FINAL REPORT
Epidemiology, 220-3W-05
Medical Department
3M Company
St. Paul, MN 55144

Date: March 19, 2001

Title: Descriptive Summary of Serum Fluorochemical Levels among Employee Participants of the Year 2000 Decatur Fluorochemical Medical Surveillance Program

Study
Start Date: March 1, 2000

Protocol Number (not applicable)
IRB Approval

Exempt	Expedited
X	

IRB Approval Date: (not applicable as these data are from a medical surveillance program)

Principal Investigator: Geary W. Olsen, D.V.M., Ph.D.[1]

Co-investigators: Perry W. Logan, M.S.[2]
Cathy A. Simpson, R.N.[2]
Jean M. Burris, R.N., M.P.H.[1]
Michele M. Burlew, M.S.[1]
James K. Lundberg, Ph.D.[3]
Jeffrey H. Mandel, M.D., M.P.H.[1]

Study Director: Jeffrey H. Mandel, M.D., M.P.H.[1]

1. 3M Medical Department, 220-3W-05, St. Paul, MN 55144-1000
2. 3M Decatur, EHS&R, P.O. Box 2206, Decatur, Alabama 35609-2206
3. 3M Environmental Laboratory, 2-3E-01, St. Paul, MN 55144-1000

ABSTRACT

Serum fluorochemical levels were measured for 263 Decatur chemical plant and site employees during the year 2000 fluorochemical medical surveillance program. Except for perfluorooctanoate (PFOA), serum fluorochemical levels were comparable to those reported in a 1998 random sample of 126 Decatur chemical plant and site employees. For example, for all employee participants the serum perfluorooctanesulfonate (PFOS) geometric mean level was 0.94 ppm (95% confidence interval (CI) 0.82-1.02) in 2000 compared to 0.91 ppm (95% CI 0.79-1.13) in 1998. However, the serum PFOA geometric mean increased to 1.13 ppm in 2000 (95% CI 0.99-1.30) from 0.90 ppm (95% CI 0.72-1.12) in 1998. The largest increase in serum PFOA levels was observed among cell operators whose geometric mean level was 4.12 ppm (95% CI 2.91-5.84) in 2000 compared to 1.43 ppm (95% CI 0.42-4.83) in 1998. This was likely due to the increased production of perfluoorooctanoic acid that has occurred at the Decatur site since 1999. Chemical operators engaged in fluorochemical production activities in Building 3 had, on average, higher serum fluorochemical levels than chemical operators and mill operators engaged in Dyneon production activities in Buildings 4, 38, 51 and 61. For example, chemical operators who worked on the monomer team in Building 3 had PFOS and PFOA geometric mean levels of 2.23 (95% CI 1.68-2.95) and 3.64 (95% CI 3.04-4.34), respectively, whereas mill operators in Building 61 had geometric mean levels of 0.69 (95% CI 0.58-0.83) and 1.32, respectively. There were five employees whose serum PFOA levels exceeded the 3M Biological Limit Value (BLV) of 5 ppm. The highest value was 12.70 ppm.

INTRODUCTION

The 3M Decatur fluorochemical medical surveillance program is conducted on a biennial basis. Prior to 1995, total organic fluorine was routinely measured. Serum perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) were assayed in 1995 and 1997 at the Decatur chemical plant (Olsen et al, 1999a). Because the voluntary nature of the medical surveillance program may not provide for a complete understanding of the distribution of serum fluorochemical levels in the Decatur workforce, a random sample of 232 employees was selected for fluorochemical testing in the Fall, 1998. A total of 180 employees (80%) participated (126 chemical plant and 60 film plant employees). These random sample findings have been reported, in detail, elsewhere (Olsen et al, 1999b). The purpose of this report is to provide the results from the year 2000 fluorochemical medical surveillance program and relate these data to previous research, in particular, the 1998 random sample survey.

METHODS

The fluorochemical medical surveillance program is available, on a voluntary basis, to Decatur chemical plant employees and those site employees who may work in the chemical plant area. Approximately 500 Decatur chemical plant and site employees were eligible to participate; 263 participated. Four film plant employees also requested their blood be tested for fluorochemical levels; their findings are not presented in this report. In addition to the fluorochemical testing program, a standard battery of clinical chemistry, pulmonary function and urinalysis tests are performed on employees. A group analysis of these clinical data will be reported in conjunction with employee data from

the Antwerp manufacturing plant's 2000 fluorochemical medical surveillance program. This report focuses solely on the employees' serum fluorochemical levels in relation to self-reported responses from a work history questionnaire (see Appendix A) that was administered at the time of the blood collection in the Spring, 2000.

Sera samples were extracted using an ion-pairing extraction procedure. The extracts were quantitatively analyzed for PFOS (perfluorooctanesulfonate), PFOA (perfluorooctanoate, which is also known as C8 acid or POAA), PFHS (perfluorohexanesulfonate), PFOSAA (N-ethyl perfluorooctanesulfonamidoacetate), M570 (N-methyl perfluorooctanesulfonamidoacetate), PFOSA (perfluorooctanesulfonateamide) and M556 (perfluorooctanesulfonamidoacetate) using high-pressure liquid chromatography/electrospray tandem mass spectrometry (HPLC/ESMSMS) and evaluated versus an extracted curve from a human serum matrix. Endogenous levels of certain fluorochemical were determined in the standard serum matrix and additional fluorochemical was spiked into the matrix. The total amount of each specific fluorochemical (endogenous + spiked) was used to construct an extracted standard curve. All serum fluorochemical analyses were determined by Northwest Bioanaltyical Laboratory Inc. (Salt Lake City, UT).

Employee work history questionnaire data were computerized. A review of the employees job titles by an industrial hygienist (PWL) and an epidemiologist (GWO) categorized the employees' self-reported job titles into eight job classifications: cell operators, chemical operators, engineers/laboratory workers, maintenance, mill operators, waste operators, administrative assistants and managers. These eight job classifications were nearly comparable to those used in the 1998 random sample analysis. The one

difference was that crew supervisors and team leaders that were categorized in the supervisor/manager job classification in 1998 were categorized in the chemical operator category in 2000. Although the job tasks did not change, the term "secretaries" which was used as a job classification in 1998 was defined as "administrative assistants" in 2000.

Because the serum distributions for PFOS, PFHS, PFOA, PFOSAA, M570, PFOSA and M556 appeared log normally distributed (see Figures 1 and 2 for PFOS and PFOA), natural log transformations of the fluorochemicals were performed to calculate geometric means $[e^{(\text{sum } \ln x)/n)}]$ and 95% confidence intervals were calculated for the geometric mean. The random variable X is said to have a log normal distribution if log X is normally distributed, that is, if X is of the form e^Y where Y is normal (i.e., the normal bell shaped curve). The pertinent properties of a log normal distribution can then be derived from properties of the normal distribution. The mean and variance are of the normally distributed Y, that is, of log X.

All employee serum values for PFOS, PFHS, PFOA and M570 were above the respective lower limit of quantitation (LLOQ). There were 8 employees who with PFOSAA were determined to be below the LLOQ (0.006 ppm); 111 employees were below the LLOQ for PFOSA (0.001 ppm); and 13 employees were below the LLOQ for M556 (0.0043 ppm). For statistical purposes, serum fluorochemical values that were less than the LLOQ were assumed to be the midpoint between zero and the LLOQ. Therefore, employees with serum values reported at below the LLOQ for PFOSAA, PFOSA and M556, were assigned the values 0.003 ppm, 0.0005 ppm and 0.00215 ppm, respectively. All fluorochemical measurements were reported in parts per million (ppm)

to the second decimal point (or to the 3rd or 4th decimal point if the LLOQ was at the 3rd decimal point).

RESULTS

Provided in Table 1 are the summary statistics for the 263 chemical plant and site employees) who participated in the year 2000 fluorochemical medical surveillance program. Also provided are the previously reported findings from the 126 chemical plant and site employees who participated in the 1998 random sample survey. The 95% confidence interval of the geometric mean was nearly identical for the two sets of data. There were 113 employees who participated in both the year 2000 fluorochemical medical surveillance program and in the 1998 random sample study. Figures 3, 4 and 5 show the categorical differences between these two time periods for serum PFOS, PFOA and PFHS levels. The mean difference (i.e., arithmetic average of the individual's 2000 fluorochemical-specific data minus their 1998 data) between these employees' serum PFOS, PFOA and PFHS values were (95% confidence interval in parenthesis): -0.13 ppm (-0.27 to +0.02) , +0.21 ppm (+0.06 to +0.36) and -0.01 ppm (-0.04 to +0.01), respectively.

The demographic distribution of the eight major job classifications is found in Table 2. As expected, participants were predominately male, and mill operators were the youngest employees because of their entry level position at the Decatur facility.

Presented in Table 3 are the arithmetic mean, range, geometric mean and the 95% confidence interval of the geometric mean of the seven fluorochemicals for the eight major job classifications. [Note: Provided in Appendix B is a comparable table from the

1998 random sample study.] Cell operators, chemical operators and maintenance workers had significantly higher serum PFOS levels than engineer/lab workers, mill operators, administrative assistants and managers. Cell operators had significantly higher geometric mean serum PFOA and PFHS levels than all other job classifications. Chemical operators and maintenance workers had significantly higher PFOSAA, M570, PFOSA and M556 geometric mean levels than most of the other job classifications.

Regardless of work location, the 95% confidence intervals for serum PFOS and PFOA overlapped for chemical operators who worked primarily in Building 3 (Table 4). Geometric mean levels of M570, PFOSAA and M556 were higher for chemical operators who worked exclusively in Building 3 compared to those who spent time working in Buildings 3, 4N and 42. PFHS levels were comparable regardless of work location within Building 3.

Analyzed by the teams that these employees self-reported on their work history questionnaires, higher serum PFOA levels were observed among chemical operators in the alcohol, monomer, Scotchban™ and Scotchgard™ teams than in the cell feed and lightwater teams (Table 5). The alcohol and monomer teams had significantly higher geometric means for M570. PFHS levels were comparable regardless of the work team.

Among chemical and mill operators who worked primarily in Dyneon™ production operations which included work in Buildings 4, 38, 51 and 61, geometric mean serum fluorochemical levels were lower (Table 6) than those reported by chemical operators who worked primarily in Building 3 operations (Table 4). The Dyneon building 4 team had lower serum PFOS, M570 and M556 levels than the Building 4 inert and FC teams.

Maintenance workers were requested to self-report their job descriptions as either day mechanic, day electrician, shift mechanic or shift electrician. Geometric mean serum fluorochemical levels were higher among the mechanics than the electricians (Table 8).

DISCUSSION

The year 2000 serum PFOS levels were comparable to the distribution observed in the 1998 random sample study. The geometric mean serum PFOS level was 0.91 ppm in 2000 compared to 0.94 ppm in 1998. The highest serum PFOS value measured in 2000 (10.06 ppm) was of the same person who had the highest serum PFOS value measured in 1998 (10.60 ppm).

Serum PFOA levels were higher among cell operators in 2000 due to the increased production of perfluorooctanoic acid that occurred beginning in 1999 at the Decatur chemical plant. The geometric mean level of serum PFOA was 1.43 ppm (95% CI 0.42-4.83) among the cell operators tested in 1998 compared to 4.57 ppm (95% CI 1.85-7.99) among the cell operators tested in 2000. The other serum fluorochemical levels, by major job categories, were comparable between the two time periods.

Five employees had serum PFOA levels greater than the 5 ppm Biological Limit Value (BLV) that was established by the 3M Exposure Guideline committee in 2000. The highest value was 12.70 ppm for a chemical operator on the Scotchgard team. The other 4 employees had serum PFOA levels that ranged between 5 and 9 ppm. Two of these four employees were cell operators and the other two employees worked on the Building 3 Scotchgard and monomer teams where production and/or use of perfluorooctanoic acid does not occur. Interestingly the inert team in Building 4 does

have occupational exposure to perfluorooctanoic acid but this team's operators' serum PFOA levels on this inert team were lower than those reported for employees on the Building 3 alcohol, monomer, Scotchgard and Scotchban teams where production and/or use of perfluoroctanoic acid does not occur. An industrial hygienist (PWL) will further evaluate this issue.

Employees who participated in the year 2000 fluorochemical medical surveillance program received a personal letter with their individual results for the seven fluorochemicals measured. In addition, if the employee participated in the 1998 random sample study, he/she was also provided a copy of the letter from this study. Group employee communications occurred on December 11 and 12, 2000 where these analyses, as described in this report, were presented.

REFERENCES

Olsen GW, Burris JM, Mandel JH, Zobel LR (1999a). Serum perfluorooctane sulfonate and hepatic and lipid clinical chemistry tests in fluorochemical production employees. JOEM 41(9):799-806.

Olsen GW, Logan PW, Simpson CA, Hansen KJ, Burris JM, Burlew MM, Schumpert JC, Mandel JH (1999b). Fluorochemical exposure assessment of Decatur chemical and film plant employees. St. Paul:3M Company (unpublished report).

Figure 1
Year 2000 Decatur Fluorochemical Medical Surveillance
Number of Employees (N = 263) by Serum PFOS Levels (ppm)
(Each x axis tick represents 0.1 ppm)

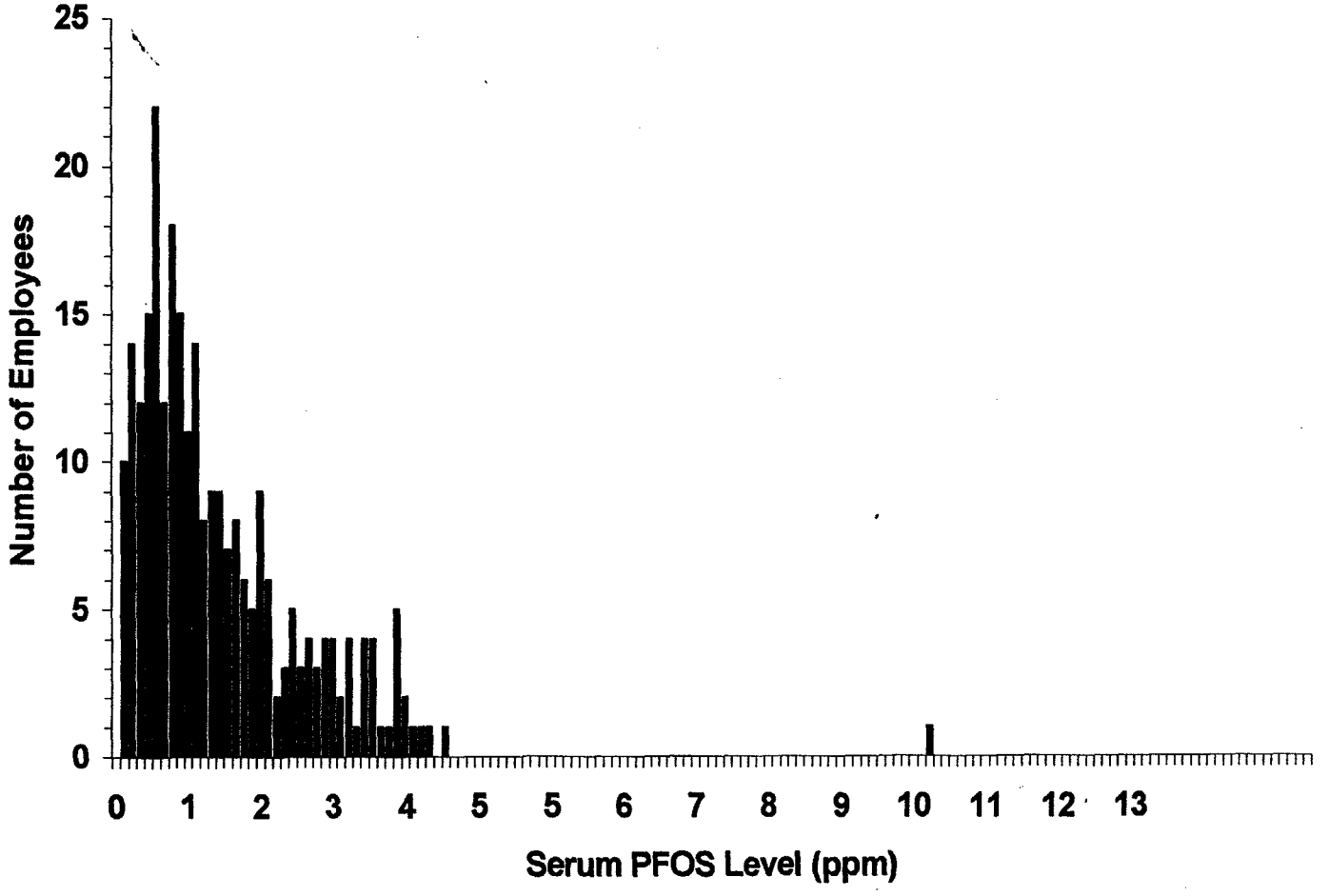

Figure 2
Year 2000 Decatur Fluorochemical Medical Surveillance
Number of Employees (N = 263) by Serum PFOA Levels (ppm)
(Each x-axis tick represents 0.1 ppm)

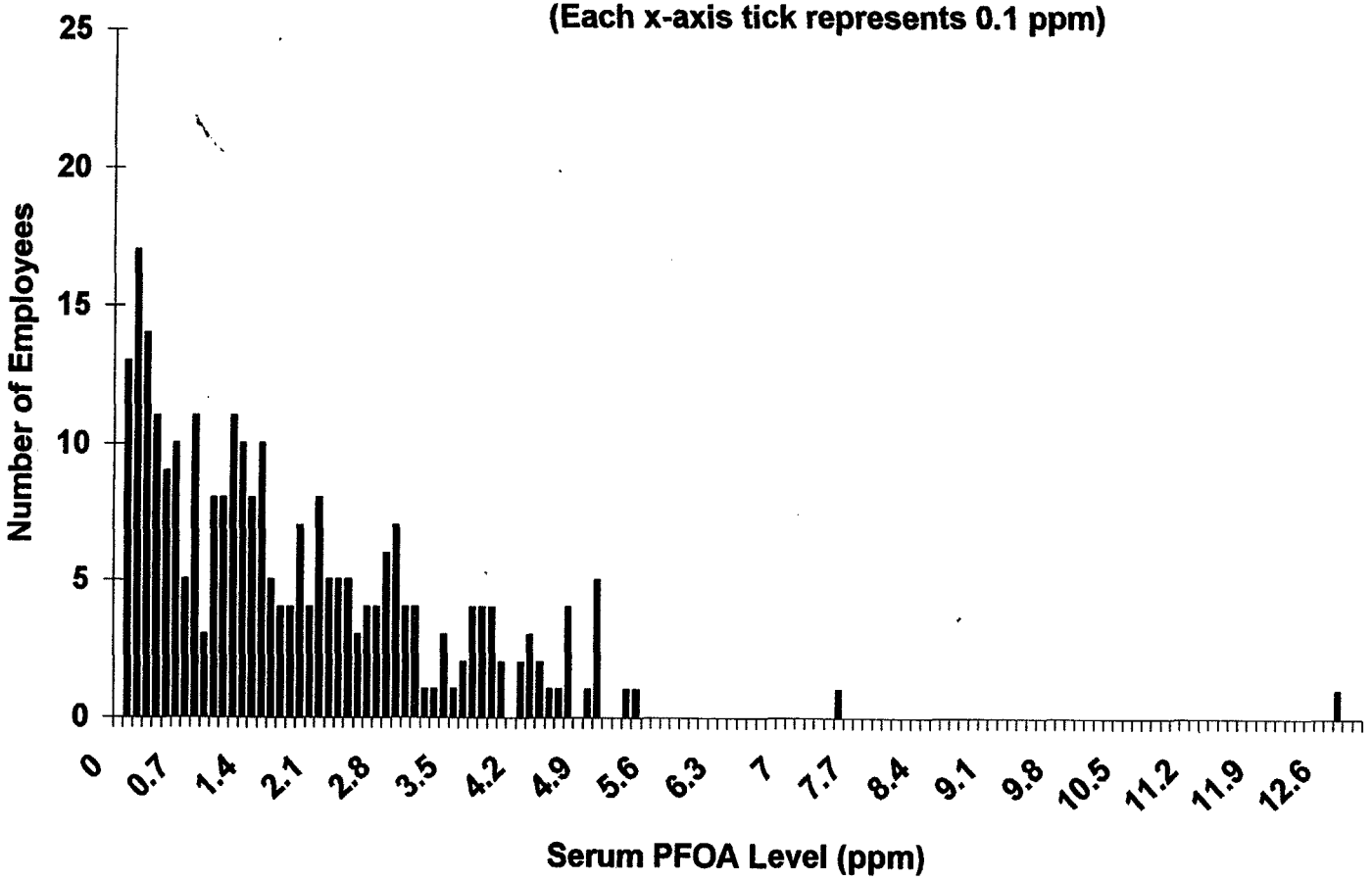

Figure 3
Serum PFOS Difference (ppm) Among Those Employees Who Participated in the Year 2000 Decatur Fluorochemical Medical Surveillance Program and the 1998 Random Sample Study

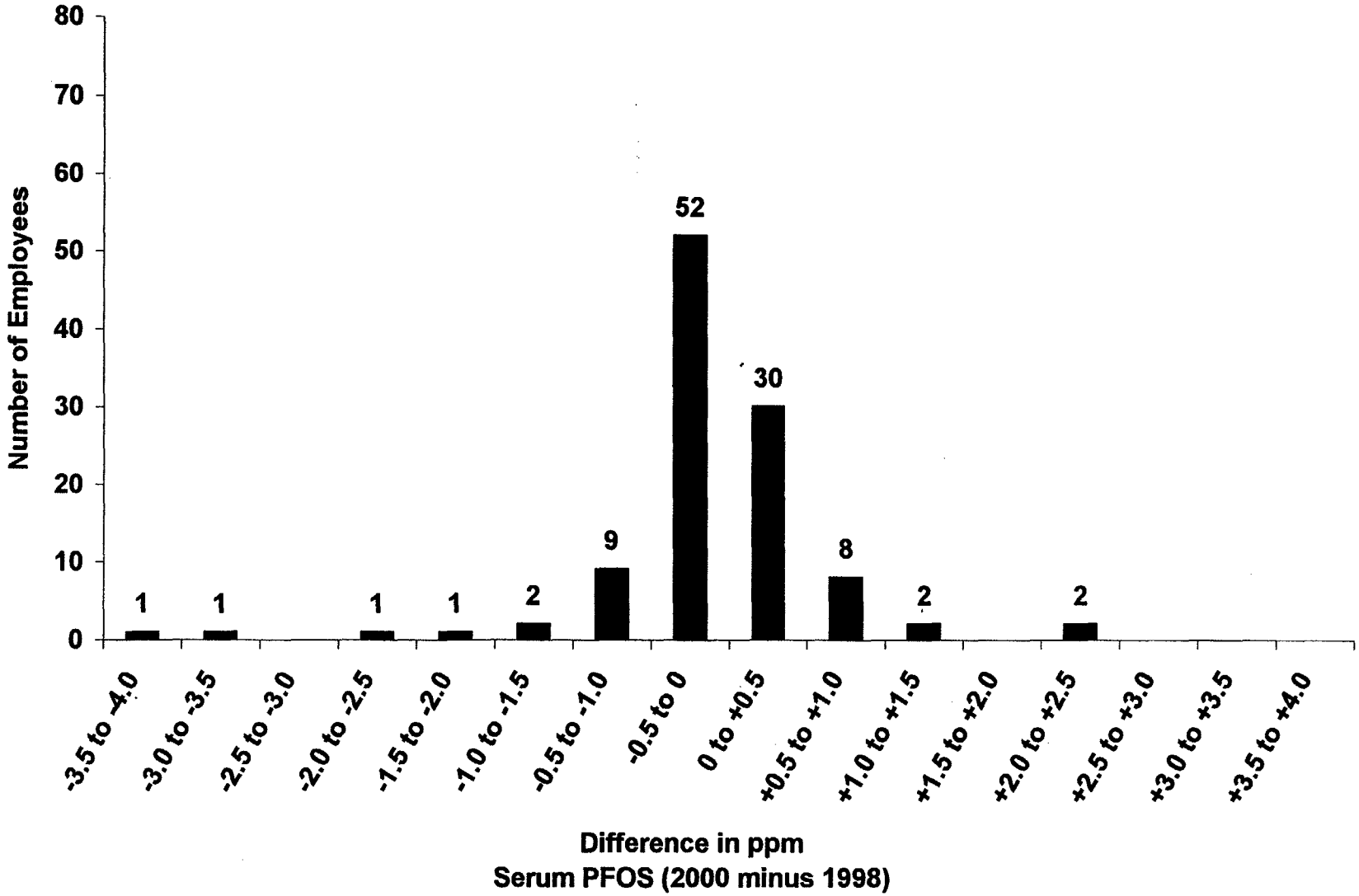

Figure 4
Serum PFOA Difference (ppm) Among Those Employees Who Participated in the Year 2000 Decatur Fluorochemical Medical Surveillance Program and the 1998 Random Sample Study

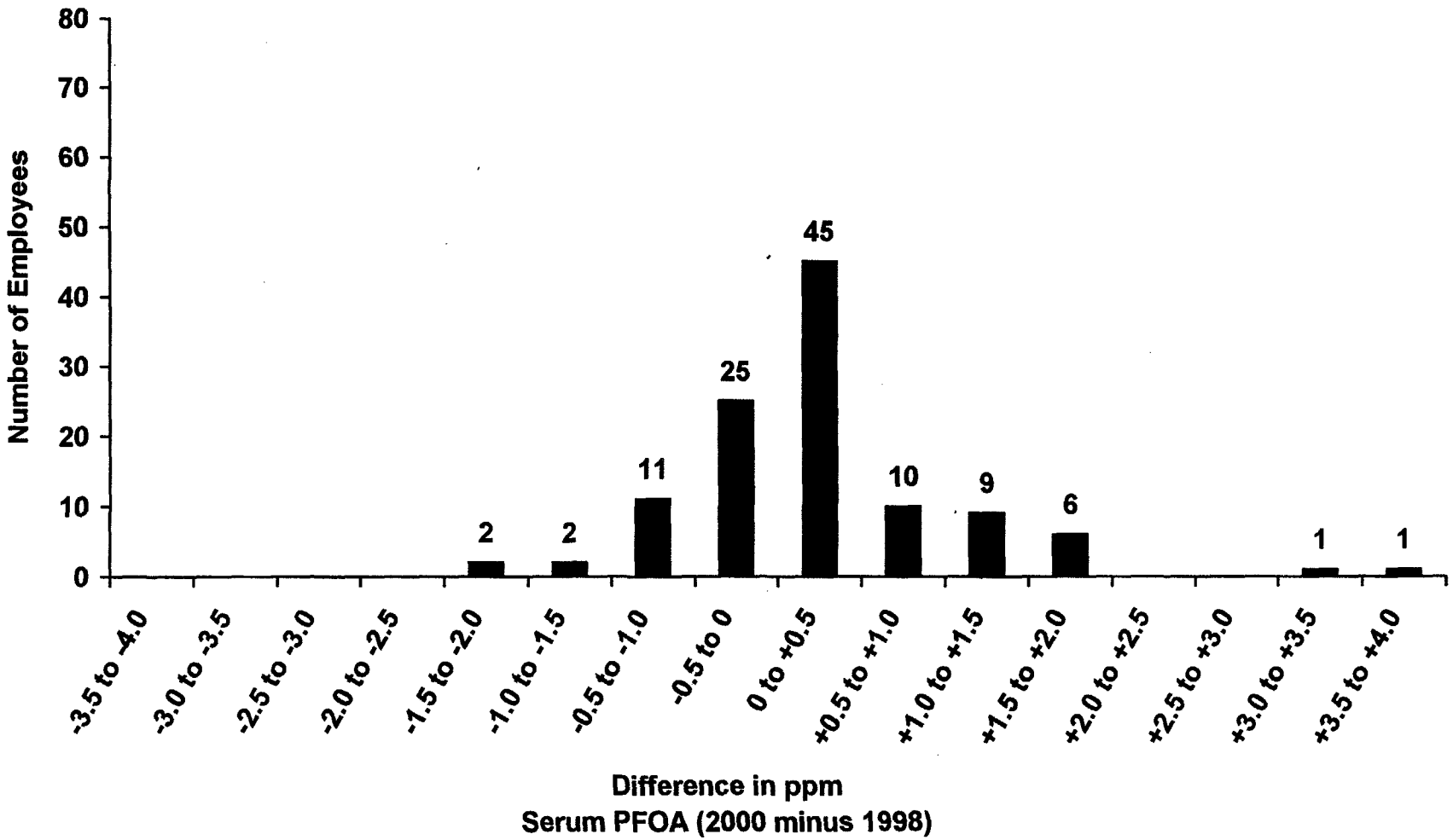

Figure 5
Serum PFHS Difference (ppm) Among 113 Employees Who Participated in the Year 2000 Decatur Fluorochemical Medical Surveillance Program and the 1998 Random Sample Study

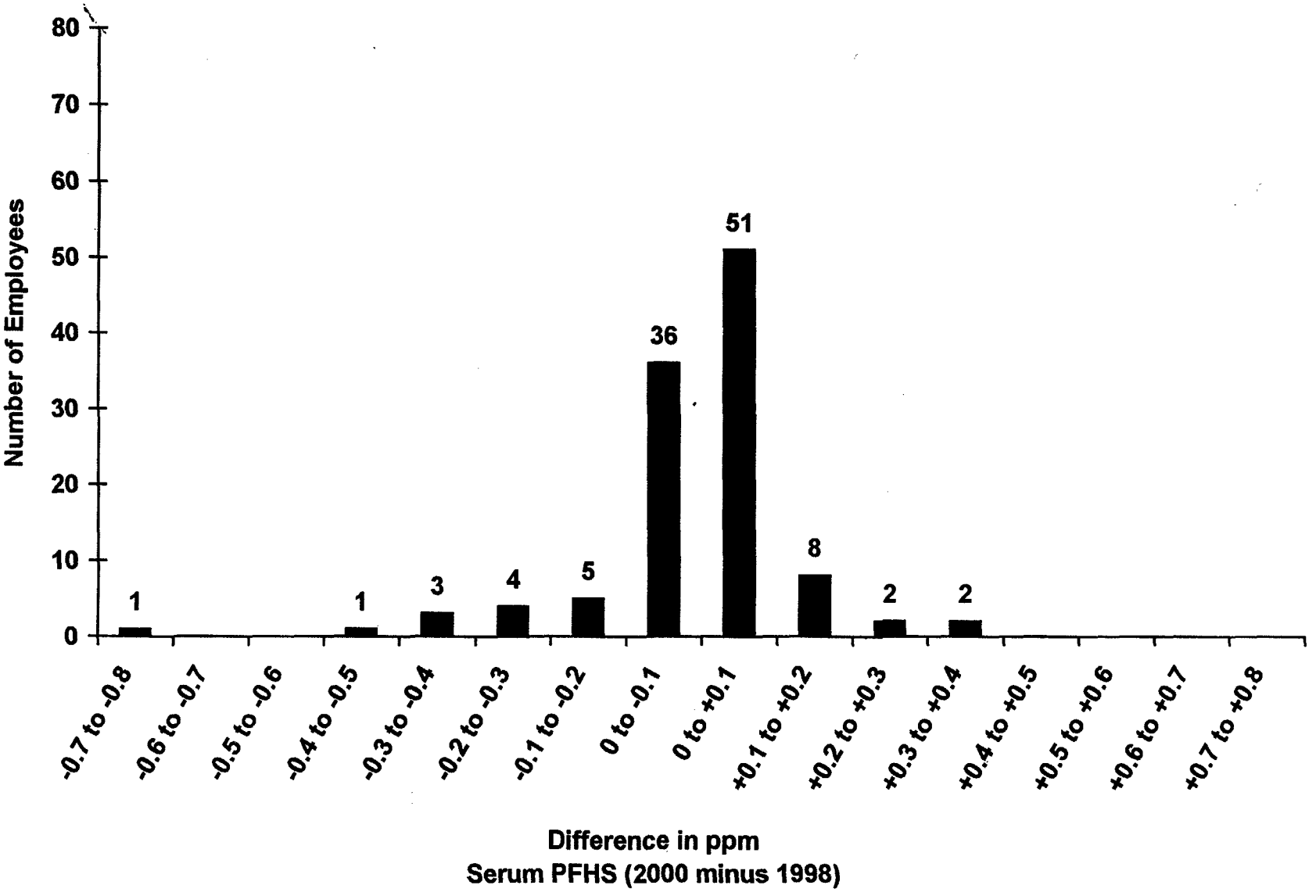

TABLE 1

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Comparison of Year 2000 Serum Fluorochemical Level (ppm) Data (N = 263) and Year 1998 Random Sample Data (N = 126)

	2000				1998			
Fluorochemical	Arithmetic Mean	Range	Geometric Mean	95% C.I.	Arithmetic Mean	Range	Geometric Mean	95% C.I.
PFOS	1.32	0.06 – 10.06	0.91	0.82 – 1.02	1.51	0.09 – 10.60	0.94	0.79 – 1.13
PFOA	1.78	0.04 – 12.70	1.13	0.99 – 1.30	1.54	0.02 – 6.76	0.90	0.72 – 1.12
PFHS	0.30	0.007 – 1.67	0.18	0.16 – 0.21	0.35	0.005 – 1.88	0.18	0.15 – 0.22
PFOSAA	0.06	0.003 – 0.44	0.04	0.001 – 0.04	0.02	0.001 – 0.27	0.008	0.006 – 0.01
M570	0.25	0.008 – 2.31	0.11	0.10 – 0.13	0.15	0.008 – 0.99	0.08	0.07 – 0.10
PFOSA	0.003	0.0005 – 0.02	0.002	0.001 – 0.02	0.06	0.001 – 0.61	0.01	0.009 – 0.02
M556	0.08	0.002 – 0.57	0.04	0.03 – 0.05	0.05	0.001 – 0.41	0.02	0.02 – 0.03

TABLE 2

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Demographics of Decatur Chemical Plant Employees by Eight Major Job Categories

	Cell Operator	Chemical Operator	Maintenance	Mill Operator	Waste Operator	Engineer/ Laboratory	Administrative Assistants	Managers*
Number	8	128	29	22	4	57	4	11
Age (yrs)	47.6	41.9	43.2	38.5	52.3	43.1	44.5	46.2
Gender								
Male (%)	8 (100)	104 (81)	28 (97)	17 (77)	4 (100)	46 (81)	0 (0)	8 (73)
Female (%)	0 (0)	24 (19)	1 (3)	5 (23)	0 (0)	11 (19)	4 (100)	3 (27)
Average Year Started Current Job	1995	1991	1990	1997	1992	1991	1990	1995
Body Mass Index	26.0	29.3	28.2	28.5	27.7	27.9	24.3	28.3

TABLE 3

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Mean, Range, Geometric Mean and 95% Confidence Interval of Geometric Mean of Serum Fluorochemical Levels (ppm)
by Eight Major Job Categories

	Cell Operator[a] (N = 8)	Chemical Operator[b] (N = 128)	Engineer/ Lab[c] (N = 57)	Maintenance[d] (N = 29)	Mill Operator[e] (N = 22)	Waste Operator[f] (N = 4)	Administrative Assistant[g] (N = 4)	Manager[h] (N = 11)
PFOS								
Arithmetic Mean	1.71	1.72	0.64	1.57	0.72	1.10	0.53	0.66
Range	0.87 – 2.89	0.18 – 4.17	0.06 – 2.95	0.11 – 10.06	0.31 – 1.56	0.45 – 1.88	0.32 – 0.90	0.19 – 2.57
Geometric Mean	1.57[c,e,g,h]	1.39[c,e,g,h]	0.43[a,b,d,e]	1.12[c,e,g,h]	0.68[a,b,d]	0.89	0.49[a,b,d]	0.45[a,b,d]
95% C.I.	1.16 – 2.13	1.23 – 1.58	0.34 – 0.56	0.83 – 1.50	0.58 – 0.79	0.42 – 1.91	0.30 – 0.78	0.27 – 0.75
PFOA								
Arithmetic Mean	4.57	2.45	0.53	1.53	1.35	1.55	0.38	0.58
Range	1.85 – 7.99	0.10 – 12.70	0.04 – 2.10	0.06 – 4.03	0.50 – 2.49	0.46 – 2.25	0.10 – 0.78	0.16 – 1.94
Geometric Mean	4.12[b,c,d,e,f,g,h]	1.99[a,d,e,f,g,h]	0.36[a,b,d,e,f]	1.12[a,b,c,g,h]	1.30[a,b,c,g,h]	1.33[a,c,g,h]	0.30[a,b,d,e,f]	0.42[a,b,d,e,f]
95% C.I.	2.91 – 5.84	1.75 – 2.27	0.29 – 0.46	0.80 – 1.57	1.14 – 1.47	0.65 – 2.73	0.12 – 0.71	0.26 – 0.68
PFHS								
Arithmetic Mean	0.78	0.39	0.17	0.25	0.07	0.24	0.11	0.18
Range	0.17 – 1.43	0.02 – 1.67	0.01 – 0.70	0.02 – 1.05	0.03 – 0.13	0.02 – 0.66	0.05 – 0.21	0.02 – 0.77
Geometric Mean	0.67[b,c,d,e,f,g,h]	0.30[a,c,d,e,f,g,h]	0.10[a,b,d]	0.16[a,b,c,e]	0.07[a,b,d]	0.12[a,b]	0.09[a,b]	0.10[a,b]
95% C.I.	0.43 – 1.05	0.27 – 0.35	0.07 – 0.13	0.12 – 0.23	0.06 – 0.08	0.03 – 0.53	0.05 – 0.19	0.05 – 0.20
PFOSAA								
Arithmetic Mean	0.01	0.10	0.02	0.07	0.02	0.01	0.02	0.02
Range	0.003 – 0.03	0.003 – 0.44	0.003 – 0.08	0.008 – 0.39	0.01 – 0.04	0.01 – 0.02	0.01 - 0.02	0.008 – 0.04
Geometric Mean	0.01[b,d]	0.08[c,d,e,f,g,h]	0.02[b,d]	0.05[a,b,c,e,f,g,h]	0.02[b,d]	0.01[b,d]	0.02[b,d]	0.02[b,d]
95% C.I.	0.0004 – 0.02	0.002 – 0.09	0.005 – 0.02	0.001 – 0.07	0.004 – 0.02	0.001 – 0.02	0.0003 – 0.02	0.0006 – 0.03
M570								
Arithmetic Mean	0.07	0.40	0.08	0.28	0.05	0.09	0.07	0.07
Range	0.03 – 0.23	0.01– 2.31	0.008 – 0.47	0.02 – 0.94	0.02 – 0.12	0.05 – 0.17	0.02 – 0.11	0.02 – 0.16
Geometric Mean	0.05[b,d]	0.20[a,c,e,g,h]	0.05[b,d]	0.20[a,c,e,g,h]	0.04[b,d]	0.08	0.05[b,d]	0.05[b,d]
95% C.I.	0.03 – 0.09	0.16 – 0.25	0.04 – 0.06	0.14 – 0.28	0.04 – 0.05	0.05 – 0.15	0.03 – 0.12	0.03 – 0.09

TABLE 3 (continued)

PFOSA								
Arithmetic Mean	0.0007	0.004	0.0009	0.004	0.006	0.002	0.0005	0.001
Range	0.0005 – 0.002	0.0005 – 0.02	0.0005 – 0.009	0.0005 – 0.02	0.0005 – 0.01	0.0005– 0.002	0.0005 – 0.0005	0.0005 – 0.004
Geometric Mean	0.0007[b,d,e]	0.002[a,c,e,g,h]	0.0007[b,d,e]	0.002[a,c,e,g,h]	0.005[a,b,c,d,f,g,h]	0.001[e]	0.0005[b,d,e]	0.0009[b,d,e]
95% C.I.	0.0005 – 0.001	0.002 – 0.003	0.0006 – 0.0008	0.001 – 0.003	0.004 – 0.007	0.0007 – 0.003	0.0005 – 0.0005	0.0005 – 0.001
M556								
Arithmetic Mean	0.03	0.13	0.03	0.10	0.02	0.03	0.02	0.02
Range	0.008 – 0.06	0.0002 – 0.57	0.002 – 0.18	0.002 – 0.36	0.002 – 0.07	0.01 – 0.05	0.006 – 0.03	0.005 – 0.07
Geometric Mean	0.02[b,d]	0.03[a,c,e,g,h]	0.02[b,d]	0.06[a,c,e,g,h]	0.02[b,d]	0.03[b,d]	0.01[b,d]	0.02[b,d]
95% C.I.	0.01 – 0.04	0.01 – 0.09	0.01 – 0.02	0.04 – 0.09	0.01 – 0.02	0.02 – 0.05	0.007 – 0.03	0.01 – 0.03

(a-h), comparisons for each current job category using student's t, $p < 0.05$

TABLE 4

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Arithmetic Mean, Range, Geometric Mean and 95% Confidence Interval of Geometric Mean of Serum Fluorochemical Levels (ppm)
by Building 3 Area for Chemical Operators

LOCATION		PFOS	PFOA	PFHS	PFOSAA	M570	PFOSA	M556
Building 3 (N = 21)	Arith. Mean	2.51	3.35	0.46	0.15	0.87	0.008	0.27
	Range	1.40 – 4.17	1.28 – 5.41	0.23 – 0.80	0.05 – 0.44	0.35 – 2.31	0.002 – 0.02	0.12 – 0.47
	G. Mean	2.38	3.18	0.43	0.13	0.77	0.006	0.25
	95% C.I.	2.06 – 2.74	2.73 – 3.69	0.37 – 0.51	0.005 – 0.16	0.62 – 0.96	0.004 – 0.008	0.20 – 0.29
Building 3 (OSCL/OSF area) (N = 10)	Arith. Mean	2.28	2.99	0.53	0.10	0.70	0.006	0.22
	Range	0.97 – 3.67	1.23 – 4.73	0.13 – 1.67	0.04 – 0.27	0.21 – 1.26	0.002 – 0.01	0.008 – 0.44
	G. Mean	2.10	2.70	0.40	0.09	0.61	0.005	0.19
	95% C.I.	1.58 – 2.77	1.97 – 3.69	0.25 – 0.65	0.004 – 0.12	0.42 – 0.89	0.004 – 0.008	0.13 – 0.27
Building 3 (besides OSCL/OSF area) (N = 18)	Arith. Mean	2.28	3.85	0.46	0.14	0.87	0.008	0.24
	Range	0.48 – 3.80	1.93 – 12.70	0.06 – 0.84	0.04 – 0.38	0.11 – 2.30	0.002 – 0.02	0.04 – 0.57
	G. Mean	2.05	3.40	0.38	0.12	0.71	0.006	0.20
	95% C.I.	1.60 – 2.63	2.72 – 4.24	0.26 – 0.54	0.005 – 0.16	0.50 – 0.99	0.005 – 0.009	0.15 – 0.27
Building 3 (besides OSCL/OSF area), Building 4N and Building 42 (N = 5)	Arith. Mean	1.65	2.20	0.58	0.04	0.17	0.002	0.07
	Range	0.74 – 2.04	1.20 – 3.03	0.13 – 1.04	0.02 – 0.06	0.07 – 0.33	0.0005 – 0.004	0.004 – 0.09
	G. Mean	1.55	2.10	0.44	0.03	0.15	0.001	0.06
	95% C.I.	1.07 – 2.26	1.52 – 2.90	0.20 – 1.00	0.0007 – 0.05	0.09 – 0.25	0.0004 – 0.003	0.04 – 0.09
Building 3 (OSCL/OSF area) Building 4N, Building 42 (N = 4)	Arith. Mean	2.10	1.93	0.58	0.10	0.17	0.002	0.11
	Range	1.32 – 3.93	1.17 – 2.85	0.34 – 0.92	0.03 – 0.26	0.12 – 0.24	0.0005 – 0.003	0.05 – 0.24
	G. Mean	1.89	1.82	0.53	0.07	0.16	0.001	0.09
	95% C.I.	1.15 – 3.11	1.21 – 2.73	0.32 – 0.88	0.0005 – 0.17	0.12 – 0.22	0.0006 – 0.003	0.04 – 0.18

TABLE 5

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Arithmetic Mean, Range, Geometric Mean and 95% Confidence Interval of Geometric Mean of Serum Fluorochemical Levels (ppm)
by Building 3 Teams for Chemical Operators

Building 3 Teams		PFOS	PFOA	PFHS	PFOSAA	M570	PFOSA	M556
Alcohol	Arith. Mean	2.84	3.96	0.42	0.25	1.39	0.01	0.32
(N = 7)	Range	1.81 – 3.80	2.14 – 4.97	0.20 – 0.84	0.09 – 0.44	0.53 – 2.31	0.005 – 0.02	0.21 – 0.47
	G. Mean	2.75	3.82	0.38	0.21	1.17	0.01	0.30
	95% C.I.	2.25 – 3.37	3.02 – 4.82	0.26 – 0.54	0.007 – 0.34	0.72 – 1.92	0.008 – 0.02	0.25 – 0.38
Monomer	Arith. Mean	2.36	3.73	0.43	0.17	1.18	0.006	0.31
(N = 7)	Range	1.18 – 3.62	2.64 – 5.41	0.13 – 0.70	0.12 – 0.28	0.88 – 1.78	0.002 – 0.01	0.14 – 0.47
	G. Mean	2.23	3.64	0.39	0.16	1.15	0.005	0.28
	95% C.I.	1.68 – 2.95	3.04 – 4.34	0.25 – 0.59	0.004 – 0.20	0.96 – 1.38	0.003 – 0.009	0.20 – 0.41
Cell Feed	Arith. Mean	1.94	2.22	0.47	0.06	0.42	0.007	0.16
(N = 4)	Range	0.97 – 3.34	1.23 – 2.70	0.26 – 0.67	0.05 – 0.10	0.26 – 0.60	0.002 –0.02	0.08 – 0.20
	G. Mean	1.76	2.12	0.43	0.06	0.40	0.004	0.15
	95% C.I.	1.06 – 2.93	1.47 – 3.06	0.28 – 0.68	0.003- 0.08	0.28 – 0.56	0.002 – 0.01	0.10 – 0.23
Scotchban	Arith. Mean	2.32	3.43	0.38	0.14	0.67	0.006	0.28
(N = 5)	Range	1.29 – 4.17	2.58 – 4.73	0.18 – 0.73	0.09 – 0.20	0.47 – 1.02	0.003 – 0.01	0.13 – 0.39
	G. Mean	2.15	3.34	0.34	0.13	0.64	0.005	0.25
	95% C.I.	1.47 – 3.15	2.66 – 4.19	0.21 – 0.55	0.003 – 0.18	0.49 – 0.86	0.003 – 0.009	0.17 – 0.36
Scotchgard	Arith. Mean	2.34	5.06	0.51	0.09	0.86	0.009	0.24
(N = 6)	Range	0.48 – 3.11	1.97 – 12.70	0.06 – 0.84	0.04 – 0.15	0.11 – 1.17	0.003 – 0.01	0.04 – 0.35
	G. Mean	2.02	4.17	0.39	0.09	0.69	0.005	0.20
	95% C.I.	1.12 – 3.63	2.46 – 7.06	0.18 – 0.87	0.006 – 0.13	0.32 – 1.48	0.005 – 0.01	0.10 – 0.38

TABLE 5 (continued)

Lightwater (N = 6)	Arith. Mean	2.29	2.78	0.65	0.09	0.56	0.006	0.22
	Range	1.03 – 3.41	1.28 – 4.73	0.12 – 1.67	0.06 – 0.11	0.36 – 0.90	0.002 – 0.01	0.11 – 0.44
	G. Mean	2.09	2.54	0.48	0.09	0.54	0.005	0.20
	95% C.I.	1.40 – 3.11	1.72 – 3.74	0.24 – 0.99	0.004 – 0.10	0.41 – 0.70	0.003 – 0.009	0.14 – 0.30
Scotchgard and Lightwater (N = 4)	Arith. Mean	2.63	3.52	0.59	0.13	0.98	0.006	0.28
	Range	1.79 – 3.20	2.43 – 4.71	0.56 – 0.69	0.11 – 0.18	0.55 – 1.52	0.003 – 0.01	0.16 – 0.57
	G. Mean	2.56	3.40	0.59	0.13	0.91	0.005	0.24
	95% C.I.	1.94 – 3.38	2.47 – 4.66	0.53 – 0.66	0.004 – 0.16	0.59 – 1.42	0.003 – 0.009	0.13 – 0.45
Scotchban and Cell Feed (N = 4)	Arith. Mean	2.71	3.36	0.51	0.12	0.68	0.008	0.20
	Range	1.40 – 3.95	2.76 – 3.97	0.39 – 0.80	0.06 – 0.16	0.47 – 0.92	0.002 – 0.02	0.12 – 0.32
	G. Mean	2.54	3.32	0.48	0.11	0.66	0.006	0.18
	95% C.I.	1.65 – 3.91	2.79 – 3.96	0.35 – 0.68	0.004 – 0.18	0.50 – 0.87	0.002 – 0.02	0.11 – 0.29

TABLE 6

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Arithmetic Mean, Range, Geometric Mean and 95% Confidence Interval of Geometric Mean of Serum Fluorochemical Levels (ppm)
by Dyneon Production Areas for Chemical Operators

LOCATION		PFOS	PFOA	PFHS	PFOSAA	M570	PFOSA	M556
Buildings 4 and 61 (Expander/Dryer) (N = 11)	Arith. Mean	0.66	2.43	0.16	0.10	0.07	0.002	0.03
	Range	0.38 – 0.91	1.39 – 4.00	0.07 – 0.33	0.05 – 0.19	0.04 – 0.11	0.0005 – 0.005	0.009 – 0.06
	G. Mean	0.63	2.30	0.14	0.09	0.06	0.002	0.02
	95% C.I.	0.52 – 0.77	1.87 – 2.84	0.10 – 0.19	0.001 – 0.12	0.05 – 0.08	0.0009 – 0.003	0.02 – 0.03
Building 4N (Not Expander/Dryer) (N = 12)	Arith. Mean	1.81	1.43	0.36	0.12	0.16	0.002	0.08
	Range	0.40 – 3.64	0.53 – 2.80	0.09 – 0.67	0.03 – 0.24	0.07 – 0.27	0.0005 – 0.006	0.02 – 0.22
	G. Mean	1.58	1.30	0.31	0.10	0.14	0.002	0.07
	95% C.I.	1.12 – 2.21	0.98 – 1.71	0.21 – 0.44	0.001 – 0.14	0.11 – 0.19	0.001 – 0.003	0.05 – 0.10
Buildings 4N and 38/51 (N = 9)	Arith. Mean	1.14	1.64	0.31	0.06	0.07	0.0009	0.02
	Range	0.44 – 2.71	0.59 – 3.15	0.14 – 0.91	0.04 – 0.09	0.03 – 0.08	0.0005 – 0.003	0.01 – 0.05
	G. Mean	0.93	1.41	0.24	0.03	0.07	0.001	0.02
	95% C.I.	0.17 – 3.17	0.97 – 1.88	0.06 – 0.42	0.001 – 0.04	0.03 – 0.08	0.0004 – 0.003	0.006 – 0.10
Buildings 38/51 (N = 4)	Arith. Mean	1.82	2.39	0.40	0.09	0.09	0.0009	0.05
	Range	1.33 – 2.98	1.36 – 3.85	0.24 – 0.73	0.02 – 0.14	0.03 – 0.14	0.0005 – 0.002	0.01 – 0.08
	G. Mean	1.72	2.19	0.37	0.07	0.08	0.0005	0.04
	95% C.I.	1.18 – 2.49	1.35 – 3.55	0.23 – 0.59	0.0003 – 0.17	0.04 – 0.14	0.0003 – 0.001	0.02 – 0.09
Buildings 4 and 61 (Expander/Dryer) and Buildings 38/51 (N = 4)	Arith. Mean	0.61	1.87	0.21	0.08	0.05	0.0009	0.02
	Range	0.29 – 0.83	1.01 – 2.44	0.11 – 0.38	0.05 – 0.10	0.04 – 0.06	0.0005 – 0.002	0.01 – 0.03
	G. Mean	0.56	1.77	0.19	0.08	0.05	0.0007	0.02
	95% C.I.	0.34 – 0.91	1.19 – 2.64	0.11 – 0.32	0.0005 – 0.11	0.04 – 0.06	0.0004 – 0.001	0.02 – 0.03

TABLE 6 (continued)

Buildings 4 and 61 (Expander/Dryer) Building 61 (Millroom)	Arith. Mean	1.12	1.39	0.20	0.03	0.05	0.002	0.04
	Range	0.18 – 2.15	1.07 – 1.86	0.07 – 0.36	0.03 – 0.04	0.03 – 0.06	0.0005 – 0.002	0.007 – 0.06
Buildings 38/51 (N = 3)	G. Mean	0.74	1.35	0.16	0.03	0.05	0.001	0.03
	95% C.I.	0.17 – 3.17	0.97 – 1.88	0.06 – 0.42	0.001 – 0.04	0.03 – 0.08	0.0004 – 0.003	0.006 – 0.10
Building 61 (Millroom) (Mill Operators) (N = 17)	Arith. Mean	0.73	1.39	0.07	0.02	0.006	0.05	0.02
	Range	0.31 – 1.56	0.50 – 2.49	0.03 – 0.13	0.01 – 0.04	0.02 – 0.12	0.0005 – 0.01	0.008 – 0.03
	G. Mean	0.69	1.32	0.07	0.02	0.04	0.004	0.02
	95% C.I.	0.58 – 0.83	1.12 – 1.56	0.05 – 0.08	0.004 – 0.02	0.03 – 0.05	0.003 – 0.007	0.01 – 0.02

TABLE 7

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Arithmetic Mean, Range, Geometric Mean and 95% Confidence Interval of Geometric Mean of Serum Fluorochemical Levels (ppm)
by Building 4 Teams for Chemical Operators

Building 4 Teams		PFOS	PFOA	PFHS	PFOSAA	M570	PFOSA	M556
Dyneon	Arith. Mean	0.99	2.12	0.25	0.08	0.07	0.001	0.03
(N = 31)	Range	0.18 – 2.71	0.59 – 4.00	0.07 – 0.91	0.02 – 0.19	0.03 – 0.14	0.0005 – 0.005	0.007 – 0.08
	G. Mean	0.81	1.93	0.20	0.07	0.06	0.0009	0.03
	95% C.I.	0.64 – 1.02	1.63 – 2.27	0.16 – 0.25	0.0008 – 0.08	0.05 – 0.07	0.0007 – 0.001	0.02 – 0.03
Inert	Arith. Mean	1.84	2.26	0.54	0.07	0.15	0.001	0.08
(N = 12)	Range	0.70 – 3.93	1.17 – 4.37	0.13 – 0.96	0.02 – 0.26	0.07 – 0.33	0.0005 – 0.003	0.03 – 0.24
	G. Mean	1.61	2.12	0.43	0.05	0.14	0.001	0.07
	95% C.I.	1.18 – 2.20	1.71 – 2.63	0.27 – 0.66	0.0007 – 0.07	0.11 – 0.18	0.0007 – 0.002	0.05 – 0.09
FC	Arith. Mean	1.68	1.40	0.35	0.11	0.16	0.003	0.08
(N = 16)	Range	0.40 – 3.64	0.53 – 2.80	0.09 – 0.67	0.03 – 0.24	0.07 – 0.27	0.0005 – 0.001	0.02 – 0.22
	G. Mean	1.50	1.27	0.30	0.09	0.15	0.002	0.07
	95% C.I.	1.15 – 1.94	1.02 – 1.57	0.22 – 0.40	0.001 – 0.13	0.12 – 0.18	0.001 – 0.003	0.05 – 0.09

TABLE 8

Year 2000 Decatur Fluorochemical Medical Surveillance Program
Arithmetic Mean, Range, Geometric Mean and 95% Confidence Interval of Geometric Mean of Serum Fluorochemical Levels (ppm)
by Type of Maintenance Job

Maintenance Job Category		PFOS	PFOA	PFHS	PFOSAA	M570	PFOSA	M556
Day Mechanic (N = 11)	Arith. Mean	2.16	2.14	0.32	0.12	0.41	0.006	0.02
	Range	0.49 – 10.06	0.42 – 4.03	0.04 – 1.05	0.02 – 0.39	0.08 – 0.94	0.0005 – 0.02	0.02 – 0.36
	G. Mean	1.41	1.76	0.19	0.08	0.29	0.002	0.10
	95% C.I.	0.84 – 2.37	1.13 – 2.73	0.10 – 0.36	0.001 – 0.14	0.17 – 0.50	0.001 – 0.006	0.05 – 0.19
Day Electrician (N = 8)	Arith. Mean	1.05	1.03	0.17	0.04	0.18	0.002	0.06
	Range	0.50 – 1.82	0.42 – 1.86	0.06 – 0.34	0.02 – 0.07	0.05 – 0.34	0.0005 – 0.003	0.01 – 0.12
	G. Mean	0.95	0.93	0.14	0.4	0.16	0.005	0.05
	95% C.I.	0.68 – 1.34	0.66 – 1.32	0.09 – 0.22	0.0008 – 0.06	0.10 – 0.25	0.0006 – 0.002	0.03 – 0.08
Shift Mechanic (N = 3)	Arith. Mean	2.37	2.52	0.42	0.07	0.38	0.006	0.11
	Range	0.96 – 3.72	1.03 – 3.42	0.13 – 0.58	0.05 – 0.11	0.30 – 0.48	0.002 – 0.01	0.06 – 0.15
	G. Mean	2.05	2.22	0.35	0.07	0.38	0.005	0.10
	95% C.I.	0.92 – 4.58	1.03 – 4.79	0.13 – 0.93	0.003 – 0.11	0.29 – 0.50	0.002 – 0.13	0.06 – 0.18
Shift Electrician (N = 3)	Arith. Mean	1.21	1.04	0.25	0.04	0.19	0.001	0.08
	Range	0.98 – 1.49	0.73 – 1.33	0.09 – 0.37	0.03 – 0.05	0.17 – 0.20	0.0005 – 0.002	0.007 – 0.09
	G. Mean	1.19	1.01	0.21	0.04	0.19	0.001	0.08
	95% C.I.	0.94 – 1.52	0.71 – 1.43	0.09 – 0.50	0.0007 – 0.06	0.17 – 0.21	0.0004 – 0.002	0.06 – 0.09

APPENDIX A

DECATUR SUPPLEMENTAL QUESTIONNAIRE

Thank you for participating in these exams. Please respond to each question with either a short answer or an 'x' in the appropriate box.

Last Name _____ First Name _____ MI __

Employee Number _____

1. What is your current job title? _____
2. What year did you start working in your current job? _____
3. Please indicate in which area(s) you work in your current job. Mark an 'x' in all boxes that apply.

   ☐ **Building 1**
   ☐ **Buildings 2 and/or 49**
   ☐ **Building 3 (OSCL/OSF area)**
   ☐ **Building 3 (besides OSCL/OSF area)**
   ☐ **Building 4 North**
   ☐ **Building 4 (expander/dryer)**
   ☐ **Building 17**
   ☐ **Buildings 38 and/or 51**
   ☐ **Building 42 (packaging FC inerts)**
   ☐ **Building 61 (millroom)**
   ☐ **Building 61 (expander/dryer)**
   ☐ **Film plant (all buildings)**
   ☐ **Wastewater treatment plant (Buildings 36 and 57)**
   ☐ **Other. Please specify** _____

If you *currently work* in Building 3 or 4, or you are a maintenance worker please proceed to questions 4 and 5. If you do not currently work in Building 3 or 4, and you are not a Maintenance worker your supplemental questionnaire is complete.

4. If you *currently work* in Building 3 or 4, on a *routine basis*, what is your team name? Answer only if you work in Building 3 or 4.

   Building 3
   ☐ **Alcohol**
   ☐ **Monomer Team**
   ☐ **Cell Feed**
   ☐ **Scotchban**
   ☐ **Scotchguard**
   ☐ **Lightwater**
   ☐ **Other** _____

   Building 4
   ☐ **Inerts (work in specific areas of 3 & 4)**
   ☐ **FC**
   ☐ **Dyneon**
   ☐ **Other** _____

5. For Maintenance Workers only

   a. Please check the appropriate box that best describes your job:

   ☐ **Day Mechanic**
   ☐ **Day Electrician**
   ☐ **Shift Mechanic**
   ☐ **Shift Electrician**
   ☐ **Other:** _____

   b. For Day Mechanics and Day Electricians only: If you are a Day Mechanic or Day Electrician, please indicate which building area you work in:

   ☐ **Bldg. 2/49**
   ☐ **Bldg 3 East**
   ☐ **Bldg 4 West**
   ☐ **Bldg 17**
   ☐ **Bldg 4 North, 38, 51**
   ☐ **Bldg 17**
   ☐ **Bldg 4 North, 38, 51**
   ☐ **Bldg 4 South, 61, wastewater, riverwater pump house**
   ☐ **HVAC**
   ☐ **Other: (please specify)** _____

Appendix B

Table Geometric mean, 95% confidence interval and range of fluorochemical levels (ppm) by current job categories among the 1998 random sample (N = 126) of chemical employees

	Cell Operator[a] (N = 5)	Chemical Operator[b] (N = 47)	Engineer/ Lab[c] (N = 23)	Maintenance[d] (N = 11)	Mill Operator[e] (N = 13)	Secretary[f] (N = 4)	Supervisor/ Mgmt[g] (N = 18)	Waste Operator[h] (N = 5)
PFOS								
G. Mean	1.970[c,e,f]	1.481[c,e,g,h]	0.391[a,b,d,g,h]	1.299[c,e,f]	0.589[a,b,d,h]	0.397[a,b,d,h]	0.885[c]	1.504[c,e,f]
95% C.I.	0.732 – 5.304	1.250 – 1.755	0.256 – 0.597	0.822 – 2.054	0.419 – 0.828	0.195 – 0.807	0.480 – 1.630	0.493 – 4.589
Range	0.325 – 6.840	0.471-7.260	0.095-1.740	0.291-4.060	0.230-2.040	0.220-1.140	0.091-10.600	0.254-7.880
PFOA								
G. Mean	1.428[c,f]	1.887[c,f,g]	0.208[a,b,d,e,f,g,h]	1.095[c,f]	1.266[c,f,g]	0.172[a,b,d,e,g,h]	0.637[b,c,e,f]	1.542[c,f]
95% C.I.	0.422 – 4.833	1.573 – 2.265	0.134 – 0.324	0.670 – 1.791	0.985 – 1.629	0.113 – 0.260	0.310 – 1.308	1.052 – 2.259
Range	0.126-3.64	0.150-6.760	0.035-2.320	0.211-4.680	0.450-2.340	0.095-2.611	0.021-4.540	0.936-2.710
PFHS								
G. Mean	0.697[c,d,e,f,g]	0.308[c,e,f]	0.078[a,b,g,h]	0.153[a]	0.074[a,b,g,h]	0.066[a,b,g]	0.215[c,e,f]	0.232[c,e]
95% C.I.	0.228 – 2.130	0.246 – 0.386	0.046 – 0.134	0.084 – 0.280	0.047 – 0.116	0.031 – 0.140	0.115 – 0.402	0.069 – 0.775
Range	0.083-1.880	0.071-1.860	0.005-0.905	0.023-0.790	0.028-0.374	0.027-0.172	0.010-1.420	0.038-1.210
PFOSAA								
G. Mean	0.003[b,d,e]	0.011[a,c,f]	0.005[b,d,e]	0.017[a,c,f]	0.015[a,c,f]	0.002[b,d,e]	0.006	0.006
95% C.I.	0.001 – 0.009	0.007 – 0.018	0.003 – 0.010	0.007 – 0.043	0.010 – 0.024	0.001 – 0.003	0.003 – 0.010	0.003 – 0.013
Range	0.001-0.016	0.001-0.269	0.001-0.073	0.001-0.083	0.004-0.038	0.001-0.004	0.001-0.054	0.003-0.017
PFOSA								
G. Mean	0.002[b,e]	0.028[a,c,d,g]	0.005[b,e]	0.009[b]	0.026[a,c]	0.021	0.007[b]	0.012
95% C.I.	0.001 – 0.005	0.017 – 0.048	0.002 – 0.010	0.003 - 0.025	0.016 – 0.040	0.009 – 0.054	0.003 – 0.020	0.003 – 0.048
Range	0.001-0.011	0.001-0.487	0.001-0.063	0.001-0.569	0.012-0.204	0.009-0.080	0.001-0.612	0.002-0.161
M570								
G. Mean	0.033[b,d]	0.131[a,c,e,f,g]	0.049[b,d]	0.204[a,c,e,f,g]	0.042[b,d]	0.030[b,d]	0.064[b,d]	0.079
95% C.I.	0.024 – 0.045	0.094 – 0.182	0.034 – 0.071	0.124 – 0.335	0.034 – 0.051	0.013 – 0.071	0.037 – 0.111	0.052 – 0.121
Range	0.024-0.056	0.009-0.992	0.008-0.410	0.038-0.701	0.025-0.115	0.010-0.072	0.010-0.553	0.050-0.159

M556

G. Mean	0.011[b,d]	0.044[a,c,e,f,g]	0.010[b,d]	0.074[a,c,e,f,g]	0.009[b,d]	0.010[b,d]	0.015[b,d]	0.027
95% C.I.	0.005 – 0.218	0.032 – 0.061	0.006 – 0.015	0.041 – 0.135	0.006 – 0.015	0.003 – 0.031	0.007 – 0.030	0.011 – 0.068
Range	0.003-0.028	0.001-0.380	0.002-0.127	0.016-0.406	0.002-0.045	0.003-0.030	0.003-0.336	0.013-0.157

(a-h) $p < 0.5$ comparison for each job category