

Childhood adverse health outcomes and drinking water exposures to chlorinated solvents at the U.S. Marine Corps Base Camp Lejeune, North Carolina

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ATSDR project team

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Outline

- ❖ Site background
- ❖ Previous epidemiological study at the base
- ❖ Current case-control study

Site background

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Site background

- ❖ **Area**
 - ❖ ~ 164 square miles
- ❖ **Population:**
 - ❖ ~100,000 active duty and dependents
- ❖ **Considerable in- and out-migration from base**
 - ❖ **Estimated one-third of mothers receiving prenatal care at naval hospital during 1970s-80s were transferred before delivery**
 - ❖ **Average duration in base housing is about 2 years**



Base family housing areas and drinking water systems

- ❖ 10 base family housing areas
- ❖ 3 water treatment plants (WTPs) serving base housing areas:
 - ❖ Tarawa Terrace (TT - constructed in 1951/52)
 - ❖ Holcomb Boulevard (HB - constructed in 1972)
 - ❖ Hadnot Point (HP - constructed in the 1943)

Contamination of base drinking water supplies

❖ Contamination of HP wells:

- ❖ Underground storage tanks containing degreasing solvents were installed near HP wells in 1940s-1950s
- ❖ Spills and dumping of benzene, toluene, ethyl benzene, xylenes

❖ Contamination of TT wells:

- ❖ ABC One-Hour Cleaners began operation near the base in 1953
- ❖ Supply wells for TT installed 900 feet from septic tank of ABC One-Hour Cleaners in May 1951



Contamination of base drinking water supplies

- ❖ Contamination of HP and TT drinking water systems was intermittent
 - ❖ Each system had more wells than necessary to supply water on any given day
 - ❖ Wells rotated in and out of service
- ❖ Contamination levels in drinking water distribution system depended on the wells being used at a particular time
- ❖ In each system, water from all wells in use was mixed before treatment and distribution



Contamination of base drinking water supplies

- ❖ Chlorinated solvents first detected in TT and HP wells in 1982 during routine sampling
 - ❖ Contamination of TT wells began in the late 1950s
 - ❖ Start of contamination of HP wells is still being determined, but likely began by 1950 or earlier.
- ❖ Highly contaminated wells at HP and TT were shut down in 1985



Maximum concentrations of chlorinated solvents in drinking water at the base, 1982-1985 (tap water samples)

❖ Hadnot Pt

- ❖ TCE = 1,400 $\mu\text{g/L}$ (MCL = 5 $\mu\text{g/L}$)
- ❖ t-1,2-dichloroethane = 407 $\mu\text{g/L}$ (MCL = 70 $\mu\text{g/L}$)

❖ Tarawa Terrace

- ❖ PCE = 215 $\mu\text{g/L}$ (MCL = 5 $\mu\text{g/L}$)
- ❖ TCE = 8 $\mu\text{g/L}$
- ❖ t-1,2-dichloroethane = 12 $\mu\text{g/L}$



1997 ATSDR Public Health Assessment

- ❖ Limited information in scientific literature on how chlorinated solvents in drinking water might affect a fetus or child
- ❖ Recommendation: Conduct epidemiological studies to evaluate
 - ❖ Whether maternal exposure was associated with a higher risk of having an adverse birth outcome (e.g., birth defects, low birth weight, preterm birth, fetal death)
 - ❖ Whether maternal or infant (up to 1 year of life) exposure was associated with a childhood cancer (e.g., leukemia)



Epidemiological studies at Camp Lejeune

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1998 ATSDR study on adverse pregnancy outcomes

- ❖ Evaluated potential maternal exposure to drinking water contaminants on base and:
 - ❖ Preterm birth
 - ❖ Small for gestational age (SGA)
 - ❖ Mean birth weight deficit
- ❖ Only used available databases
 - ❖ Electronic birth certificates available beginning in 1968
 - ❖ 12,493 singleton live births on base during 1968-1985
 - ❖ Base family housing records linked to mother's address at delivery and (in most instances) father's name
 - ❖ Study could not evaluate birth defects and childhood cancers



1998 ATSDR study on adverse pregnancy outcomes: results

- ❖ **Exposure to TT water (PCE):**
 - ❖ **Elevated risk for SGA among infants born to:**
 - ❖ **mothers aged >35 years**
 - ❖ **mothers with ≥ 2 prior fetal losses**
- ❖ **Exposure to HP water (TCE):**
 - ❖ **Elevated risk for SGA only among male infants**
- ❖ **Exposure assessment error may have biased results towards the null**



Current ATSDR epidemiological study

**“Exposure to volatile organic compounds in drinking water and specific birth defects and childhood cancers”
(case-control study)**

- ❖ Multi-step process
 - ❖ Review scientific literature to identify specific birth defects and childhood cancers associated with drinking water contaminated with chlorinated solvents
 - ❖ Conduct telephone survey to ascertain potential cases
 - ❖ Obtain medical records to verify diagnoses of reported cases
 - ❖ Conduct a case-control study
 - ❖ interview parents
 - ❖ obtain estimates of exposure from the water modeling component



Childhood adverse health outcomes from exposures to TCE in drinking water

- ❖ Childhood leukemia
 - ❖ Woburn, Northern NJ study
- ❖ Small for gestational age
 - ❖ Woburn, Camp Lejeune study
- ❖ Fetal death
 - ❖ Woburn



Childhood adverse health outcomes from exposures to TCE in drinking water

❖ Birth defects

❖ Neural tube defects (spina bifida, anencephaly)

❖ Northern NJ study, (Woburn)

❖ Oral clefts (cleft lip & cleft palate)

❖ Northern NJ study, (Woburn)

❖ Major heart defects

❖ Tucson, AZ study



Childhood adverse health outcomes from exposures to TCE in drinking water

- ❖ Birth defects (continued)
 - ❖ Choanal atresia (nasal defect)
 - ❖ Cluster in Woburn (3 observed, 0.15 expected)
 - ❖ Eye defects
 - ❖ Woburn



Childhood adverse health outcomes from exposures to PCE in drinking water

- ❖ Small for gestational age
 - ❖ 1998 Camp Lejeune study
- ❖ Oral cleft defects (cleft lip & cleft palate)
 - ❖ Northern NJ study



Current ATSDR epidemiological study: results of literature review

- ❖ Based on the review of the scientific literature, the following outcomes were selected for further study
 - ❖ Neural tube defects (NTD)
 - ❖ Oral cleft defects (cleft lip and cleft palate)
 - ❖ Conotruncal heart defects
 - ❖ tetralogy of Fallot
 - ❖ D-transposition of the great arteries
 - ❖ truncus arteriosus
 - ❖ pulmonary valve atresia with ventricular septal defect
 - ❖ double outlet right ventricle
 - ❖ Choanal atresia (a nasal defect)
 - ❖ Childhood leukemia
 - ❖ Childhood non-Hodgkin's lymphoma



Current ATSDR epidemiological study: telephone survey

- ❖ Telephone survey was conducted to identify potential cases of the selected adverse childhood outcomes among births occurring during 1968-1985 to mothers residing on base any time during their pregnancy
 - ❖ Estimated number of births was between 16,000 and 17,000
- ❖ Questions addressed by survey:
 - ❖ Could a high percentage of the population be identified and contacted?
 - ❖ Could most of the cases of these adverse outcomes in the population be reliably ascertained and verified?
 - ❖ Would there be sufficient numbers of cases to study?



Current ATSDR epidemiological study: results of telephone survey

- ❖ Parents of 12,598 eligible children were surveyed
 - ❖ Overall participation rate of 74%-80%

- ❖ Sufficient numbers of NTDs, oral clefts, and childhood cancers reported
 - ❖ 106 reported cases:
 - 35 NTDs
 - 42 oral cleft defects
 - 29 childhood hematopoietic cancers



Current ATSDR epidemiological study: verification of cases

- ❖ Verification of diagnoses of cases ascertained by survey has been completed
- ❖ Confirmed cases (N=57):
 - ❖ 17 NTD
 - ❖ 24 clefts
 - ❖ 16 hematopoietic cancers
- ❖ 32 confirmed not to have the reported diseases
- ❖ 7 refused to participate
- ❖ 7 could not be verified (no medical records)
- ❖ 3 were ineligible



Current ATSDR epidemiological study: case/control recruitment

- ❖ Parents of 54 cases were interviewed
 - ❖ 52 mothers interviewed
 - ❖ 45 mothers and fathers interviewed
 - ❖ 7 mothers only interviewed
 - ❖ 2 fathers only interviewed
- ❖ Parents of 3 cases could not be located or contacted
- ❖ Parents of 7 potential cases refused to participate in the verification process and interviews
- ❖ **Participation rate: $54/64 = 84.4\%$**



Current ATSDR epidemiological study: case/control recruitment

- ❖ 816 controls randomly sampled from the survey population to obtain ~10:1 ratio of controls to cases

- ❖ Efforts were made to contact 651 of the 816 controls
 - ❖ Parents of 548 controls were interviewed
 - ❖ 461 mothers interviewed
 - 359 mothers and fathers interviewed
 - 102 mothers only interviewed
 - ❖ 87 fathers interviewed only
 - ❖ Parents of 103 controls refused or could not be contacted

- ❖ **Participation rate: $548/651 = 84.2\%$**



Current ATSDR epidemiological study: parent interviews

- ❖ Interviews were conducted in Spring-Summer 2005 to parents of cases and controls to obtain information on:
 - ❖ Maternal water consumption habits
 - ❖ Maternal residential history
 - ❖ Maternal exposures during pregnancy
 - ❖ Occupation, medications, illnesses, smoking, passive smoke, hobbies, (etc.)
 - ❖ Parental risk factors
 - ❖ Occupational history, service in Vietnam, (etc.)



Current ATSDR epidemiological study: water modeling component

- ❖ Lack of historical, contaminant-specific data at Camp Lejeune requires a modeling approach
 - ❖ Modeling of groundwater flow and water distribution system
 - ❖ Historical reconstruction to provide a quantitative estimate of exposure
 - ❖ Similar to (but more complex than) the approach taken in Dover Township, NJ Childhood Cancers Study

