestational age ranged from 4 to 15 weeks post LMP with 95% of the SABs occurring by 13 weeks gestation.

Risk factors for SAB among this population corresponded to those expected from the literature.¹² Women over 34 years of age were at increased risk, as were women with a history of SAB. These risk factors were distributed similarly among women exposed in the first trimester and unexposed women.

Spontaneous Abortion Rate

Of the 11 pregnancies exposed in the first trimester, five ended in a reported SAB. One SAB was confirmed during the follow-up interview and four were not confirmed (two women were not reached and two women had participated anonymously). The rate of confirmed SAB was 14% (95% CI = 0-58) among fetuses exposed in the first trimester compared to 21% (95% CI = 9-39) in the unexposed group. For women who conceived after the spill, the rates were 23% (95% CI = 8-45) and 20% (95% CI = 1-72) respectively among the exposed and unexposed post-spill groups (Table 2).

The rate of all reported SAB was 45% (95% CI = 17-77) among fetuses exposed in the first trimester compared to 26% (95% CI = 13-43) in the unexposed group. For the post-spill groups, the rates were 26% (95% CI = 10-48) and 20% (95% CI = 1-72) among the exposed and unexposed (Table 3).

All confidence intervals are wide reflecting small numbers. Additionally, confidence intervals overlap implying no statistically significant differences between groups.

When exposure was defined as occurring in the first 20 weeks gestation, results for both confirmed and all reported SABs were similar.

TABLE 2. ANALYSIS OF CONFIRMED SPONTANEOUS ABORTIONS CATEGORIZED BY EXPOSURE IN THE FIRST TRIMESTER

	Exposure Group			
	Exposed 1st Trimester ¹	Unexposed 1st Trimester ²	Exposed Post-Spill ³	Unexposed Post-Spill ⁴
Confirmed SABs ⁵	1	7	5	1
Non-SABs ⁶	6	26	17	4
Total	7	33	22	5
Spontaneous Abortion Rate	14%	21%	23%	20%
95% Confidence Interval	(0-58)	(9-39)	(8-45)	(1-72)

TABLE 3. ANALYSIS OF ALL REPORTED SPONTANEOUS ABORTIONS CATEGORIZED BY EXPOSURE IN THE FIRST TRIMESTER

	Exposure Group			
	Exposed 1st Trimester ¹	Unexposed 1st Trimester ²	Exposed Post-Spill ³	Unexposed Post-Spill ⁴
All Reported SABs ⁷	5	9	6	1
Non-SABs ⁶	6	26	17	4
Total	11	35	23	5
Spontaneous Abortion Rate	45%	26%	26%	20%
95% Confidence Interval	(17-77)	(13-43)	(10-48)	(1-72)

1. Exposed 1st Trimester: Last menstrual period 4/15/91 through 7/16/91 and mother/fetus in Dunsmuir during 7/15/91 to 7/16/91.
2. Unexposed 1st Trimester: Last menstrual period 7/1/90 through 7/16/91 and mother/fetus not exposed in the first trimester or pregnancy ended before exposure.
3. Exposed Post-Spill: Last menstrual period 7/17/91 through 2/29/92 and mother was in Dunsmuir during 7/15/91 to 7/16/91.
4. Unexposed Post-Spill: Last menstrual period 7/17/91 through 2/29/92 and mother was not in Dunsmuir during 7/15/91 to 7/16/91.
5. Confirmed SABs: Spontaneous abortion was confirmed through medical record review or physician review of the follow-up interview information.
6. Non-SABs: Pregnancy ended in a live or still birth or lasted at least 20 weeks gestation.
7. All Reported SABs: Spontaneous abortion may or may not have been confirmed.

1991 California Birth Certificates

Analysis of the 1991 California birth certificate tape identified 26 live births for which the residence of the mother was determined to be Dunsmuir. Of these live births, 69% (18/26) were identified in the April 1992 survey. For the eight live births not identified in the survey, seven women were no longer at the address listed on the birth certificate and had not participated in the survey. Residents at the eighth address refused to participate in the survey. These data suggest an underascertainment of live births by the April 1992 survey.

Assessment of Information Provided by a Proxy

A total of 14 women, age 18 to 42, whose pregnancy information had been provided by a proxy were contacted and all confirmed that they had not been pregnant between July 1, 1990 to February 29, 1992.

Comparing April 1992 survey data provided by a proxy and October 1992 interview data provided by the woman, the ending date for two pregnancies provided by a proxy were incorrect. One pregnancy (live birth) did not occur during the study period and one pregnancy was conceived following the spill (reported by proxy as being conceived just prior to the spill). Information on the women's whereabouts for the first three days following the spill provided by a proxy was similar to that provided by the women themselves.

DISCUSSION

A major limitation of this study is the inability to confirm one-third of the reported SABs (7/21). Some individuals participated in the survey anonymously, possibly due to litigation. This made it impossible to date to confirm four SABs. Unconfirmed SABs which were reported by a proxy (5/7) could have errors with regard to exposure and outcome.

Another limitation was the small number of pregnancies occurring in the study population. Due to the small numbers, the SAB rates are not stable as evidenced by the wide confidence intervals. Therefore the results can be interpreted as due to chance.

In addition, limited exposure information was available. Since environmental monitoring was not available for the first two days after the spill, it is not known for certain what by-products of metam sodium were present in the air, at what concentrations, and for how long. Therefore it is not possible to evaluate a dose-response relationship, only the possibility of exposure. If the period of greatest exposure was not July 15 to 16 or extends beyond that time period then exposure may be misclassified. Exposure is also based on reported presence in the spill area and the date of the LMP, both of which may be imprecise.

When only confirmed SABs were examined, no increased risk was observed for exposure in the first trimester. However, when all reported (confirmed and unconfirmed) SABs were examined, an elevated rate was observed for exposure in the first trimester, although the confidence interval was wide and this finding could be due to chance alone. It would have taken eight of the 11 exposed pregnancies to have ended in a SAB (for a rate of 73%) in order for the result to achieve statistical significance at the 95% confidence level. The small population in Dunsmuir precluded our ability to obtain "statistically significant" results for any observed rate less than 73%.

It is possible that risk of SAB could have been increased by stress generated by the spill. Stress has been associated with an increase in some reproductive outcomes,¹³⁻¹⁷ but research to date on the relationship between stress and SAB is limited.

Confirmed and reported unexposed and post-spill SAB rates were similar. However, both the unexposed rate for confirmed SABs (21%) and for all reported SABs (26%) are higher than unexposed rates reported in two other DHS studies which used similar ascertainment methods. In these studies, the rates for confirmed SABs range from 7-10% and for reported SABs the rates range from 9-11%.^{18, 19}

The higher SAB rates, even among the unexposed pregnancies (many of which ended before the spill), may be due to a number of reasons. One possibility is under-ascertainment of live births. Indeed review of the 1991 birth certificate data suggested that not all of the live births were identified during the April 1992 survey. This may be due to refusal to participate in the April 1992 survey, absence from home at the time of the survey, or movement out of the area prior to the survey. In addition, the design of the study limited our ability to examine other possible risk factors which may increase the risk of SAB. These include maternal illness and medication use, contraceptive use, nutrition, parental occupation or environmental exposures, and socioeconomic characteristics.²⁰

It is possible that the April 1992 survey did not ascertain all the SABs that occurred in the study population. Women may have refused to participate, may have been away from home, moved from the area or failed to recognize an early fetal loss.

CONCLUSIONS

Although a possible increase in the SAB rate among pregnancies exposed in the first trimester cannot be confirmed it should not be discounted. However, women who were exposed and subsequently became pregnant do not appear to be at increased risk of SAB.

Using only confirmed SABs, this study does not show a higher rate of SAB among fetuses exposed in the first trimester. Including the four unconfirmed SABs exposed in the first trimester increases the rate above the unexposed, but the confidence intervals are wide and overlap. The higher rates of confirmed SAB even in unexposed groups and the review of birth certificates suggest that not all women whose pregnancies ended in live births participated in our study.

Due to the inherent limitations of epidemiological studies, we cannot determine whether the elevated rate of reported SAB among fetuses exposed in the first trimester was due to exposure to the by-products of metam sodium. Other factors such as imprecise reporting of exposure and pregnancy ending date, chance, differential recall of missed menstrual periods in the unconfirmed SABs, under-ascertainment of live births and SABs, and stress generated by the spill could have influenced the rate. Even if all reported SABs are confirmed, we may never be able to explain the pattern seen in this study. We do believe that it is worthwhile to document it in the medical literature.

RECOMMENDATIONS

DHS will make another attempt to confirm the seven reported but unconfirmed SABs. Women who participated in the April 1992 survey anonymously will be encouraged to identify themselves to us. Additional attempts will be made to contact the women who have been lost to follow-up.

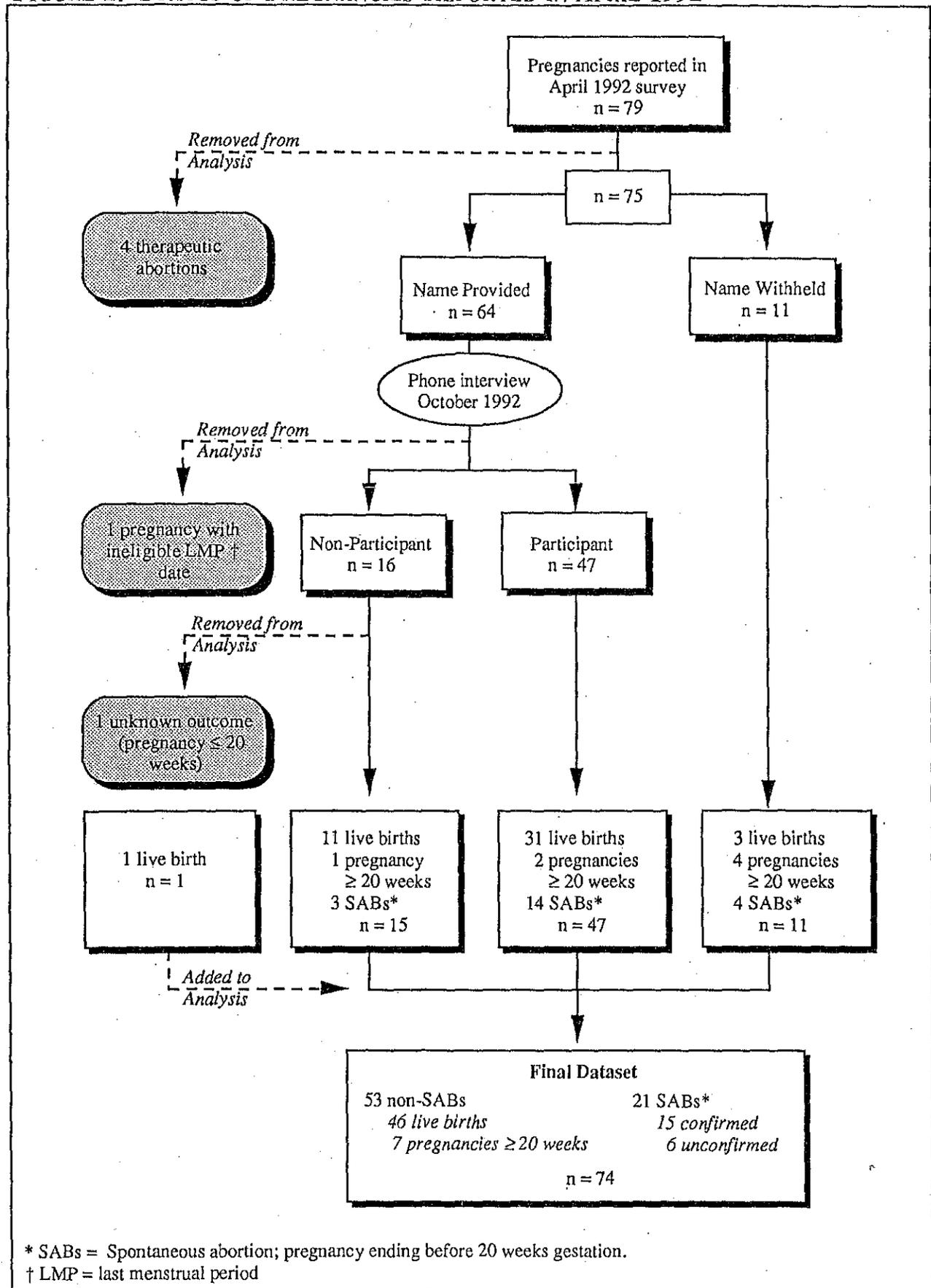
To further examine the pregnancies among post-spill conceptions, the birth certificate file for 1992 will be examined and used to confirm live births.

REFERENCES

1. California Department of Health Services. Acute health effects of the Cantara metam sodium spill: An epidemiologic assessment. Emeryville, CA: Environmental Epidemiology and Toxicology Program, June 1992.
2. US Department of Commerce, Economics and Statistics Administration, Bureau of the Census. 1990 Census of Population and Housing: Summary Population and Housing Characteristics of California. Washington DC: US Government Printing Office, August, 1991.
3. California Department of Health Services. Acute health effects of the Cantara metam sodium spill: An epidemiologic assessment. Emeryville, CA: Environmental Epidemiology and Toxicology Program, June 1992. Page 26.
4. California Environmental Protection Agency. Evaluation of the Health Risks Associated with the Metam Spill in the Upper Sacramento River. Berkeley, CA: Hazard Identification and Risk Assessment Branch, (Draft September 1992). Page D-14.
5. California Environmental Protection Agency. Evaluation of the Health Risks Associated with the Metam Spill in the Upper Sacramento River. Berkeley, CA: Hazard Identification and Risk Assessment Branch, (Draft September 1992). Page 18.

6. California Environmental Protection Agency. Evaluation of the Health Risks Associated with the Metam Spill in the Upper Sacramento River. Berkeley, CA: Hazard Identification and Risk Assessment Branch, (Draft September 1992). Page H-11.
7. California Environmental Protection Agency. Evaluation of the Health Risks Associated with the Metam Spill in the Upper Sacramento River. Berkeley, CA: Hazard Identification and Risk Assessment Branch, (Draft September 1992). Page B-17.
8. California Environmental Protection Agency. Evaluation of the Health Risks Associated with the Metam Spill in the Upper Sacramento River. Berkeley, CA: Hazard Identification and Risk Assessment Branch, (Draft September 1992). Page B-19.
9. California Department of Health Services. Monitoring for Birth Defects following the Cantara Loop Spill, December 1992. Emeryville, CA: California Birth Defects Monitoring Program, December 1992.
10. California Department of Health Services. Vital Statistics of California, 1986. Sacramento, CA: Health Data and Statistics Branch, April 1988.
11. Beyer W.H. Ed. Confidence Limits for Proportions: CRC Handbook of Tables for Probability and Statistics, Second Edition. Boca Raton, FL: CRC Press Inc., 1968. Pages 222-227.
12. Kline J, Stein Z. Spontaneous abortion. In: Bracken M. ed. Perinatal Epidemiology. London: Oxford University Press, 1984. Pages 23-51.
13. Norbeck JS, Tilden VP. Life stress, social support, and emotional disequilibrium in complications of pregnancy: A prospective, multivariate study. Journal of Health and Social Behavior, 1983; 24:30-46.
14. Nuckolls KD, Cassel J, Kaplan BH. Psychosocial assets, life crisis, and the prognosis of pregnancy. American Journal of Epidemiology, 1972; 95:431-441.
15. Gorsuch RL, Key MK. Abnormalities of pregnancy as a function of anxiety and life stress. Psychosomatic Medicine, 1974; 36:352-362.
16. McDonald RL. The role of emotional factors in obstetrical complication: A review. Psychosomatic Medicine, 1968; 30:222-237.
17. Newton RW, Hunt LP. Psychological stress in pregnancy and its relation to low birthweight. British Medical Journal, 1984; 288:1191-1194.
18. California Department of Health Services. Health Survey of the Community Near the Purity Oil Sales Toxic Waste Site, Draft. Berkeley, CA: Epidemiological Studies and Surveillance Section. Page 6-3.
19. California Department of Health Services. Pregnancy Outcomes in Santa Clara County 1980-1985. Berkeley, CA: Epidemiological Studies and Surveillance Section, May 1988. Page 2.45.
20. Kline J, Stein Z. Spontaneous abortion. In: Bracken M. ed. Perinatal Epidemiology. London: Oxford University Press, 1984. Pages 23-51.

FIGURE 2. STATUS OF PREGNANCIES REPORTED IN APRIL 1992



* SABs = Spontaneous abortion; pregnancy ending before 20 weeks gestation.
 † LMP = last menstrual period

Revised April 22, 1993.

TABLE 2. ANALYSIS OF CONFIRMED SPONTANEOUS ABORTIONS CATEGORIZED BY EXPOSURE IN THE FIRST TRIMESTER

	Exposure Group			
	Exposed 1st Trimester ¹	Unexposed 1st Trimester ²	Exposed Post-Spill ³	Unexposed Post-Spill ⁴
Confirmed SABs ⁵	2	7	5	1
Non-SABs ⁶	6	26	17	4
Total	8	33	22	5
Spontaneous Abortion Rate	25%	21%	23%	20%
95% Confidence Interval	(3-65)	(9-39)	(8-45)	(1-72)

Revised April 22, 1993.

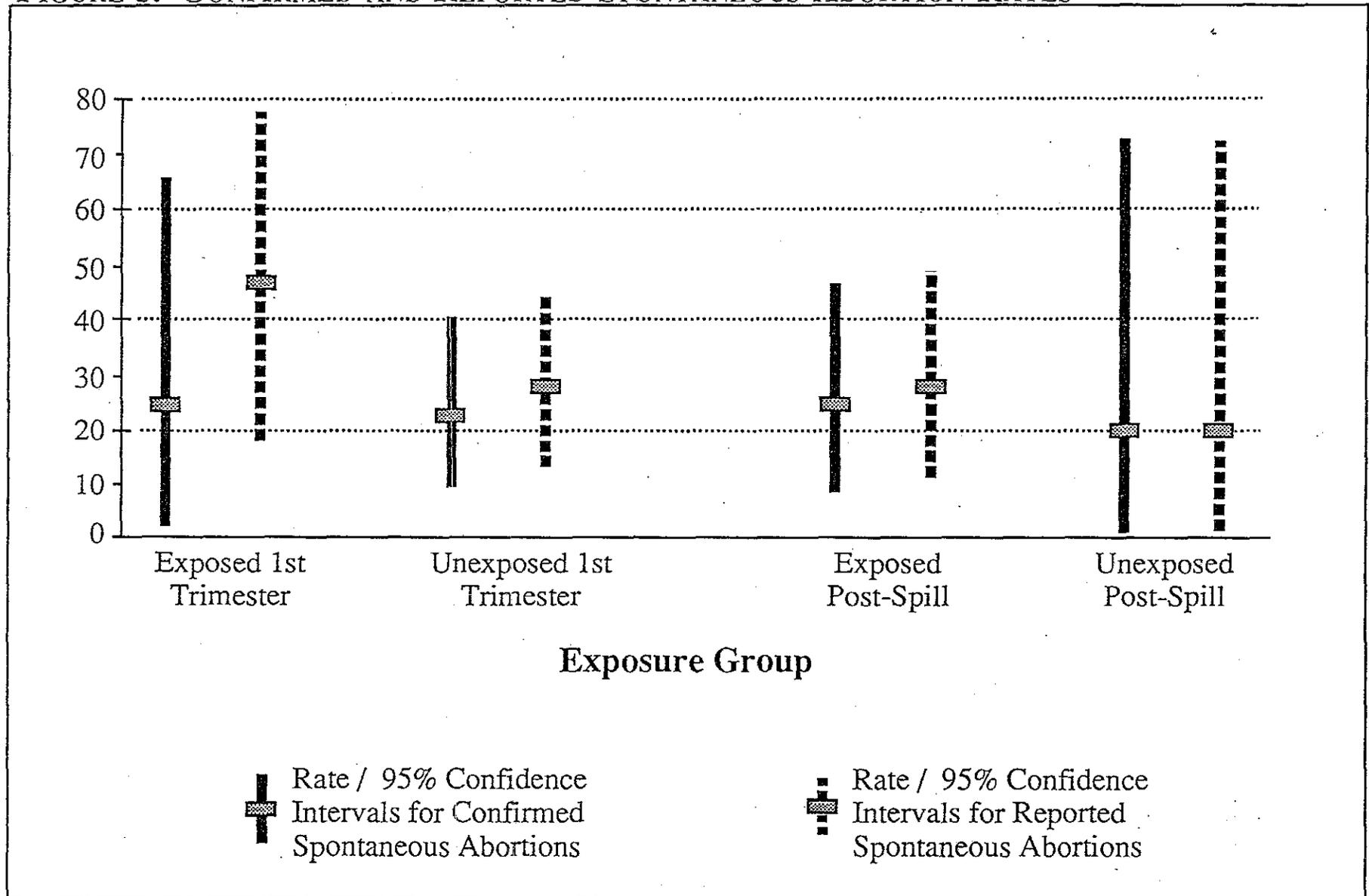
TABLE 3. ANALYSIS OF ALL REPORTED SPONTANEOUS ABORTIONS CATEGORIZED BY EXPOSURE IN THE FIRST TRIMESTER

	Exposure Group			
	Exposed 1st Trimester ¹	Unexposed 1st Trimester ²	Exposed Post-Spill ³	Unexposed Post-Spill ⁴
All Reported SABs ⁷	5	9	6	1
Non-SABs ⁶	6	26	17	4
Total	11	35	23	5
Spontaneous Abortion Rate	45%	26%	26%	20%
95% Confidence Interval	(17-77)	(13-43)	(10-48)	(1-72)

Revised April 22, 1993.

1. Exposed 1st Trimester: Last menstrual period 4/15/91 through 7/16/91 and mother/fetus in Dunsmuir during 7/15/91 to 7/16/91.
2. Unexposed 1st Trimester: Last menstrual period 7/1/90 through 7/16/91 and mother/fetus not exposed in the first trimester or pregnancy ended before exposure.
3. Exposed Post-Spill: Last menstrual period 7/17/91 through 2/29/92 and mother was in Dunsmuir during 7/15/91 to 7/16/91.
4. Unexposed Post-Spill: Last menstrual period 7/17/91 through 2/29/92 and mother was not in Dunsmuir during 7/15/91 to 7/16/91.
5. Confirmed SABs: Spontaneous abortion was confirmed through medical record review or physician review of the follow-up interview information.
6. Non-SABs: Pregnancy ended in a live or still birth or lasted at least 20 weeks gestation.
7. All Reported SABs: Spontaneous abortion may or may not have been confirmed.

FIGURE 3. CONFIRMED AND REPORTED SPONTANEOUS ABORTION RATES



Revised April 22, 1993.