BOSTON UNIVERSITY MEDICAL CENTER
SCHOOL OF MEDICINE • SCHOOL OF PUBLIC HEALTH • GOLDMAN SCHOOL OF DENTAL MEDICINE • BOSTON MEDICAL CENTER

Boston University
School of
Public Health

Department of
Environmental Health

715 Albany Street
Boston, Massachusetts
02118-2526
Tel: 617-638-4620
Fax: 617-638-4857

written only

November 10, 2004

Jeff O'Donnell
Committee Assistant
New York State Assembly
Program & Counsel Staff
Capitol/ Room 520
Albany, NY 12248

Dear Sir

This testimony relates to your Committee's interest in the public health aspects of exposure to tricholoroethene (TCE) via vapor intrusion into indoor environments from contaminated groundwater. I have had a long interest in the health effects of the chlorinated ethylenes, TCE and its very close relative, PCE (tetrachloroethylene), and have authored numerous peer-reviewed epidemiological studies on these chemicals. I have attached my Curriculum Vitae for your reference as to my standing and qualifications to give my opinions on this important matter.

TCE has been implicated in at least four kinds of adverse health effects: neurotoxic effects (effects on the central nervous system); cancer; birth defects; and autoimmune disease (scleroderma, lupus erythematosus and mixed connective tissue disease). For historical reasons and force of circumstance much of the study of the effects of TCE on human beings has taken place in the occupational environment, raising the question as to what effects might be expected, if any, at the substantially lower levels normally encountered in an indoor air environment from vapor intrusion. While this is not an easy question to answer, I have substantial concerns about effects even at these levels. This is founded on two main arguments.

1. We have been studying the effects of PCE in drinking water for almost 15 years and are able to see substantial increased cancer risks in these circumstances, which are orders of magnitude lower than occupational exposures. Drinking water exposures within homes come both from ingestion and air stripping and dermal absorption. The latter are roughly of the same order of magnitude as ingestion. The current MCL for drinking water is 5 micrograms per liter. Thus allowing for a doubling of dose from air/dermal and a consumption of 2 liters/day (a likely overestimate) this is a dose of 20 micrograms per day. Since the average adult breathes approximately one cubic meter/hour, this corresponds (roughly) to an indoor air exposure of 1 microgram/m^3. The MCL is an old

standard based on outdated cancer risk estimates. The proposed level of 5 micrograms/m^3 is thus not consistent with the current (now fairly old) water standard.

However there is reason to believe the 10^{-6} risk level is considerably lower than previously thought. To be health protective one normally uses the most conservative estimates. I call your attention to work by Cronin et al.[1] In this physiologically-based pharmacokinetic model ("PBPK model") account is taken of the actual physiological processes of absorption, distribution and metabolism in animals and humans. Mice and humans, for example, are built on the same "organization chart" of blood, brain, digestive system, lungs, etc., but the extent to which the different "boxes" in the chart absorb, distribute, exchange and metabolize TCE might vary from species to species. The object of the PBPK exercise is a better extrapolation of a representative response from mouse to human by substituting the correct species-specific values for things like absorption coefficients, rate constants, and other values ("parameters") that determine the details of how TCE is handled in an organism.

A major difficulty with PBPK modeling is the paucity of information on two things: the correct biologically effective endpoint to use (is it the peak concentration of the metabolite TCA?, cumulative TCA?, the metabolite DCVC?, some DNA-adduct?, the metabolite trichloroethanol?); and accurate determination of the parameters that describe important physiological processes, like the rate of absorption or excretion in different species and between different organs and tissues in the same species. Considerable uncertainty in the correct parameter estimates can lead to very large differences in estimates of biologically effective dose, and hence of dose-response modeling. The way parameter uncertainties are currently handled is to incorporate a distribution of values in the model, and then determine the impact on the dose estimate (so-called Monte Carlo modeling). There is a wide range of legitimate estimates using PBPK models when coupled with the linearized multistage model used by NYDOH. Cronin et al., for example, have estimates as low as .02 micrograms/m^3 TCE as the 1 in 1,000,000 risk in air.

I note that the choice of a linearized multistage model, as used by NYDOH, is not the only possible choice. Choosing another biologically plausible model for the dose-response function can also result in a large variation in estimated risks. These variations for estimates of the risk of TCE in drinking water were investigated by Cothern, et al.[2] Four different functional forms were used, including the one chosen by NYDOH (the multistage model), and the estimated risks compared. Cothern et al. note there are no biologically based criteria for choosing one model over another. The results are a dramatic example of the effects of model choice. It turns out that the NYDOH choice was one of the most permissive (in the public health protection sense) compared to the least permissive, the Weibull model.[3] The difference in estimated risks among the models was almost a factor

---

[1] Cronin WJ, Oswald EF, Shelley ML, Fisher JW, Flemming CD, "A trichloroethylene risk assessment using a Monte Carlo analysis of parameter uncertainty in conjunction with physiologically-based pharmacokinetic modeling," *Risk Analysis* 15:555-565, 1995.

[2] Cothern CR, Coniglio WA, Marcus WL. "Estimating risk to human health: trichloroethylene in drinking water is used as the example," *Environ Sci Technol* 20:111-116, 1986.

[3] The model is based on the Weibull distribution, which can be thought of either as a time-to-tumour model, or in terms of a tolerance distribution.

of 10,000, i.e., the Weibull model predicted risks from TCE in drinking water to be 10,000 times higher than the risks from the most permissive model.

2. My second line of argument relates to the kinds of health effects one might expect to result from extremely tiny exposures. To summarize a longer argument, the effects are just those where some kind of biological amplification of damage occurs. The classic example is cancer, where a tiny alteration in the genetic program of the cell (the DNA code) that makes a cell into a cancer cell is reproduced each time the cell divides. Thus the original damage is biologically reproduced along with it and the offending tiny amount of chemical need no longer be present. This is essentially the reason we believe there is some cancer risk at every level of exposure. The dose response relation discussed above tries to estimate the size of that risk at various exposures.

However, there are other biological systems where such intrinsic amplification might be expected, among them the immune system (one need only think of bee stings and the dramatic, sometimes fatal effect of tiny exposures); the nervous system (where tiny signals are amplified into large responses); and human reproduction (where a entire organism comes from a single fertilized egg). Thus the health effects seen in occupational environments are plausibly also present, although at a lesser frequency, at much lower exposure levels as well.

There has been a huge volume of scientific work done on this environmentally prevalent contaminant and these comments only highlight two considerations I though pertinent to the question before your committee. I am attaching a table I did a few years ago of epidemiologic studies of cancer and TCE/PCE. I hope you find it useful.

Please do not hesitate to get in touch with me if you have further questions. I regret that my schedule does not permit me to appear before your Committee in person.

Sincerely yours

David Ozonoff, MD, MPH
Professor of Environmental Health
Boston University School of Public Health

SUMMARY OF EPIDEMIOLOGICAL STUDIES PERTAINING TO TCE, PCE AND CANCER*

REFERENCE	STUDY POPULATIONS	STUDY DESIGN	RESULTS
McMichael et al., 1975	Rubber workers	Retrospective cohort mortality study	Leukemia in rubber workers exposed to several solvents, including TCE
Blair et al., 1979	330 deceased members of laundry and dry cleaning union, St. Louis	Proportional mortality study US population	Relative excess total cancers, lung, cervix; slight excesses in liver & leukemia
Kaplan, 1980	1597 drycleaners whose principal exposure was PCE	Retrospective cohort mortality study	Colon cancer (SMR 182) plus elevations involving small numbers for cancers of the pancreas and urinary tract and diseases of the blood forming organs
Olsson and Brandt, 1980	25 men admitted with HD, 50 matched controls	Case-control study	OR solvents 6.6, 3 cases, no controls exposed to TCE
Hardell, 1981	169 lymphoma cases, 338 controls in Sweden	Case-control study	OR solvents 4.6; OR TCE 4.8
Katz and Jowett, 1981	671 white female drycleaning workers who died in Wisconsin	Proportional mortality study	Relative excess in deaths from cancer of the kidney (unspecified site), with smaller excesses in bladder cancer, skin cancer and lymphosarcoma
Peters, 1981	Parents 92 children with brain CA ≤ 10 yrs., 92 matched controls in LA	Case-control study	OR = 9 for employment in aircraft industry, 2 fathers exposed to TCE
Duh and Asal, 1984	Deaths from 1975-1981 among laundry and drycleaning workers in Oklahoma	Proportional mortality study	Elevated standardized proportional mortality odds ratios for respiratory cancer and cancer of the kidney
Barret, 1984	235 deaths in TCE and cutting oil exposed workers	Cohort study	Naso- and oropharynx CA (SMR 2.5)
Hardell, 1984	102 liver cancers and 204 matched controls in Sweden	Case-control study	OR solvents and primary liver CA 1.8, hepatocellular CA 2.1

Hernberg et al., 1984	126 primary liver CA from Finnish registry 1979-80; 324 hospitalized controls with dx MI	Case-control study	OR solvents 2.3
Shindell and Urich, 1985	2646 workers (production and office) employed ≥ 3 months 1957-1983 in plant where TCE used as degreaser; some water contamination at plant; f/u to 1983	Cohort study	Decreased mortality from all causes in workers compared to national rates
Brown and Kaplan, 1985	1597 drycleaners whose principal exposure was PCE, exposed > 1 year before 1960	Extension of cohort study reported in Kaplan, 1980	Excess deaths from malignant neoplasms, cervical cancer, urinary tract cancer (both bladder and kidney)
Barret et al., 1985	Workers exposed to TCE and cutting oils	Cohort study	Excess cancer of the naso- and oropharynx
Axelson et al., 1986	Workers exposed to TCE and PCE	Cohort study	Slight excess incidence of bladder cancer and lymphoma
Lagakos et al., 1986	Population of Woburn, MA	Nested case-control	Leukemia OR = 2.2 (1.5-2.9)
Lowengart, et al., 1987	Parents of children with leukemia	Case-control study	Excess risk if parents occupationally exposed to TCE
Garabrant et al., 1988	14,067 workers employed ≥ 4yr in aircraft plant 1958-1982	Cohort study	No excesses
Hernberg, 1988	344 primary liver CA in Finnish registry, 1976-1978, 1981; 385 controls with dx MI and 476 deceased stomach CA controls	Case-control study	OR solvents .6 men, 3.4 women
Silverman, et al., 1989	Bladder cancer patients in national study	Case-control study	Excess risk in solvent-exposed workers
Sharpe, 1989	164 kidney CA, 161 non-CA kidney disease controls	Case-control study	OR solvents 3.4 (TCE, PCE, TCA and DCM most commonly used)
Fredricksson, et al., 1989	Colon cancer patients	Case-control study	Excess cancer in solvent-exposed workers

Olsen, 1989	2610 white males employed ≥ 1yr in chemical company in LA between 1956 and 1980; f/u to 1981; plant made PCE and other solvents	Cohort study	Leukemia/aleukemia SMR 4.9 (various types, differing employment histories)
Blair, 1990	5365 members of a drycleaning union employed ≥ 1yr between 1945 and 1977, followed through 1978	Retrospective cohort mortality study	Increased mortality from esophagus (SMR 2.1, black men 3.5), larynx (SMR 1.6), lung (SMR 1.3), cervix (SMR 1.7), bladder (SMR 1.7), NHL (SMR 1.7), HD (SMR 2.1), thyroid (SMR 3.3), high exposure to drycleaning solvents, blood CA (SMR 4.0)
Bond, 1990	44 liver CA from 6259 deaths in hourly workers Dow Chemical 1940-1982; random sample of other deaths (1888) as controls	Nested case-control study	OR PCE 1.8
Lynge and Thygesen, 1990	10,600 Danish laundry and dry cleaning workers, followed for 10 years from 1970; 1/4 worked in dry cleaning but could not be individually identified; PCE, TCE and CFC exposure	Cohort study	Excesses in lung (1.2), liver (2.2) and pancreatic CA (1.7)
Mallin, 1990	Town in NW Illinois	Cross-sectional	Bladder, RR = 1.7 male, RR = 2.6 female
Fagliano et al., 1990	Residence in one of 42 towns in NJ	Cross-sectional, TCE in town water	Leukemia RR = 1.4 (1.1-1.9) females, RR = 1.0 (.7 – 1.5) for males
Vartiainen et al., 1993	Residence in two villages	Cross sectional, TCE exposure in town water; comparison nat'l rates	Leukemia Town A, 1.2 (.8-1.7), Town B .7 (.4-1.1); HD Town A, .8 (.3-1.7), Town B, 1.4 (.7-2.5); Liver Town A, .7 (.3-1.4), Town B, .6 (.2-1.3) Multiple myeloma Town A, .7 (.3-1.3),Town B, .6 (.2-1.3) NHL Town A, .6 (.3-1.1), Town B, 1.4 (1.0-2.0)

Cohn et al., 1994	Residence in one of 75 towns in NJ	Cross-sectional, TCE exposure in town water	Leukemia RR = 1.4 (1.1, 1.9) females, RR = 1.1 (.8, 1.4); NHL RR = 1.4 (1.1, 1.7) females, RR = 1.2 (.9, 1.5) males
Spirtas et al., 1991	6929 employees exposed to solvents (include. PCE) and TCE in aircraft maintenance 1952-56	Cohort mortality	SMRs men Buccal/pharynx .9 (.3, 2.1) Esoph. 1.1 (.4, 2.3) Stomach .9 (.5, 1.5) Colon 1.1 (.7, 1.6) Rectum .6 (.2, 1.6) Bil./liver 2.0 (.9, 3.9) Pancreas .8 (.5, 1.4) Larynx .3 (.0, 1.9) Lung 1.0 (.8, 1.3) Prostate .8 (.5, 1.2) Kidney 1.2 (.5, 2.4) Bladder 1.4 (.7, 2.5) Melanoma1.0 (.3, 2.2) Brain .9 (.4, 1.7) Bone 2.6 (.5, 7.7) NHL 1.0 (.5, 1.9) HD.9 (.3, 2.4) Leukemia, .7 (.3, 1.3) Mult. Myeloma 1.1 (.4, 2.6) SMRs women: Colon .4 (.0, 1.3) Pancreas .8 (.1, 2.9) Breast .8 (.4, 1.5) Uterus 1.0 (.3, 2.5) Cervix 2.2 (.6, 5.7) NHL 2.9 (.8, 7.3) SMRs PCE exposure, women Mult. myeloma 17.1 (2.1, 61.6) NHL 9.7 (1.2, 35.0)
Aschengrau et al., 1993	Permanent residents of 5 towns on Cape Cod, MA, exposed to PCE in water	Case-control	Leukemia OR = 8.3 (1.5-45.3) Bladder OR = 4.0 (.7-25.1)

Axelson et al., 1994	1421 workers exposed to TCE, 1958-1987, biomonitored for U-TCA	Cohort mortality	SIRs Stomach .7 (.2, 1.6) Colon 1.0 (.4, 2.0) Liver 1.4 (.4, 3.6) Pancreas .3 (.0, 1.4) Larynx 1.4 (.2, 5.0) Lung .7 (.3, 1.3) Prostate 1.3 (.8, 1.8) Testis 2.0, (.3, 2.5) Kidney 1.2 (.4, 2.5) Bladder 1.0 (.4, 2.0) Skin 2.4 (1.0, 4.7) NHL 1.6 (.5, 3.6) HD 1.1 (.0, 6.0) Multiple myeloma .6 (0.0, 3.2)

Ruder et al., 1994	1109 women, 592 men drycleaners, employed at least 1 yr. before 1960 at shop using PCE followed through 1990 (update Brown/Kaplan)	Cohort mortality	SMRs PCE-only sub-cohort (CI) All 1.01 (.76, 1.32) Buccal 2.5 (.52, 7.33) Tongue 7.25 (.88, 26.2) Esoph. 2.64 (.72, 6.76) Stomach 0 Colon 1 (.32, 2.33) Rectum 0 Pancreas .73 (.09, 2.62) Lung 1.12 (.61, 1.88) Breast 1 (.36, 2.17) Female genital 1.57 (.68, 3.1) Male genital .89 (.11, 3.21) Kidney 1.16 (.03, 6.45) Bladder 0 Lymph/hem .49 (.06, 1.77) SMRs PCE-plus sub-cohort (CI) All 1.33 (1.13, 1.56) Buccal 1.2 (.3, 3.6) Tongue 1.8 (.0, 9.7) Esoph. 1.9 (.7, 4.1) Stomach.9 (.3, 2.0) Colon 1.8 (1.1, 2.7) Rectum 1.8 (.6, 4.2) Pancreas 2.1 (1.1, 3.6) Lung/resp. 1.2 (.8, 1.7) Breast 1.1 (.6, 1.9) Female genital 1.2 (.6, 2.0) Male genital .9 (.3, 2.0) Kidney 1.6 (.3, 4.7) Bladder 3.5 (1.6, 6.7) Lymph/hem. .8 (.3, 1.6)

Anttila et al., 1995	2050 men and1924 women who were biomonitored and followed up between 1962 and 1992	Cohort study	SIRs PCE Cervix 3.2 (.4, 12) Kidney 1.8 (.2, 6.6) Brain 1.2 (.1, 4.2) NHL 3.8 (.8, 11) SIRs TCE Stomach 1.3 (.8, 2.0) Colon .8 (.4, 1.7) Liver/bil. [1.9. IARC] (.9, 3.6) Cervix 2.4 (1.1, 4.8) Prostate 1.4 (.7, 2.4) Kidney .9 (.3, 1.9) Bladder .8 (.3, 1.9) Brain 1.1 (.5, 2.1) Lymp./hem. 1.5 (.9, 2.3) NHL 1.8 (.8, 3.6) HD 1.7 (.4, 5.0) Leukemia 1.1 (.3, 2.5)
Henschler et al., 1995	169 men exp. to TCE at factory working at least 1 yr. between 1956 and 1975, followed to 1992; control of 190 men at same factory w/o exposure to TCE (no office workers)	Cohort study	Kidney SIRs with 3 comparisons 11.2 (4.5, 23.00)Den. reg. 13.5 (5.4, 27.9) GDR reg. 7.2, internal comparison SMRs Lung 1.4 (.6, 2.9) Kidney 3.3 (.4, 11.8) Brain 3.7 (.1, 20.6) Lymph./hem. 1.1 (.0, 6.1)
Mass DPH, 1997	19 leukemia cases/37 controls, Woburn Mal, 1969-89	Case control	Leukemia OR with TCE contam. water 2.4 (.54, 10.6), overall OR w/ exp. in preg. 8.3 (.7, 95) OR 2 y before concep. 2.6 (.5, 14) OR p/birth 1.2 (.3, 5)
Aschengrau et al., 1998	258 breast cancer cases and 686 controls, permanent residents of 5 towns on Cape Cod, MA , exposed to PCE in water	Case control	Breast CA OR 7.8 (.9,16.7), 9 yrs latency and 90th%

Blair et al., 1998	Cohort of 7204 aircraft maintenance workers(1952-1990) exposed to TCE	Cohort mortality study	Esophagus SMR 5.6 (.7, 44.5) Stomach SMR .9 (.4, 1.9) Colon SMR 1.4 (.8, 2.4) Rectum SMR.4 (.1, 1.5) Biliary/liver SMR 1.3 (.5, 3.4) Prim. liver SMR 1.7 (.2, 16.2) Pancreas SMR 1.2 (.6, 2.3) Lung SMR .9 (.6, 1.3) Breast SMR 1.8 (.9, 3.3) Cervix SMR 1.8 (.5, 6.5) Prostate SMR 1.1 (.6, 1.8) Kidney SMR 1.6 (.5, 5.1) Bladder SMR (.5, 2.9) Melanoma SMR 1.0 (.3, 3.1) Brain SMR .8 (.2, 2.9) Endocrine SMR .7 (.1, 5.4) Bone SMR 2.1 (.2, 18.8) Lymph./Hem. SMR 1.1 (.7, 1.8) NHL SMR 2.0 ((.9, 4.6) Leukemia SMR .6 ((.3, 1.2) HD SMR 1.4 (.2, 12) Mult. myel. SMR 1.3 (.5, 3.4)
Morgan et al., 1998	4733 aerospace workers exposed to TCE	Cohort mortality study	RR from internal analysis w/ Cox prop. hazards, cum. high Lymph/hemat. 1.03 (.59, 1.79) Lymphoma .81 (.1, 6.49) Liver 1.19 (.34, 4.16) Kidney 1.59 (.68, 3.71) Bladder 2.71 (1.1, 6.65) Prostate 1.35 (.75, 2.44) Ovarian 7.09 (2.14, 23.54)
Vamvakas et al., 1998	58 kidney cancer cases and 84 controls (accident wards)	Hospital-based case-control study	Adj. ORs TCE/PCE 10.8 (3.36, 34.75)

Paulu et al., 1999	326 colorectal CA, 252 lung CA, 37 brain CA, 37 pancreas CA, and controls, permanent residents of 5 towns on Cape Cod, MA , exposed to PCE in water	Case control	Adj. ORs Lung CA, 90th% 3.7 (1.0,11.7) Colorectal CA 1.7 (.8,3.8) ever exp. and 9 yrs latency Crude OR Brain .7 (0,3.4), ever exp., 9 yrs latency Pancreas 0, ever exp. 9 yrs latency

Boice et al, 1999	77,965 aircraft manufacturing workers potentially exposed to TCE, PCE and CrVI, 1960-1997	Historical cohort	SMRs (C.I.)/TCE, tbl 8 All .86 (.76, .97) Buccal .93 (.2, 1.4) Esophagus 83 (.34, 1.72) Stomach 1.32 (.77, 2.12) Colon 1.07 (.72 1.52) Rectum 1.29 (.59, 2.45) Liver .54 (.15, 1.38) Pancreas ..41 (.17, .85) Larynx 1.1 (.3, 2.82) Lung .76 (.6, .95) Bone 1.44 (.04, 8.02) Connec. Tissue .1.94 (.4, 5.67) Melanoma ..46 (.06, 1.67) Breast 1.31 (.53, 2.69) Uterus .74, (.02, 3.57) Cervix 0 (0, 5.42) Ovary .58 (.01, 3.22) Prostate 1.03 (.7, 1.45) Testis/genital 0 (0, 5.42) Kidney .99 (.4, 2.04) Bladder .55 (.18, 1.28) CNS (.54 (.15, 1.37) NHL 1.19 (.65, 1.99) HD (2.77 (.76, 7.1) MM .91 (.3, 1.99) Leukemia 1.05 (.54, 1.84) SMRs (C.I.)/PCE, tbl 8 All .89 (.82, .86) Buccal .43 (.2, .82) Esophagus .83 (.49, 1.31) Stomach .76 (.48, 1.13) Colon 1.05 (.81, 1.33) Liver .92 (.54, 1.47) Pancreas .77 (.52, 1.09) Larynx .55 (.18, 1.29) Lung .88 (.77, 1.01) Bone .57 (.01, 3.18) Connec. Tissue 1.21 (.39, 2.82) Melanoma .87 (.42, 1.6) Breast 1.26 (.7, 2.07) Uterus .31 (.01, 1.71) Cervix 0 (0, 2.37) Ovary .57 (.07, 2.07) Prostate 1 (.78, 1.26) Testis/genital 3.04 (1.12, 6.63) Kidney .81 (.44, 1.36) Bladder .85 (.49, 1.35) CNS .68 (.36, 1.16) NHL 1.02 (.68, 1.47) HD 1.61 (.59, 3.51) MM .98 (.55, 1.61) Leukemia 1.02 (.68, 1.48)

Dosemici et al., 1999	796 cases, 707 controls (both population based, controls stratified for age and gender	population-based case-control for kidney cancer	TCE OR men OR 1.04 (.6, 1.7) women OR 1.96 (1.0, 4.0) PCE OR men OR 1.12 (.7, 1.7) women OR .82 (.3, 2.1)

*citations[4]

---

[4] McMichael A, Spirtas R, et al, "Solvent exposure and leukemia among rubber workers: an epidemiological study," *Journal of Occupational Medicine,* 17: 234-39,1975; Blair, A, Decoufie, P, Grauman, D. "Causes of death among laundry and drycleaning workers." *Am J Public Health* 69:508-511, 1979; Kaplan S, *Dry Cleaners Workers Exposed to Perchloroethylene—A Retrospective Cohort Mortality Study* NTIS PB81-231-367, 1980; Olsson H, Brandt L, "Occupational exposure to organic solvents and Hodgkin's disease in men. A case-referent study," *Scand J Work Environ Health* 6:302-305, 1980; Hardell L, Eriksson M, Lennert P, Lundgren E, "Malignant lymphoma and exposure to chemicals, especially organic solvents, chlorophenols and phenoxy acids: a case-control study," *Br J Cancer* :169-176, 1981; Katz R, Jowett D, "Female laundry and dry cleaning workers in Wisconsin: a mortality analysis," *Am J Pub Health,* 71: 305-307, 1981; Peters J, Preston-Martin S, Yu M, "Brain tumors in children and occupational exposure of parents," *Science* 213:235-2371981; Duh R, Asal N, "Mortality among laundry and drycleaning workers in Oklahoma," *Am J Pub Health* 74:1278-1280, 1984; Barret L, Faure J, Danel V, "Epidemiological study of cancer in a community of workers occupationally exposed to trichloroethylene and cutting oils (Abstract 34), Stockholm, Association Europeenne des Centres Anti-poison, 1984 [cited in IARC, vol. 63]; Hardell L, Bengtsson N, Jonsson U, Eriksson S, Larsson L, "Aetiological aspects on primary liver cancer with special regard to alcohol, organic solvents and acute intermittent prophyria—an epidemiological investigation," *Br J Cancer* 50:389-397,1984; Shindell S, Ulrich S, "A cohort study of employees of a manufacturing plant using trichloroethylene," *J Occup Med* 27:577-579, 1985; Brown D, Kaplan S *Retrospective cohort mortality study of dry cleaning workers using tetrachloroethylene,* NIOSH. Industrywide Studies Branch. Cincinnati, OH, 1985; Barret L, Faure J, Danel V, "Epidemiological study of cancer in a community of workers occupationally exposed to trichloroethylene and cutting oils," *J Toxicol Clin Toxicol* 23:438, 1985; Axelson, O, Epidemiological studies of workers with exposure to tri- and tetrachloroethylene. In: *New Concepts and Developments in Toxicology,* Chambers, PL, Gehring, P and Sakai, P, Eds., Elsevier, 1986, pp. 223-230; Lowengart R, Peters J Cicioni C, et al, "Childhood leukemia and parents' occupational and home exposures," *JNCI,* 79: 39-46,1987; Garabrant D, Held J, Langholz B, Bernsn L, "Mortality of aircraft manufacturing workers in southern California," *Am J Ind Med* 13:683-693, 1988; Blair A, Stevens Tolbert P, Grauman D, Moran F, Vaught J, Rayner J. "Cancer and other causes of death among a cohort of dry cleaners." *Br J Ind Med.* 47: 162-168,1990; Hernberg S, Kauppinen T, Riala R, Korkala M, Asikainen U, "Increased risk for primary liver cancer among women exposed to solvents," *Scand J Work Environment Health* 14:356-365, 1988; Silverman D, Levin L, et al. "Occupational risks of bladder cancer in the United States: I. White Men," *JNCI,* 81:1472-1483, 1989; Sharpe C, Rochon J, Adam J, Suissa S, "Case-control study of hydrocarbon exposures in patients with renal cell carcinoma," *Can Assoc J* 140: 1309-1318, 1989; Fredricksson M, Bengtsson N, et al., "Colon cancer, physical activity, and occupational exposures," *Cancer* 9:1838-1842, 1989; Olsen G, Hearn S, Cook R, Currier M, Allen S, "Mortality experience of a cohort of Louisiana chemical workers," *J Occup Med* 31:32-34, 1989; Blair A, Stewart P, Tolbert P, Grauman D, Moran F, Vaught J, Rayner J, "Cancer and other causes of death among a cohort of dry cleaners," *Br J Ind Med* 47:162-168, 1990; Bond G, McLaren E, Sabel F, Bodner K, Lipps T, Cook R, "Liver and biliary tract cancer among chemical workers," *Am J Ind Med* 18:19-24, 1990; Lynge E, Thygeson L, "Primary liver cancer among women in laundry and dry-cleaning work in Denmark," *Scand J WorkEnvironment Health* 16:108-112, 1990; Fagliano J, Berry M, Bove F, Burke T, "Drinking water contamination and the incidence of leukemia: an ecologic study," Am J Public Health 80:1209-1212, 1990; Spirtas R, Stewart, Lee J, Marano D, Forbes C, Grauman D, Pettigrew H, Blair A, Hoover R, Cohen J, "Retrospective cohort mortality study of workers at an aircraft maintenance facility. I. Epidemiological results," *Br J Indust. Med.* 48:515-530, 1991; Aschengrau, A., Ozonoff, D. Paulu, C., Coogan, P. Vezina, R., Heeren, T., Zhang, Y., "Cancer risk and tetrachloroethylene (PCE) contaminated drinking water in Massachusetts," *Archives of Environmental Health,* 48:284-292, 1993; Varianinen T, Pukkala E, Rienoja T, Strandman T, Kaksonen D, "Population exposure to tri- and tetrachloroethene and cancer risk: two cases of drinking water pollution," *Chemosphere* 27:1171-1181, 1993; Cohn P, Klotz J, Bove F, Berkowitz M, Fagliano J, "Drinking water contamination and the incidence of leukemia and non-Hodgkin's lymphoma," *Environ Health Perspectives* 102:556-561, 1994; Anttila A, Pukkala E, Salimen M, Hernberg S, Hemminki K, "Cancer incidence among Finnish workers exposed to halogenated hydrocarbons," *J Occup Med* 37:797-806, 1995; Axelson O, Andersson K, Selden A, Hogstedt C, "Updated and expanded Swedish cohort study on trichloroethylene and cancer risk," *J Occup Med* 36:556-562, 1994; Ruder A, Ward E, Brown D, "Cancer mortality in female and male dry-cleaning workers," *J Occup Med* 36:867-874, 1994; Henschler D, Vamvakas S, Lammert M, Dekant W, Kraus B, Thomas B, Ulm K, "Increased incidence of renal cell tumors in a cohort of cardboard workers exposed to trichloroethene. " *Arch Toxicol.* 69:291-299, 1995;; Morgan R, Kelsh M, Zhao K, Heringer S "Mortality of aerospace workers exposed to trichloroethylene," *Epidemiology* 9:424-431, 1998; Blair A Hartge P, Stewart PA, McAdams M, Lubin J, "Mortality and cancer incidence of aircraft maintenance workers exposed to trichloroethylene and other organic solvents and chemicals: extended