Mortality of welders and other craftsmen at a shipyard in NE England

MURIEL L NEWHOUSE, D OAKES, AND AJ WOOLLEY

From the TUC Centenary Institute of Occupational Health, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK

ABSTRACT Personnel records of over 1000 welders and electricians but only 235 caulkers and 557 platers employed at a shipyard in NE England between 1940 and 1968 were obtained and the mortality followed up to December 1982. The observed number of deaths (13 from mesothelial tumours, nine among the electricians) were compared with the number to be expected in the Newcastle conurbation. Welders and caulkers were most exposed to welding fumes, electricians to asbestos. The study was limited by the lack of accurate job exposure details, and there was no record of smoking habits, but welders and caulkers showed a higher standardised mortality ratio for all causes, lung cancer, ischaemic heart disease, pneumonia, and accidents than platers and electricians.

For the past 10-15 years there has been concern about a possible excess of respiratory disease and lung cancer among welders. This concern relates to both acute and chronic respiratory disease, and cross sectional studies have indicated that welders, particularly smokers, are more prone to respiratory disease than their controls.^{1,2} Increased risks of lung cancer have been found in several studies of welders.³⁻⁵ Currently, the role of chromium (CrVI) and nickel, which are found in the fume in stainless steel welding, is the main focus of interest, but previous mortality studies of mild steel workers in the United Kingdom have not given definitive information.

In 1980 a set of personnel records from a shipyard in NE England containing identification and brief job details of workers employed between 1940 and 1968 became available. It was decided to undertake a historical mortality study, although it was recognised that detailed information on important confounding factors—namely, smoking and exposure to asbestos—was lacking.

At a meeting with the current management of the shipyard and representatives of the unions the aims of the investigation were explained and their cooperation obtained.

Selection of population for study

The records of four groups of craftsmen only were selected: welders, caulker burners, platers, and electricians. We assumed that all these workers, of similar socioeconomic status, would have similar smoking habits, and that comparison of the four groups would clarify the effects of exposure to both welding fume and asbestos.

Work practices in the shipyard

In the late 1940s and early 1950s welding was established as the main method of ship construction. Before this ships' hulls had been riveted or bolted together, welding playing a minor part in the fitting out process. The basic construction of a ship is the province of boilermakers—that is, welders, caulker burners, platers, and shipwrights, who measure, cut, assemble, and weld steel plates to form the shell. Once this basic structure is complete, the ship is fitted out with the services required to make it functional and habitable.

Welding fume composition

Rutile welding electrodes were widely used in ship construction during the period. The constituents of the electrode are unlikely to have changed appreciably over the years. Any differences in the components of welding fume could be attributed to the

Table 1 *Important fume constituents*

Zinc (from primers)
Fluorides (low hydrogen electrodes)
Nickel
Lead
Chromium
Iron oxide
Cobalt
Copper
Manganese
Vanadium
Nitrogen dioxide ²
Ozone
Carbon monoxide

increased use of basic (low hydrogen) electrodes introduced in the late 1950s. Much welding was on unprimed steel. Nevertheless, lead and zinc in primed steel and zinc from galvanised steel would at times have been an additional fume component. There is evidence that stainless steel welding did occur but on a small scale. Important constituents of welding fume are given in table 1⁶ and typical measurements in the 1960s in the north east shipyards in table 2.⁷ These measurements collected as part of a special investigation of zinc and other possible hazardous components of fume show levels of iron oxide in a variety of situations in the late 1960s. Iron oxide was the fume constituent most commonly measured and was at the time compared with the recommended exposure limit for iron oxide of 10 mg/m³. The levels of total welding fume, the parameter most commonly measured nowadays to compare with a current recommended exposure limit of 5 mg/m³, would have been correspondingly higher.

No data are available for the 1950s, but there is no doubt that in confined spaces, without the provi-

sion of exhaust ventilation (introduced in the 1960s), exposure would have been greater.

Exposure to welding fume

Those with the highest exposure to fume would have been the welders themselves. Individual exposures would have depended on whether welding on the ships' hull took place in a confined space, in the open air, or in the workshops. Some welders were seconded to service the needs of the fitting out trades where exposures were probably lower.

Platers whose task is to mark and position steel plates ready for welding would also have been exposed to fume if working in the vicinity of a welder. The level of exposure would have been lower by comparison with that of welders. Caulkers, originally involved in producing water tight joints and later in edge preparation for welding, would have been similarly exposed. Importantly, however, the tasks of burning and oxypropane cutting became associated with the caulking trade. Thus many of the caulker burner group would have been exposed to fume from cutting, similar in magnitude and composition to welding fume, and often containing higher levels of nitrogen dioxide. This would be tempered in that most burning was apparently carried out in workshops or open air rather than in confined spaces.

Electricians are one of the fitting out trades and may, on occasion, have been exposed to weld fume, but probably to a lesser extent than the other groups. A subjective ranking of the four groups in terms of level/degree of exposure to welding fume would therefore be: (1) welders, (2) caulker burners, (3) platers, (4) electricians, although individual

Table 2 *Environmental measurements in north east shipyards in the 1960s. (From report on shipbuilding and ship repair⁷)*

Rutile welding of zinc coated and non-zinc coated steel. Mean levels of iron oxide in mg/m ³ (range in parentheses)					
		General atmosphere Av level (No samples)		Personal respirimeter* Av level (No samples)	
A	Total	6.3 (0.1-56.0)	(37)	13.6 ($<0.1-60.0$)	(31)
B	Confined and semiconfined spaces	9.3 (0.1-56.0)	(23)	15.6 ($<0.1-60.0$)	(23)
C	Open air and workshop	1.5 (0.1-3.7)	(14)	7.8 (0.3-26.8)	(8)
D	Confined and Semiconfined spaces	Ventilation 1.7 (0.1-7.5)	(15)	8.4 (0.1-29.0)	(16)
E		Without ventilation 23.6 (1.4-56.0)	(8)	31.9 (3.0-60.0)	(7)

*Non-standard measurement technique using a converted respirator.

caulker burners might have suffered higher exposure than some welders.

Other airborne contaminants

Other contaminants likely to be encountered were smoke from the coke fires used in the early days to heat rivets and asbestos. Asbestos insulation was installed extensively throughout ships in the engine and boiler rooms, around the pipework, and in the ventilation systems to the accommodation areas. This work formed part of the fitting out activities. Of the four groups in the study, the electricians probably received highest exposure to asbestos, either through being in the vicinity of asbestos ladders or through having to disturb insulation to complete their own work. Those welders who were seconded to the fitting out trades may also have been exposed on occasion. All three main types of asbestos were probably used throughout the whole period but particularly in the 1940s and 1950s.

Methods

The personnel cards of all those recorded in the four selected occupations were abstracted by shipyard personnel and sent to the TUC Centenary Institute. Identification details, job title, and dates of first and last employment at the yard were entered on to code forms suitable for computer analysis and for search purposes by the Office of Population Censuses and Surveys. The file contained a few women who were excluded from the study. Further checks were carried out to eliminate cards with incomplete information and duplicates.

Vital status was ascertained through the NHS Central Registry at Southport, the Central Register of the DHSS, and the Scottish and Northern Irish Registries. We received copies of death certificates with underlying cause and other mentions coded according to 8th revision of the International Classification of Diseases.⁸ The survivors of the study population have been flagged at Southport, so that death notifications will continue to be received. The closing date for the present analysis is December 1982.

Table 3 *Standardised mortality ratios for welders based on population for England and Wales, and for Newcastle conurbation*

	England and Wales	Newcastle
All causes	147	114
Lung cancer excluding mesothelioma (ICD 162-163)	191	113
Pneumonia (ICD 480-486)	269	184
Bronchitis emphysema, and asthma (ICD 490-493)	164	85
Ischaemic heart disease (ICD 410-414)	155	130
Accidents	132	115

For each of the four occupational groups, observed deaths from all causes and from certain specific causes were tabulated. "Expected" deaths were calculated following the method of Hill.⁹

Thus man-years were accumulated within five years age/time subdivisions, starting for each man with the date of his first employment at the shipyard and ending at (the earliest) of his death, or emigration, or the close of the study.

As mortality from many causes, particularly from lung cancer, is raised in the Newcastle area as a whole, two sets of figures for expected deaths were calculated, using rates from England and Wales and for the Newcastle area respectively. The Newcastle rates were found by applying an age specific correction factor calculated from the (cause specific) mortality rates for the Newcastle on Tyne conurbation,¹⁰ given in the 1969-73 decennial supplement¹¹ of area mortality.

It became clear from examination of the original records and discussion with shipyard personnel that most craftsmen were not employed continuously at the same yard but would move from yard to yard as work in their trade became available. Although the records analysed appeared to provide a complete and accurate history of employment in the particular yard studied, they could provide only incomplete detail about the total work experience of any man. Thus we could not reliably estimate total employment duration or even the date of first employment in the trade. Accordingly the tabulations are presented here without regard for duration of employ-

Table 4 *Status of population at December 1982*

	Alive	Emigrated	Dead	Untraced	Total
Welders	784	53	195	5	1027
Caulkers	183	2	50	1	235
Platers	445	24	87	1	557
Electricians	1385	64	211	10	1670
Total	2734	143	543	17	3489

Table 5 Standardised mortality ratios for four groups of craftsmen

	Welders		Caulkers		Platers		Electricians	
No	1027		235		557		1670	
Man-years	26541.8		5792.2		13626.7		41974.6	
	<i>O</i>	<i>E</i>	<i>O</i>	<i>E</i>	<i>O</i>	<i>E</i>	<i>O</i>	<i>E</i>
All causes	195	171.6	50	38.2	87	90.5	211	257.8
SMR	114	(100,127)*	131	(100,161)	96	(79,113)	82	(73,91)
All neoplasms	49	47.7	18	10.7	28	25.1	78	70.9
(including mesothelioma)								
SRM	103	(79,127)	168	(109,249)	111	(79,153)	110	(90,130)
Lung cancer	26	22.9	12	5.2	12	12.1	35	33.6
(excluding mesothelioma)								
(ICD 162-163)								
SMR	113	(80,157)	232	(133,374)	100	(57,161)	104	(75,133)
Mesothelioma	1		1		2		9	
Pneumonia (ICD 480-486)	10	5.4	2	1.2	1	3.0	3	8.3
SMR	184	(100,314)	165	(30,525)	33	(2,158)	36	(10,93)
Bronchitis, emphysema, and	9	10.6	4	2.4	1	5.8	7	16.0
asthma (ICD 490-493)								
SMR	85	(44,148)	164	(57,381)	17	(1,82)	44	(21,82)
Ischaemic heart disease	66	50.7	14	11.2	24	26.5	64	75.1
(ICD 400-414)								
SMR	130	(104,156)	125	(75,195)	90	(64,127)	85	(68,103)
Accidents (ICD EXVII)	18	15.6	8	3.4	9	8.1	16	24.4
SMR	115	(74,171)	233	(117,424)	112	(58,194)	66	(41,100)

* () 90% Confidence limits on SMR.

ment or latency.

The standardised mortality ratio was calculated in the usual way as a percentage of observed to expected deaths. Two sided 90% confidence limits were calculated using the expectation of a Poisson variable.

Results

All but 97 of the subjects were traced by the National Health Central Register. Subsequent tracing exercises by the Central Register of the DHSS and the Scottish and Irish Central Registers has reduced the number of untraced men to 17, with an overall trace rate of 99.5%. Approximately 15% of the workforce have died (table 4).

Examination of the population according to the date of birth showed that 56.5% of the welders and caulkers and 64% of the platers and electricians were born after 1925, and so are still under 60. Approximately 65% of the population has been followed up for over 20 years.

MORTALITY

There were 13 deaths from mesothelial tumours, nine among electricians, two among platers, and one each among welders and caulkers. All but one were known to the Newcastle Pneumoconiosis Panel, and full occupational histories were obtained.

Table 5 shows the mortality for all causes and certain selected causes of death. In the smaller groups, particularly the caulkers, the number of deaths is small and confidence limits of the SMRs

are wide, and the results must be interpreted with caution. Nevertheless, the SMR for all causes for welders and caulkers is significantly raised even above the Newcastle figures, which are already high compared with national rates, whereas it is below 100 for platers and electricians. Combining the welders and caulkers, the excess of deaths from lung cancer is also significant whereas among the electricians, despite the asbestos effect shown by the nine deaths from mesothelial tumours, the SMR is 104. Welders and caulkers also show a raised mortality from pneumonia not shown by the other two groups. But here again the number of deaths is small, and confidence limits indicate that the SMR does not give a reliable estimate of the relative mortality in this instance. This table also shows an excess mortality from ischaemic heart disease among welders and caulkers, as well as a greater number of accidents than would be expected in these two trades.

Discussion

The distribution of deaths from mesothelioma among the four groups of workers in the shipyard suggests that as was found in the Naval Dockyard in Plymouth¹² the electricians were at an increased risk of asbestos related disease. Cancer of lung is also asbestos related¹³ but the SMR for lung cancer at 104 was only slightly raised among the electricians, a similar finding to that of Rossiter and Coles¹⁴ in Devonport. The welders show an overall SMR for lung cancer of 113. Among caulkers there were 12

deaths from this cause with 5.2 expected, SMR 232. Beaumont and Weiss quote 11 studies of welders, only five of which show a significantly raised relative risk for lung cancer.³ The present study shows suggestive but not conclusive evidence of a raised risk, there is no information on smoking habits, and the degree of exposure to asbestos is uncertain. Caulkers also have a high SMR for lung cancer, but the interpretation of these results in view of the smallness of the group and the wide confidence interval is difficult but suggestive of some adverse influence operating during the period. The welders and caulkers also show raised SMRs for pneumonia. In general welders and caulkers apart from the mortality from mesothelial tumours fare worse than platers and electricians. Overall, 15.7% of the population have died. The number of deaths may be expected to accelerate during the coming years and the study will continue.

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