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BRIEF COMMUNICATION

Mortality of Workers Hired During World War II

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There has been some suggestion that men first hired during World War II do not show the typical healthy worker effect and may have been more unhealthy than their counterparts who entered military service. We have studied 41,000 workers at six plants to determine whether men hired during World War II had higher mortality than men hired just before or after WWII. No evidence was found of any "unhealthy WWII worker" effect.

Key words: healthy worker effect, military service, unhealthy WWII worker effect

INTRODUCTION

The issue of whether World War II (WWII) hires show high mortality for nonoccupational reasons could affect interpretation of studies of occupational cohorts in which the exposure of interest occurred primarily during WWII or in which large numbers of workers were hired at that time. Two examples are beryllium workers and workers exposed to halowax, a chloracnegen used during WWII for insulating cable [Levine and Eisenbud, 1988]. In these examples, exposed cohorts are the subjects of ongoing studies at NIOSH (Elizabeth Ward, personal communication). To investigate further possible excess mortality among WWII hires, the mortality of male hourly workers hired before, during, and after WWII was examined in six cohorts previously shown to exhibit no excess mortality due to occupation.

MATERIALS AND METHODS

All NIOSH cohorts were reviewed that had existing computer files in standard format and for which a written report (usually a publication) was available (n = 27). From these, all cohorts were chosen in which there were at least 500 deaths, in which there were no major categories of death for which a significant standard mortality rate (SMR) (compared to the U.S. population) was observed, and in which there were no pronounced positive trends with duration of exposure for any major category of

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deaths. Thus, these were generally "negative" studies. Cohorts were restricted to those in which any minimum length-of-employment criteria used to define the cohort was ≤ 1 year. Ten studies fulfilled these criteria. These ten studies were then further restricted by a requirement that at least 200 men had to have been hired prior to 1940. This left six studies, with the industries represented being automobile, mining, leather, paper and pulp production, shipbuilding, and chemical. The six studies varied widely in size, contributing 2%, 3%, 7%, 12%, 30%, and 45%, respectively, to the total number of workers studied (n = 41, 167). Hence results were highly dependent on the two or three largest studies.

Three separate cohorts were created from the six studies: those hired prior to 1940, those hired during 1940–1944, and those hired in 1945 or later but before 1955. The third cohort was truncated at 1955 so that it not differ so widely in age and calendar time from the other two cohorts yet would have a comparable number of deaths. Analyses were restricted to hourly male workers (most cohorts were composed uniquely of hourly workers). One study (the chemical plant study) excluded workers who ended employment prior to 1940 because of the relative difficulty of determining their vital status. This meant that, at that plant, the workers hired before 1940 had to have worked until 1940, and hence generally were workers of longer duration.

Causes of death considered here included all causes mortality and mortality from all cancers (ICD 140–208, 9th revision), from lung cancer (ICD 162, 9th revision), from ischemic heart disease (ICD 410–414, 9th revision), from stroke (ICD 430–438, 9th revision), from diabetes (ICD 250, 9th revision), from nonmalignant respiratory disease (ICD 460–466, 470–478, 480–487, 490–519), from all external causes (ICD 800–978, 9th revision), from transportation accidents (ICD 800–848, 929.0–929.1, 9th revision), from homicide (ICD 960–978, 9th revision), from alcoholism (ICD 303, 9th revision), from cirrhosis (ICD 571, 9th revision), and from rheumatic heart disease (ICD 390–398, 9th revision). These causes were chosen either 1) because of a priori interest based on two prior publications [Bond et al., 1989; Wen et al., 1986] (external causes, homicide, transportation accidents, alcoholism, cirrhosis) or 2) because they represented major categories of death (e.g., all deaths, all cancers, lung cancer, heart disease), or 3) because they were causes of death that might be expected among those who were unhealthy and therefore excluded from military service (e.g., rheumatic heart disease, diabetes, nonmalignant respiratory disease).

SMR analyses based on person-years were conducted using the NIOSH life table system [Steenland et al., 1990]. Person-years were stratified by age and calendar time by 5-year intervals and by race (white vs. nonwhite). Deaths were coded into the ICD revision at time of death and then grouped into NIOSH death categories. U.S. male mortality rates (1940–1989) were used as referent rates. Only general work histories (first and last employment dates) were considered, and gaps in employment were ignored (several of the larger cohorts lacked detailed work histories). Person-years for individuals from each cohort generally began at date first employed or 1940, which ever was later. For the three cohorts that had a required minimum length of employment, person-years began only after the minimum was fulfilled. Two cohorts (paper and pulp workers, shipyard workers) had as requirements for cohort entry employment between 1945 and 1955 and employment as of 1952 or later, and, for these cohorts, person-years could not begin prior to these dates. Person-years

TABLE I. Description of the Three Cohorts

	Hired before 1940	Hired 1940–1944	Hired 1945–1954
Number	8,049	13,276	19,842
Deaths (%)	4,392 (55)	4,766 (36)	4,301 (22)
Person-years (pyrs) total	222,222	357,646	522,114
Percent pyrs with >20 years from first hire	67	46	31
Percent pyrs with >20 years duration	50	26	11
Percent pyrs actively employed	46	41	42
Average age at hire (years)	28	30	29
Average employment (years)	27	17	11
Average age at death (years)	67	63	59
Average years of follow-up	40	32	27
Average year of hire	1931	1942	1949

continued until the study end date (which varied from study to study) or the date last observed, which ever was earlier.

By way of confirmation of the SMR analyses using the U.S. population as the referent, Poisson regression was used to compare the mortality of the three date-of-hire cohorts directly to each other for all causes, all cancers, and heart disease [Frome and Checkoway, 1985]. These analyses avoided the problem of comparing indirectly standardized SMRs and avoided the use of an external referent population, among whom the healthy worker effect would be expected to play a role for all year-of-hire subcohorts.

RESULTS

Table I describes the three year-of-hire cohorts (hired before WWII, during WWII, and after WWII). The three cohorts were similar regarding the number of observed deaths and the average age at hire. As expected, average length of follow-up and average age at death diminished as year of hire increased. Average duration of employment decreased as year of hire increased, largely the result of 1) the "cross-sectional" study definition at two plants in which current employment at a given point in time (1945–1955 and 1952) was required for cohort entry and 2) the exclusion at one plant of workers who terminated employment prior to 1940. These restrictions meant that those hired before or during WWII at these three plants generally needed to have relatively long durations of employment to have been included in the studies.

Table II shows the results for the three cohorts by cause of death. It is clear from Table II that neither the all-cause mortality nor any cause-specific mortality is particularly increased in the WWII hires compared to either those hired before WWII or those hired afterwards.

In general, all three cohorts show similar SMRs for most causes considered. One exception is nonmalignant respiratory disease, for which the SMRs increase with year of hire. This trend, which is reflected to a lesser degree for lung cancer, is possibly the result of increased smoking after WWII by a blue collar work force vs. the general population.

TABLE II. Observed Deaths and SMRs for Selected Causes*

	Hired before 1940		Hired 1940–1944		Hired 1945–1954	
	Deaths	SMR	Deaths	SMR	Deaths	SMR
All causes	4,392	0.92	4,766	0.95	4,301	0.94
All cancers	901	0.99	906	0.93	840	0.93
Lung cancer	248	0.94	298	0.98	304	1.02
Ischemic heart disease	1,704	0.94	1,828	0.99	1,506	0.96
Cerebral vascular disease (stroke)	344	0.86	318	0.89	232	0.87
Rheumatic heart disease	33	0.69	35	0.61	32	0.59
Nonmalignant respiratory disease	216	0.71	263	0.89	240	0.98
External causes	245	0.84	361	0.86	514	0.91
Motor vehicle accidents	70	0.73	129	0.86	194	0.87
Homicide	13	0.85	22	0.83	37	0.76
Alcoholism	8	0.68	14	0.80	19	0.84
Cirrhosis	75	0.87	96	0.79	108	0.77
Diabetes	48	0.68	31	0.55	48	0.75

*See text for ICD 9th revision codes.

Poisson regression results generally upheld the SMR findings shown in Table II. After correction for age, calendar time, race, and length of follow-up, no significant differences between the mortality rates for the three hire groups were found for all causes, all cancers, or heart disease.

DISCUSSION

The results presented here are based on a large study population (1,208,149 person-years, 13,468 deaths) from six plants. While results were highly dependent on the two or three larger plants (a chemical plant, a shipyard, and a pulp and paper plant), results across plants were consistent and no plant showed any pronounced excess for WWII hires vs. prewar or postwar hires. However, the study population may or may not be representative of WWII workers as a whole. For example, our study population was based on workers at large plants.

The two prior studies of men hired during WWII were somewhat smaller than this one but were nevertheless based on large study populations [Wen et al., 1986; Bond et al., 1989]. Both these prior studies were limited to single worksites (an oil refinery and a chemical plant). Wen et al. [1986] compared the mortality of 3,330 white male workers hired at an oil refinery during WWII to the mortality of workers hired at the same plant before 1940 (n = 4,079) and after 1945 (n = 5,117). The WWII hires failed to show the typical healthy worker effect when compared to the U.S. population (all-causes SMR = 1.00), unlike the prewar cohort (SMR = 0.84) and the postwar cohort (SMR = 0.73). The higher mortality among the WWII hires was primarily to due an excess in external causes (SMR 1.23; 131 deaths, primarily due to homicide, accidents, and motor vehicle accidents) and alcoholism (SMR 5.78; 13 deaths). The authors speculated that the excess mortality from external causes and alcoholism among the WWII hires was due to lifestyle factors and might have been

the result of WWII hires being less healthy than the general population (i.e., unfit for military duty).

Bond et al. [1989] provided further data in studying the mortality of 37,682 male chemical workers hired during WWII, 5,231 workers hired before 1941, and 23,942 workers hired after 1945. These workers failed to show the same excess mortality for WWII hires seen by Wen et al. [1986]. The all-causes SMRs for those hired before 1941, during 1941–1945, and after 1945 were 0.97, 0.95, and 0.88, respectively. The causes of death that were elevated for WWII hires in the data of Wen et al. [1986] generally failed to show such elevations in the data of Bond et al. [1989].

In our data, SMRs for men hired during WWII were similar to SMRs for men hired either before or after WWII, regardless of the specific cause. Direct comparisons between cohorts hired at different times yielded similar results. In conclusion, our analyses do not support the hypothesis that WWII hires were less healthy than those hired before or after the war.

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