ENVIRONMENTAL WORKING GROUP

Overview of worker studies (see detailed description of studies – page 1 of 2)

Study description: Mortality among 3M workers at a perfluorooctanoic acid production plant in Cottage Groove, MN[1, 2]
Findings:

Statistically significant increase risk of dying from prostate* cancer and cerebrovascular disease**

Non-statistically significant, but elevated risk of dying from any type of cancer, general category of cancers of the testis and other male reproductive organs*; prostate* cancer; testicular* cancer; pancreatic* cancer; bladder cancer; large intestine* cancer; diabetes**; lymphopoietic* cancer; colon* cancer; lung* cancer; malignant skin cancer; suicide

*A target organ or tissue of either PFOA or PFOS in monkeys or rats
** Cerebrovascular disease and diabetes not studied in animals

Key study weaknesses: Cause of death rather than disease incidence measured; based on a small number of deaths, which makes it difficult to find statistically significant effects; blood PFOA not measured, but is based on job description which is not a good predictor of blood PFOA since "unexposed" workers can have blood PFOA 20 to 50 times higher than the general population[3]; workers are fairly young; workers exposed to other chemicals, including PFOS, asbestos and benzene

Study description: Episodes of care in 3M workers in Decatur, AL[4]
Findings:

Statistically significant increases in seeking care for cancers of the male reproductive tract* (mostly due to prostate cancer); gastrointestinal tract* lesions (mostly benign colon polyps); biliary tract** disorders (mostly gallbladder stones with gallbladder infection); pancreatic disorders*; inflammation of the urinary bladder; lower urinary tract infections

* A target organ of either PFOA or PFOS in monkeys or rats
** Several perfluorchemcials are found in bile[5], bile concentrations are increased in monkeys treated with PFOS[6]

Key study weaknesses: excludes workers on disability, Medicare or with HMO coverage; only covers episodes of care while employed at Decatur plant; EPA had serious reservations about this study and said it should "only be used for hypothesis generation"; PFOA serum levels not measured, exposure based on job category which was found in Cottage Groove plant to be a poor predictor or PFOA exposure since "unexposed" workers had levels 20-50 times higher than the general population[3]; episode of care does not equal disease incidence; study limited to 6 year period; people may be counted more than once

Overview of worker studies (page 2 of 2)

Study description: Blood lipids, hormones and liver enzymes in 3M workers at plants in Cottage Groove, Minnesota; Antwerp, Belgium and Decatur, Alabama; also internal correspondence from Dupont medical personnel regarding workers at the Washington Works in Parkersburg, West Virginia[3, 7-12]
Findings:

PFOA (C8)**
Liver enzymes: ↑ liver enzyme levels* detected in blood[3]; ↑ number of employees with liver enzyme levels above the reference range[7], quote from a DuPont personal and confidential memo "C-8 exposed workers may possibly have positive liver function tests more often than the plant population as a whole"[8]

Lipid profile: □ "good" (high density lipoprotein or HDL) cholesterol[9]; ↑ "good" cholesterol in moderate drinkers)[3]; ↑ cholesterol, also true for blood levels of total organic fluorine[9, 10]; ↑ triglycerides, also true for blood levels of total organic fluorine[9]

Hormone changes: trend toward ↑ estrogen (estradiol)*[11, 12]; □ free testosterone*, especially in older men[11]; ↑ thyroid stimulating hormone (TSH), TSH is increased in hypothyroidism[11]; ↑ prolactin, a reproductive hormone, in moderate drinkers[11]; ↑ 17-HP (a precursor to testosterone)[12]; ↑ triiodothyronine (T3, a thyroid hormone), also true for blood levels of total organic fluorine[9]

Other: quote from a DuPont personal and confidential memo "the number of active wage roll employees having myocardial infarction from 1974 to 1977 was somewhat higher than expected based on Company-wide experience"[8]; ↑ hemoglobin (the iron-containing pigment in red blood cells that carries oxygen)[11]; ↑ cell size[11]; ↑ leukocyte counts (white blood cells that help regulate immune function)[11]; □ cholecystokinin[13], as summarized in the US EPA revised PFOA hazard assessment, which says that stated a weak negative association between PFOA and cholecystokinin was not included in the report

* also found in laboratory animals
** mostly male workers

PFOS**
Liver enzymes: ↑ liver enzyme levels* detected in blood[9]; ↑ number of employees with liver enzyme levels above the reference range[9]

Lipid profile: ↑ triglycerides, also true for blood levels of total organic fluorine[9]

Hormone changes: positive correlation with triiodothyronine (T3, a thyroid hormone), also true for blood levels of total organic fluorine[9]; □ thyroid hormone binding ratio (THBR)[9]

Other: ↑ blood urea nitrogen* (BUN), a measure of kidney function[9]; ↑ total bilirubin (a measure of liver function that is often increased with liver and biliary tract disease, malnutrition, anemia, pulmonary blockage or heat failure) in men[9]; □ total bilirubin in women[9]

* also found in laboratory animals

Key study weaknesses (see detailed table for specifics on each study): small number of workers in higher exposure groups makes if difficult to detect statistically significant effects; some studies did not report reference ranges, so it's difficult to determine whether workers are above reference range: high variability in some measurements which makes it difficult to find statistically significant results; only a small number of females studied

Source: Environmental Working Group.

ENVIRONMENTAL WORKING GROUP

Detailed description of worker studies

Statistically significant	Increased (not statistically significant)
Mortality among 3M workers at a perfluorooctanoic acid production plant in Cottage Groove, MN[1, 2]	
Prostate cancer (3.30; 95%CI 1.02-10.6 for ten years of employment; [6 cases total, 4 in exposed workers][1] **Cerebral vascular disease** (more than 5 years but < 10 definite exposure, 15.03; 95%CI 3.02-43.91; 5 cases total, 3 in definite exposure group for this length) (> 5 years definite exposure, 6.9; 95%CI 1.39-20.24; 5 cases total, 2 in definite exposure group for this length)[2]	**Any type of cancer** (1.10; 95%CI 0.79-1.50; observed in Chemical Division males employees=40, expected in Chemical Division male employees=36.31)[1] **Prostate cancer** (1.30; 95%CI 0.03-7.20; definite exposure; 1 case)[2] **Pancreatic cancer** (1.96; 95%CI 0.53-5.01; observed in Chemical Division males employees=4, expected in Chemical Division male employees=2.04)[1]; (1.34; 95%CI 0.03-7.42; definite exposure; 1 case)[2]; (1.24; 95%CI 0.45-2.70; probable exposure; 6 cases)[2] **Cancer of the testis and other male reproductive organs** (2.75; 95%CI 0.07-15.3; probable exposure; 1 case)[2]; **Testicular cancer** (2.28; 95%CI 0.03-12.66; observed in Chemical Division males employees=1, expected in Chemical Division male employees=0.44)[1] **Bladder cancer** (1.33; 95%CI 0.02-7.40; observed in Chemical Division males employees=1, expected in Chemical Division male employees=0.75)[1]; (1.31; 95%CI 0.42-3.05; all workers; 5 deaths observed, 3.83 expected)[2] **Large intestine cancer** (1.67; 95%CI 0.02-6.02; definite exposure; 2 cases)[2] **Lymphopoietic cancer** (1.05; 95%CI 0.34-2.45 observed in Chemical Division males employees=5, expected in Chemical Division male employees=4.76)[1] **Diabetes** (1.18; 95%CI 0.24-3.44; observed in Chemical Division males employees=3, expected in Chemical Division male employees=2.55)[1] **Colon cancer** (1.15; 95%CI 0.31-4.01; observed in Chemical Division males employees=4, expected in Chemical Division male employees=3.46)[1] **Lung cancer** (1.03; 95%CI 0.51-1.84; observed in Chemical Division males employees=11, expected in Chemical Division male employees=10.70)[1] **Malignant skin cancer** (1.42; 95%CI 0.17-5.11; probable exposure; 2 cases)[2] **Suicide** (1.43; 95%CI 0.68-2.63; observed in Chemical Division males employees=10, expected in Chemical Division male employees=6.99)[1]

Study description: "Mortality among employees of a perfluorooctanoic acid production plant"[1]
Study population: 3M Cottage Groove, MN workers who had worked for at least 6 months between 1947 and 1983. A total of 347 employees were deceases (148 men and 11 females worked in chemical production). Exposure based on job description, >1 month employment in Chemical Division is considered exposed
Analysis: Standardized Mortality Ratio (SMR); proportional hazards analysis
Comparison group: US general population and MN population death rates; stratified SMR or proportional hazards analysis compared exposed and unexposed workers
Measures looked for: mortality from any cause based on death certificate
Study weaknesses: misclassification of workers because "unexposed workers" are not unexposed and can have blood levels of PFOA 20-50 times higher than the general population[3], this would make it more difficult to find effects; small number of deaths in many categories, especially for females; differences in age at risk between exposed and unexposed workers; workers exposed to other chemicals like benzene and asbestos; EPA states "this cohort needs to be followed for many years to come in order to develop an accurate picture of the mortality experience of the employees at this plant".

Study description: "Mortality study of workers employed at the 3M Cottage Grove facility. Final Report. Division of Environmental and Occupational Health, School of Public Health, University of Minnesota, April 26, 2001"[2]
Study population: 3M Cottage Groove, MN workers who had worked for at least 1 year between 1947 and 1997. A total of 607 employees were deceases. Exposure based on job description (definite PFOA exposure, n=46; probable PFOA exposure, n=267 and not exposed, n=294)
Analysis: Standardized Mortality Ratio (SMR); proportional hazards analysis
Comparison group: MN white population death rates, also mortality reference rates from 7 counties to rule out variations based on regional mortality reporting
Study weaknesses: misclassification of workers possible because "unexposed workers" are not unexposed and can have blood levels of PFOA 20-50 times higher than the general population[3], this would make it more difficult to find effects (film workers are considered unexposed); small number of deaths in definite exposure category, especially with more than a year definite exposure [n=17; total in this group is 46 (63% did not work more than a year), in contrast only 19% of probably workers did not work more than a year (51/267)]; 17 death certificates not located; EPA states "Although there are more than 200 additional deaths included in this analysis, it is a small number and the cohort is still relatively young. Given the results of the studies on fluorochemicals in both animals and humans, further analysis is warranted" Of particular interest are bladder cancer, prostate cancer, cerebrovascular disease, cancer and disorders of the liver, and pancreatic cancer.

Episodes of care in 3M workers in Decatur, AL[4]

Any type of cancer (1.6; 95%CI 1.2-2.1; all workers)[4]
Cancer of the male reproductive tract (four of five episodes of care were for prostate cancer) (9.7; 95%CI 1.1-458; high exposure, long-term employment group)[4]
Neoplasms of the gastrointestinal tract (mostly benign colonic polyps) (1.8; 95%CI 1.2-3.0; high exposure group) (2.9; 95%CI 1.7-5.2; high exposure, long-term employment group)[4]
Disorders of the biliary tract (mostly cholelithiasis with acute, chronic or unspecified cholecystitis) (2.6; 95%CI 1.2-5.5; high exposure, long-term employment group)[4]
Disorders of the pancreas ("not identified a priori but which excluded the null high hypothesis in the 95% confidence interval for the high exposure, long-term employment group")[4]
Cystitis ("not identified a priori but which excluded the null high hypothesis in the 95% confidence interval for the high exposure, long-term employment group")[4]
Lower urinary tract infection ("not identified a priori but which excluded the null high hypothesis in the 95% confidence interval for the high exposure, long-term employment group"; mostly due to reoccurring episodes of care by the same employees)[4]

Study description:
Study population: 3M chemical (n = 652) and film plant (n = 659, considered to be less exposed) workers in Decatur, AL who were employed at least one year between 1993 and 1998. Divided into 4 groups: all eligible chemical plant and film employees (Group A); all chemical plant employees who worked solely in the chemical plant and all film plant employees who worked exclusively in the film plant (Group B); all chemical plant employees with high flurochemical exposures compared to job counterparts in the film plant (Group C); all plant workers with high fluorochemicals exposure for at least 10 years prior to the study compared to their job counterparts in the film plant (Group D)
Analysis: Groups analyzed separately, then compared to each other A risk ratio of episode of care (RREpC) to estimate risk between the observed and expected episodes of care in chemical plant workers compared to the observed and expected in film plant workers. For groups analyzed together, the expected number of episodes of care for both film and chemical plant workers was calculated from health claims data of the 3M manufacturing population in the US,
Comparison group: expected levels based health claim data from 3M manufacturing population in the US
Diseases not found to be elevated: thyroid disease, diabetes, hyperlipidemia, other endocrine or nutritional disorders
Study weaknesses: excludes workers on disability, Medicare or with HMO coverage; also only covers episodes of care while employed at Decatur plant; EPA says this study should "only be used for hypothesis generation"; PFOA serum levels not measured, exposure based on job category which was found in Cottage Groove plant to be a poor predictor or PFOA exposure since "unexposed" workers had levels 20-50 times higher than the general population[3]; episode of care does not equal disease incidence; study limited to 6 year period; people may be counted more than once; utilization of health services may reflect local medical practice

Blood lipids, hormones, liver enzymes – 3M plants in Cottage Groove, MN, Antwerp, Belgium and Decatur, AL

C8

Higher blood C8 is associated with:
Liver enzymes: ↑ SGOT[14]; ↑ SGOT (or AST) and SGPT (or ALT); only in obese workers[3]; "C-8 exposed workers may possibly have positive liver function tests more often than the plant population as a whole, and that the number of active wage roll employees having myocardial infarction from 1974 to 1977 was somewhat higher than expected based on Company-wide experience"[8];
Changes in lipid profile: ↑ HDL (only in moderate drinkers)[3]; negative correlation with high density lipoprotein (HDL) or "good" cholesterol[9]; positive correlation with cholesterol (not significant when PFOS included in model)[9]; positive correlation with triglycerides[9]; positive correlation with triglycerides and total organic fluorine[9]; positive association between PFOA and cholesterol over time in Antwerp male workers[10]; positive association between PFOA and triglyceride over time in Antwerp male workers[10]; positive association between total organic fluorine and triglyceride over time in Antwerp and Decatur male workers[10]; positive association between total organic fluorine and cholesterol over time in Antwerp and Decatur male workers[10];
Changes in hormones: ↑ estrogen (estradiol)[11, 12]; 10% ↑ in serum estradiol in highest exposure category (not statistically significant, but only 5 workers in top exposure group)[12]; □ free testosterone, especially in older men[11]; ↑ thyroid stimulating hormone (TSH)[11, 12]
↑ prolactin in moderate drinkers][11]; ↑ 17-HP in highest

PFOS

Higher blood PFOS is associated with:
Liver enzymes: ↑ SGPT (or ALT) in Decatur male production workers[9]; ↑ SGPT (or ALT), alkaline phosphatase in highest exposure category male production workers (Antwerp and Decatur combined)[9]; ↑ GGT and alkaline phosphatase in highest exposure category female production workers (Antwerp and Decatur combined)[9];↑ number of Decatur male production workers in highest exposure category with liver enzyme test above the reference range [SGPT (or ALT) 28% vs. 8%, GGT, and total liver panel 35% vs. 18%]; ↑ number of male production workers (Antwerp and Decatur) in highest exposure category with liver enzyme test above the reference range [SGPT(or ALT) 12% vs. 4%, GGT 12% vs. 6%, SGOT (or AST), and total liver panel 23% vs. 14%]; positive association between total organic fluorine and increased SGPT (or ALT)[9];
Changes in lipid profile: ↑ triglycerides in highest exposure category male production workers (Antwerp and Decatur combined)[9]; positive correlation with cholesterol (not significant when PFOA included in model)[9]; positive correlation with triglyceride (not significant when PFOA included in model)[9]; positive correlation with triglycerides and total organic fluorine[9]
Changes in hormones:↑ triiodothyronine (T3, a thyroid hormone) in highest exposure category male production workers (Antwerp and Decatur combined)[9]; □ thyroid hormone binding ratio (THBR) in highest exposure category male production workers (Antwerp and Decatur combined)[9]; positive correlation with triiodothyronine (T3, a thyroid hormone)[9]; positive correlation with triiodothyronine and total organic fluorine (T3, a thyroid hormone)[9](p.165)
Other blood measurements: ↑ blood urea nitrogen (BUN) in highest exposure category Antwerp male or female production workers[9]; ↑ total bilirubin in highest exposure category male production workers (Antwerp and Decatur combined)[9]; □ total bilirubin in highest exposure category female production workers (Antwerp and

exposure category in male Cottage Groove workers (authors state due to one person, but only 4 or 5 in group depending on year)[12]; positive correlation with triiodothyronine (T3, a thyroid hormone)[9](p. 165); positive correlation with triiodothyronine and total organic fluorine (T3, a thyroid hormone)[9](p.165)

Other blood measurements: ↑ hemoglobin[11]; ↑ mean cellular volume[11]; ↑ leukocyte counts[11]; □ cholecystokinin[13] as summarized in US EPA draft that stated the weak negative association was not included in the report

total bilirubin in highest exposure category female production workers (Antwerp and Decatur combined)[9]

Study description: "An epidemiologic investigation of reproductive hormones in men with occupational exposure to perfluorooctanoic acid"[12]

Study population: Workers at a PFOA production plant, assumed to be a 3M plant in Cottage Groove, MN. Sample collection in 1993 (111 production workers) and in 1995 (80 production workers), Workers divided into 4 exposure categories (0 to < 1 ppm, 1 to <10 ppm, 10 to <30 ppm, ≥ 30 ppm)

Analysis: Simple and stratified ANOVA, Pearson's correlation, multivariable regression (confounders age, BMI, alcohol use, cigarette use)

Measures looked for: cortisol, dehydroepiandrosterone sulfate (DHEAS), estradiol, follicle-stimulating hormone (FSH), 17□-hydroxyprogesterone (17-HP), free testosterone, total testosterone, luteinizing hormone (LH), prolactin, thyroid-stimulating hormone (TSH), and sex hormone binding globulin (SHBG)

Measures not found to be elevated in any analysis: cortisol, dehydroepiandrosterone sulfate (DHEAS), follicle-stimulating hormone (FSH), free testosterone, total testosterone, luteinizing hormone (LH), and sex hormone binding globulin (SHBG)

Study weaknesses: study populations not independent (68 workers participated in both years); 1995 sample had fewer participants, so power was decreased; cross-sectional design does not allow for analysis of temporal associations; very few workers in high exposure categories; only one sample for each hormone taken; may be errors in confounding variables; workers exposed to other chemicals

Study description: "Plasma cholecystokinin and hepatic enzymes, cholesterol and lipoproteins in ammonium perfluorooctanoate production workers"[13]

Study population: Workers at a 3M PFOA production plant (Cottage Groove, MN). Sample collection in 1993 (111 production workers), 1995 (80 production workers) and 1997 (74 production workers). Workers divided into 4 exposure categories (0 to < 1 ppm, 1 to <10 ppm, 10 to <30 ppm, ≥ 30 ppm)

Analysis: Simple and stratified ANOVA, Pearson's correlation, multivariable regression (confounders age, BMI, alcohol use, cigarette use)

Measures looked for: hematology (hematocrit, hemoglobin, red blood cells, white blood cells, platelet counts), clinical chemistry [alkaline phosphatase, □-glutamyl transferase (GGT), aspartate aminotransferase (AST or SGOT), alanine aminotransferase (ALT or SGPT), cholesterol, triglyceride, direct and total bilirubin, creatinine, glucose, high density lipoprotein (HDL or good cholesterol), low density lipoprotein (LDL or bad cholesterol) blood urea nitrogen (BUN), plasma CCK-33 (in 1997)]

Measures not found to be elevated in any analysis:

Study weaknesses: study populations not independent (68 workers participated in 1993 and 1995, 20 in 1993 and 1997 and 17 for all three years); CCK only studied in 1997; small number of workers in high exposure groups; workers exposed to other chemcials

Study description: "Serum perfluorooctanoic acid and hepatic enzymes, lipoproteins, and cholesterol: a study of occupationally exposed men"[3]

Study population: Workers at a 3M PFOA production plant in Cottage Groove, MN. Workers recruited from all employees in production between 1985-1989 (n=115). Workers divided into 4 exposure categories (0 to < 1 ppm, 1 to <10 ppm, 10 to <30 ppm, ≥ 30 ppm)

Analysis: Simple and stratified ANOVA, Pearson's correlation, multivariable regression (confounders age, BMI, alcohol use, cigarette use)

Measures looked for: clinical chemistry [□-glutamyl transferase (GGT), aspartate aminotransferase (AST or SGOT), alanine aminotransferase (ALT or SGPT), cholesterol, high density lipoprotein (HDL or good cholesterol), low density lipoprotein (LDL or bad cholesterol)]

Measures not found to be elevated in any analysis: clinical chemistry [aspartate aminotransferase (AST or SGOT), alanine aminotransferase (ALT or SGPT), high density lipoprotein (HDL or good cholesterol)]

Study weaknesses: total organic fluorine used as a surrogate for PFOA; study populations not independent (68 workers participated in 1993 and 1995, 20 in 1993 and 1997 and 17 for all three years); levels of certain liver enzymes look to be on the high side, but author does not report reference ranges; authors state no adverse clinical outcomes related to PFOA exposure have been seen in employees, but it does not appear to have been follow-up; liver standard deviations are very high for many exposure categories, indicating unstable results; workers exposed to other chemcials

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Study description: " A cross-sectional analysis of serum perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) in relation to clinical chemistry, thyroid hormone, hematology and urinalysis results from male and female employee participants of the 2000 Antwerp and Decatur fluorochemical medical surveillance program"[9]

Study population: 3M chemical and film plant workers in Decatur, AL (n=215 male, 48 female) and Antwerp, Belgium (n=206 male, 49 female) Total n = 421 male, 97 female.

Analysis: Simple, stratified (by location, then by sex and production status), workers grouped into 4 exposure categories based on serum PFOS, Pearson's correlation coefficients, ANOVA, multivariable regression (PFOS and PFOA as continuous variables), confounding factors (age, BMI, alcohol consumption, cigarette use, years worked at plant, type of job)

Mean PFOS: Antwerp, Belgium = 0.96 ppm (all; 0.04-6.24); 1.16 ppm (production); 0.42 (non-production); 0.13 (female)
Decatur, AL = 1.40 ppm (all; 0.11-10.06); 1.63 ppm (production); 0.73 (non-production); 0.93 (female)

Mean PFOA: Antwerp, Belgium = 1.03 ppm (all-male); 1.28 ppm (production-male); 0.34(non-production); 0.07 (female)
Decatur, AL = 1.90 ppm (all); 2.34 ppm (production); 0.59(non-production); 1.23 (female)

Measures looked for:
TSH, T4, FTI, T3, free T4, free T3, hematology (hematocrit, hemoglobin, red blood cells, white blood cells, platelet counts), clinical chemistry [alkaline phosphatase, □-glutamyl transferase (GGT), aspartate aminotransferase (AST or SGOT), alanine aminotransferase (ALT or SGPT), cholesterol, triglyceride, direct and total bilirubin, creatinine, glucose, high density lipoprotein (HDL or good cholesterol), low density lipoprotein (LDL or bad cholesterol), blood urea nitrogen (BUN)], pulmonary function test

Measures not found to be elevated in any analysis:
TSH, T4, FTI, hematology (hematocrit, hemoglobin, red blood cells, white blood cells, platelet counts), clinical chemistry [direct bilirubin, creatinine, glucose, low density lipoprotein (LDL or bad cholesterol], pulmonary function test

Study weaknesses: PFOA levels higher than PFOS for most workers, yet workers were categorized by serum PFOS and not PFOA so analysis of PFOA by categories not conducted; Decatur and Antwerp workers differed in certain demographic and clinical chemistry results as well as PFOS and PFOA serum levels [male Antwerp workers less exposed; younger; lower BMIs; worked fewer years; drank more alcohol; had higher T3, total bilirubin, and HDL; and had lower alkaline phosphatase, GGT, SGOT (or AST), SGPT (or ALT) and triglycerides than male Decatur workers; plant populations can't be compared because PFOS serum quartiles different; only a small number of females studied; only one measurement at a certain point was collected for each subject; no mention of pharmaceutical use by workers; values for clinical chemistry, hematology and hormone reference ranges not provided; workers exposed to other chemicals

Study description: "A longitudinal analysis of serum perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) levels in relation to lipid and hepatic clinical chemistry test results from male employee participants of the 1994/95, 1997, and 2000 fluorochemical medical surveillance program"[10]

Study population: Male 3M chemical and film plant workers in Decatur, AL and Antwerp, Belgium during 1994/1995, 1997 and 2000
Total n = 175 workers who participated in 2000 and at least one other year; 41 participated in all three years (group "A"), 65 in 1194/1995 and 2000 (group "B"); and 69 in 1997 and 2000 (group "C").
Analysis: Repeated measures with random subjects effect; restricted maximum likelihood estimates of variance parameters used; adjusted regression models built by introducing covariates and testing covariate structure. Covariates include (age, BMI, alcohol consumption, cigarette use)

Mean PFOS:	Antwerp, Belgium	Decatur, AL
1994/1995	1.87 ppm	2.62 ppm
1997	1.42 ppm	1.85 ppm
2000	1.16 ppm	1.67 ppm

Mean PFOA:	Antwerp, Belgium	Decatur, AL
1994/1995	1.08 ppm	1.90 ppm
1997	1.54 ppm	1.41 ppm
2000	1.43 ppm	1.83 ppm

Measures looked for:
clinical chemistry [alkaline phosphatase, □-glutamyl transferase (GGT), aspartate aminotransferase (AST or SGOT), alanine aminotransferase (ALT or SGPT), cholesterol, triglyceride, direct and total bilirubin, high density lipoprotein (HDL or good cholesterol)]
Measures not found to be elevated in any analysis:
clinical chemistry [alkaline phosphatase, □-glutamyl transferase (GGT), aspartate aminotransferase (AST or SGOT), alanine aminotransferase (ALT or SGPT), direct and total bilirubin, high density lipoprotein (HDL or good cholesterol)]
Study weaknesses: small number of workers participated in all three years (24%, n=41); PFOA and PFOS measured by different analytical techniques in each year; Decatur and Antwerp workers differed in certain demographic and clinical chemistry results as well as PFOS and PFOA serum levels [male Antwerp workers less exposed; younger; participated more (57% vs. 43% of Decature), lower BMIs; drank more alcohol; higher total bilirubin and HDL; and had lower alkaline phosphatase and triglycerides than male Decatur workers; many study details not provided, such as details on blood collection and questionnaire content; female workers not included due to small number; only one measurement at a certain point was collected for each subject; no mention of pharmaceutical use by workers; workers exposed to other chemicals

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