

SERUM DIOXIN LEVELS IN TRICHLOROPHENOL AND PENTACHLOROPHENOL WORKERS

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Introduction

We examined serum dioxin levels among workers in production and use of 2,4,5-trichlorophenol (TCP), pentachlorophenol (PCP), and workers at the same plant without potential for workplace dioxin or furan exposures. The current study provides a rare opportunity to examine congener profiles among workers in TCP and PCP operations and compare these profiles with unexposed workers. Health outcomes studied for these chlorophenol workers at the Midland, Michigan Dow Chemical plant have included chloracne, reproductive outcomes, general morbidity, and mortality.¹ 2,187 males had exposure to TCP, PCP or both from 1937 to 1982²⁻⁴

Materials and Methods

The study included former and current male employees living within 50 miles of the plant. Seventy-two chlorophenol workers were randomly sampled to reflect a 1) history of chloracne and employment in the TCP area, 2) history of chloracne and employment in PCP area, and 3) no history of chloracne and employment in either or both chlorophenol departments. We over-sampled from the chloracne groups to assure we would include workers with high exposure potential. A second group of 72 males was selected who had not been formally assigned to the chlorophenol departments, although some of these workers may have spent undocumented time in the chlorophenol departments doing maintenance and clean-up. We matched them on birth date, and hire date to the chlorophenol department workers to produce similar age and year of hire distributions between groups.

We mailed 144 letters. Eighteen subjects were found to be not eligible for the study, for example, because their current address was outside of the required 50 mile radius of the plant, or they were deceased. Of the remaining eligible 126 subjects, 18 could not be contacted and 3 refused to participate. We scheduled 102 men for a clinic visit, and 99 showed up for the appointment. One participant could not complete the blood draw, resulting in 98 serum samples collected; 52 from the chlorophenol departments and 46 from the non-chlorophenol departments. The participation rate among chlorophenol department workers was 81% (52 of 64) and among non-chlorophenol workers was 74% (46 of 62).

We reviewed the individual job histories for the workers in the non-chlorophenol group and coded jobs of boilermaker, electrician, janitor, machinist, maintenance, millwright, painter, or pipe-fitter with plant-wide responsibility who worked in the plant between 1937 and 1982, the years of chlorophenol operation. We subsequently refer to the 10 workers in the non-chlorophenol departments with potential for chlorophenol exposures as "tradesmen", and the 36 workers in the non-chlorophenol department group without plant wide exposure potential as the comparison group.

We collected, stored and shipped the serum samples to Alta Analytical Laboratory. The analytical procedure followed method 8290 with some minor improvements to estimate the levels for 2,3,7,8-substituted dioxins and furans, and method EPA 1668 to estimate the levels for 4 coplanar polychlorinated biphenyls (PCBs), PCB77, PCB81, PCB126, and PCB169. All results are lipid adjusted. Weight and height were measured at the time the questionnaire was administered to provide an estimate of body mass index (BMI), or height in meters divided by weight in kilograms squared. We summed the 2,3,7,8-substituted Hexa-CDD, Penta-CDF, Hexa-CDF, and Hepta-CDF isomers and the PCBs for statistical evaluation. A questionnaire was administered at the time of blood draw to collect information on occupational exposures outside of Dow, and dietary and smoking habits. We used duration of time worked in TCP or PCP in conjunction with workplace estimated exposure for lower and higher chlorinated dioxins and furans used in previous Dow studies⁵ to categorize workers as mostly TCP or mostly PCP exposures. Multiple regression analyses were used to find the important predictors of the various congener specific dioxin levels. Least square means adjusting for age, body mass index, and other jobs with potential dioxin exposures were used to compare groups. We estimated serum dioxin levels for 2,3,7,8-TCDD to the time of last workplace exposure by assuming a 7 year half-life, and employing a model proposed by Aylward et al.⁶

Results and Discussion

We found age, BMI, and jobs outside of Dow with potential dioxin exposures were important predictors of serum dioxin levels. The least square means for three exposed groups and the comparison group adjusted for age, BMI, and other dioxin exposures are shown in Table 1. The 16 trichlorophenol workers have highest levels of 2,3,7,8-TCDD (30.7 ppt) of any group. For the 16 TCP workers, 2,3,7,8-TCDD and the 2,3,7,8-TCDD toxic equivalents (TEQ-WHO) were both significantly higher than the comparison group. However, no other congener grouping is significantly

different than the comparison group.

The pentachlorophenol workers had 2,3,7,8-TCDD levels (9.3 ppt) slightly higher than the comparison group (6.8 ppt). However, 1,2,3,7,8-Penta-CDD (21.4 ppt), the sum of the 2,3,7,8-substituted Hexa-CDD (250.2 ppt), 1,2,3,4,6,7,8 Hepta-CDD (263.8 ppt), the Octa-CDD (4,017.4 ppt), the sum of the 2,3,7,8-substituted Hexa-CDF (23.4 ppt), and the TEQ-WHO (66.7 ppt) were all significantly higher than the comparison group.

The tradesmen who had potential for exposure throughout the entire site generally had dioxin and furan levels similar to both TCP and PCP workers. The tradesmen had higher 2,3,7,8 TCDD levels (18.2 ppt) than the comparison group. They also had higher 1,2,3,7,8 Penta-CDD (28.5 ppt), the sum of the 2,3,7,8-substituted hexa-CDDs (163.6 ppt), 1,2,3,4,6,7,8 Hepta-CDD (234.6 ppt), the Octa-CDD (2,242.1 ppt), the sum of the 2,3,7,8 substituted Hexa-CDFs (25.9 ppt), and the TEQ-WHO (75.4 ppt) than the comparison group. Unlike the PCP workers, however, the sum of 2,3,7,8 substituted Penta-CDFs (14.5 ppt), and the sum of 4 PCBs (111.2 ppt) were significantly higher than the comparison group.

Thirty of the 52 chlorophenol workers had 2,3,7,8-TCDD levels which were higher than adjusted level for the comparison group of 6.8 ppt. We estimate that the mean level of 2,3,7,8-TCDD present in the serum of these 30 workers on the date workplace exposure terminated was 582 ppt (ranging from 10 to 2,641 ppt) assuming a 7 year half-life, and 1,928 ppt (ranging from 22 to 17,847 ppt) when the toxicokinetic model proposed by Aylward et al. is used.⁶

Table 1. Least-squares means accounting for age, body mass index, and other jobs with potential dioxin exposures among exposed workers compared to unexposed workers.

Congeners in ppt based on lipid concentration	Comparison Group Mean (Range)	Exposed Workers		
		Mostly Trichlorophenol	Mostly Pentachlorophenol	Tradesmen
2,3,7,8 TCDD	6.8	30.7*	9.3	18.2
1,2,3,7,8-PentaCDD	11.8	15.5	21.4*	28.5*
Sum of 2,3,7,8-substituted Hexa-CDDs	92.7	91.6	250.2*	163.6
1,2,3,4,6,7,8 Hepta-CDD	85.0	59.1	263.8*	234.6
Octa-CDD	544.6	266.1	4017.4*	2242.1
2,3,7,8-TCDF	0.4	0.1	0.3	0.4
Sum of 2,3,7,8-substituted PentaCDFs	9.6	9.0	11.1	14.5*
Sum of 2,3,7,8-substituted Hexa-CDFs	17.3	13.9	23.4*	25.9*
Sum of 2,3,7,8-substituted Hepta-CDFs	11.9	16.3	16.5	15.2
OctaCDF	3.2	0.6	0.0	2.5
Sum of 4 PCBs	73.0	75.7	82.3	111.2*
TEQ-WHO for PCDD/F	35.2	62.0*	66.7*	75.4*
Number	36	16	36	10

* Significant < 0.05 than the comparison group using Student's t-test.

Chlorophenol workers in the current study had higher serum dioxin and furan levels than the comparison group. We also were able to distinguish the TCP exposures from the PCP exposures when we took into account potential confounding factors such as age, BMI, and other jobs with potential dioxin exposures. As would be expected, TCP exposure was related to elevated serum 2,3,7,8-TCDD. Similarly, PCP exposure was related to elevated serum 1,2,3,7,8-Penta-CDD, Hexa-CDDs, Hepta-CDDs, Octa-CDD, and Hexa-CDFs levels. The tradesmen in this study had elevated serum dioxin, and furan levels indicating they likely received considerable past exposures from the TCP and PCP departments. These tradesmen shared the dioxin and furan profiles of both TCP and PCP workers. These tradesmen also had the highest PCB levels of any of the groups indicating workplace PCB exposure.

Our study finds dioxin and furan levels among workers with potential chlorophenol exposures above background levels. Very distinctive patterns of dioxins and furans were seen among TCP and PCP workers allowing us to distinguish exposure by department based on the congener profile. Our finding of elevated dioxin, furan, and PCB levels among tradesmen with plant wide responsibilities indicates that the selection of comparison groups and individuals for exposure assessment or health studies must be done carefully.

Reference List

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