PCDDs, PCDFs, AND PCBs IN THE SERUM OF 800 US AIR FORCE VETERANS IN 2002

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Introduction

The Air Force Health Study (AFHS) is a 20-year prospective study examining the health, mortality and reproductive outcomes in US Air Force veterans of Operation Ranch Hand, the unit responsible for the aerial spraying of herbicides, including 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)-contaminated Agent Orange and other herbicides, in Vietnam from 1962 to 1971. Included as referents were the comparison Air Force veterans who flew or serviced transport aircraft in Southeast Asia (SEA) during the same time period and did not spray herbicides. They were matched on age, race and military occupation to Ranch Hand veterans. All veterans were male and 94% were white.[1] The present study presents four main classes of organochlorine compounds used to calculate total TEQs - polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), coplanar or non-ortho substituted polychlorinated biphenyls (cPCBs) and mono-ortho substituted polychlorinated biphenyls (mPCBs) in a large random sample of the AFHS veterans from 2002.

Materials and Methods

Four hundred Ranch Hands and 400 Comparison veterans who attended the 2002 physical examination were randomly selected for the study. Organochlorine compounds were measured in serum by high-resolution gas chromathography/isotope-dilution high-resolution mass spectrometry (HRGC/ID-HRMS) in the dioxin laboratory at the Center for Disease Control and Prevention in Atlanta.[2,3] Summary results based on measurements of 7 PCDDs, 10 PCDFs, 4 cPCBs (#81, 77, 126, and 169) and 6 mPCBs (#118, 105, 167, 156, 157, and 189) are presented. The World Health Organization's Toxic Equivalency Factors (WHO-TEF) were used to report PCDDs, PCDFs, and PCBs Toxic Equivalents (TEQs).[4] For levels measured below the limit of detection we substituted the limit of detection divided by the square root of 2.

Results and Discussion

Basic demographic characteristics for 800 US Air Force veterans are shown in Table 1. Comparison veterans were matched to Ranch Hands on age, race and military occupation. Mean age in 2002, at the time of blood draw was 62 years. The mean serum TEQs for Ranch Hand and Comparison veterans are presented in Figure 1. The PCDDs TEQ in Comparisons was 17.4 pg/g lipid, 5.7 pg/g lipid for PCDFs, 3.9 pg/g lipid for cPCBs, and 10.1 pg/g lipid for mPCBs. In Ranch Hand veterans, the sum of PCDDs TEQ was higher, 24.7 pg/g of lipid, mainly due to elevated TCDD levels, 10.7 versus 3.2 pg/g of lipid (data not shown). Sums of PCDFs, cPCBs and mPCBs TEQs in Ranch Hands were 5.9, 3.6, and 9.1 pg/g lipid, respectively, similar to those measured in Comparison veterans. Consequently, the total mean TEQ was higher in Ranch Hands than in Comparisons, 43.3 versus 37.2 pg/g lipid. The difference in the total TEQ levels basically

reflected the difference in TCDD levels. The percent contribution to the total mean TEQ for the Ranch Hands were 57% PCDDs, 21% mPCBs, 14% PCDFs, and 8% for cPCBs; and 47% PCDDs, 27% mPCBs, 15% PCDFs, and 11% for cPCBs for Comparisons. The percent contribution in Comparisons is similar to that from NHANES data, while Ranch Hands have a higher contribution from PCDDs and lower from cPCBs.[5-6]

In Table 2, we compared PCDDs, PCDFs, and PCBs TEQs in this group of US Air Force veterans with reference ranges from the US general population, based on NHANES 2001-2002 data.[5] We used 90th percentiles and 95% confidence intervals (95% CI) for comparisons due to a large number of measurements below the detection limit for certain PCDD, PCDF, and PCB congeners.[5-6] We calculated 90th percentiles and 95% CIs for two age groups, 40-59 years old and 60+ years old, closely reflecting the AFHS participants age distribution with the median age of 61 years. Comparison veterans in the 40-59 age group had similar total TEQ to that of US male population. 90th percentiles for the PCDDs, PCDFs, cPCBs and mPCBs were also similar. In contrast, Ranch Hand veterans in this age group had more than two times higher PCDDs TEQ and about 50% higher total TEQ than Comparison veterans or the US male population. This corresponds well with the fact that Ranch Hands in the 40-59 years age group were mostly the higher herbicide exposed enlisted ground crew (73.4%), while veterans in the 60+ group were mostly lower exposed enlisted flyers and officers (75.3%). In the 60+ age group, levels found in Comparison veterans or in Ranch Hands were 27% to 43% lower than reference ranges for the US population, reflecting lower average age in Air Force veterans in this age group. However, the difference in PCDD TEQ between Ranch Hands and US male population was small, only about 5%, 40.2 versus 42.5 pg/g lipid. The older age groups had consistently higher TEQ levels for the PCDDs, PCDFs, cPCBs and mPCBs as presented in Table 2 with the exception of PCDDs for Ranch Hand veterans, where the younger age group was the higher exposed group.

These results support the original assumption in the AFHS that background exposures to dioxin like compounds in Ranch Hands and Comparisons would be similar and that the difference in the total TEQs could be attributed to the difference in occupational exposure to TCDD contaminated herbicides sprayed by Ranch Hands in Vietnam. This difference is still evident over 30 years after the end of exposure, particularly in younger, higher herbicide exposed Ranch Hand veterans.

References

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Table 1. Demographic characteristics of US Air Force veterans.

	Comparison	Ranch Hand
Number	400	400
Age in 2002, Mean (SD)	62.3 (7.1)	62.7 (7.2)
BMI in 2002, Mean (SD)	29.1 (4.2)	29.1 (4.4)
BMI at tour, Mean (SD)	24.9 (3)	24.9 (3)
Officers (%)	158 (40)	147 (37)
Flyers (%)	59 (14)	70 (18)
Enlisted ground (5)	183 (46)	183 (46)
Days in Vietnam, Mean (SD)	206 (199)	425 (176)
Days in SEA, Mean (SD)	760 (632)	272 (576)

Figure 1. Means and 95% confidence intervals of PCDDs, PCDFs, coplanar PCBs, and mono-ortho PCBs TEQs in US Air Force veterans in 2002 (pg/g of lipid).

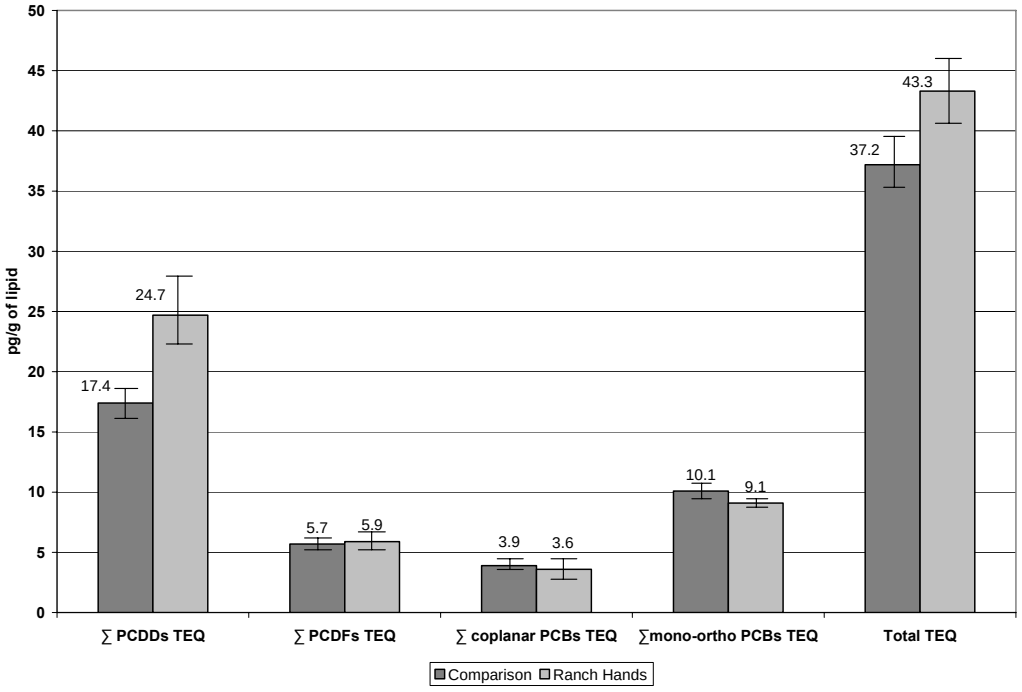

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Table 2. 90th percentiles and 95% confidence intervals of PCDDs, PCDFs, PCBs, and total TEQs in US Air Force veterans and reference ranges from the US general population, males (pg/g lipid).

	90th Percentile (95%CI)					
	Ranch Hand		Comparison		US population, males[1]	
Age (years)	40-59	60+	40-59	60+	40-59	60+
TEQ	(n=173)	(n=227)	(n=171)	(n=229)		
PCDDs	47.8 (38.3-57.2)	40.2 (34.5-44.0)	23.3 (22.0-25.8)	28.7 (27.7-30.9)	19.5 (15.3-24.6)	42.5 (35.0-48.1)
PCDFs	8.9 (7.3-9.7)	10.0 (8.9-10.9)	8.3 (7.5-9.6)	9.4 (8.8-10.5)	9.2 (7.3-11.5)	13.7 (11.8-14.8)
coplanar PCBs	5.2 (4.6-6.2)	6.9 (6.2-8.8)	5.3 (4.5-6.7)	8.1 (7.5-10.5)	5.8 (5.3-6.5)	12.0 (10.2-13.9)
mono-ortho PCBs	12.2 (10.4-14.2)	15.9 (14.3-17.1)	13.4 (11.4-17.0)	17.1 (15.6-18.8)	12.1 (10.8-14.2)	21.3 (18.2-23.1)
Total TEQ	66.6 (59.8-79.8)	66.7 (62.0-74.5)	46.9 (44.5-55.4)	58.9 (55.9-63.4)	44.4 (38.8-49.4)	81.2 (68.7-93.2)

1. Reference #5.