J Occup Health 2003; 45: 36–42

Journal of Occupational Health

Mortality among Former Shipbreaking Workers —A 13-Year Retrospective Follow-up Study in Taiwan

Yi-Kuen LIU[1], Guang-Yang YANG[2], Trong-Neng WU[2], Ruey S. LIN[3] and Fung-Chang SUNG[1]

[1]Institute of Environmental Health, National Taiwan University College of Public Health, [2]Institute of Occupational Safety and Health, Kaohsiung Medical University and [3]Institute of Preventive Medicine, National Taiwan University College of Public Health, Taiwan

Abstract: Mortality among Former Shipbreaking Workers – A 13-Year retrospective Follow-up Study in Taiwan: Yi-Kuen LIU, *et al.* Institute of Environmental Health, National Taiwan University College of Public Health, Taiwan—This study examined the mortality among shipbreaking workers from 1985 to 1997, after the shipbreaking industry was banned in 1985–1986. The study cohort consisted of men including 2,850 flame cutters, 871 lifters, 240 odd-jobbers and 225 other workers registered in 1985 at Kaohsiung Shipbreaking Workers Union. Mortality (n=336) data examined were obtained from the Vital Statistics Registry from January 1985 to December 1997. The standardized mortality ratio (SMR) and logistic regression were used to estimate the risk of mortality from neoplasms, injuries and other causes. Compared to the local reference population, the deaths that were significantly higher than the expected numbers among all workers included deaths from all cumulative causes (SMR=1.11, 95% confidence interval (CI)=1.00–1.23), and deaths from external causes of injury and poisoning (SMR=1.75, 95% CI =1.47–2.09). Flame cutters in the youngest group, on the other hand, had very significant excess deaths from nasopharynx neoplasm (SMR=5.2, 95% CI=1.7–16.2) and pleural neoplasm (SMR=104.1, 95% CI=14.0–739.0). Based on logistic regression analysis controlling for age, lifters was about 5.1 more likely times than flame cutters to die from accidental falls. This study suggests that former shipbreaking workers are more likely to be at higher risk of injuries and the young flame cutters are at higher risk from neoplasms. *(J Occup Health 2003; 45: 36–42)*

Key words: Shipbreaking industry, Standardized mortality ratio, Retrospective study, Taiwan

Received April 12, 2002; Accepted Oct 12, 2002
Correspondence to: F.-C. Sung, Institute of Environmental Health, National Taiwan University College of Public Health, 1 JEN-Ai Road Sec. 1, Taipei 100, Taiwan

Shipbreaking was once an important industry for steel recovery in several developing nations, such as Taiwan and other Asian countries. This industry involves the process of dismantling steel from the ship by using torches and lifting tools. Workers were exposed to dusts and fumes containing chromium, nickel, lead and asbestos, etc., similar to shipyard workers decades ago. This process may have exposed workers to increased risk of injury, as well as cancer.

Several epidemiology studies have investigated exposure to welding fumes and the development of cancer[1–9]. Some studies found that shipyard welders exhibited a higher incidence of lung cancer than selected reference populations[10, 11], whereas others did not have these findings[9, 12]. Asbestos and smoking were potential confounders in most of these studies. Peto[13] suggested that welders in general exhibit approximately a 30 % higher risk of lung cancer (than the non-welding population) that was not ascribed to smoking or other occupational hazards.

While some studies on health effects of shipbuilding activities have been published, little information is available on shipbreaking employees. A preliminary study incorporating statistics of Kaohsiung City in 1984 and 1985 revealed that, among 86 serious occupational accidents, 27 occurred in the shipbreaking industry with an overall mortality rate from accidents of 2.1 per 1,000 person-years[14]. There has been no investigation of health outcomes for former shipbreaking employees. The purpose of this study was to assess the mortality pattern among former shipbreaking workers. We assumed that this type of employment might have a residual effect in that workers may continue employment in other high-risk industries.

Background of the Shipbreaking Industry

Taiwan's shipbreaking industry has a history of more than thirty years. This industry started in 1949 when the

island nation was in urgent need of steel for construction after World War II and the Civil War in China, which resulted in the Chinese Nationalist government moving to Taiwan from the Chinese mainland. Because of the demand for steel and the lack of a steel industry, dismantling coastal ships and riverboats became a means of steel recovery. In parallel with economic development and industrialization in Taiwan there was continued growth in the shipbreaking industry. When old riverboats and coastal ships available in Taiwan had been dismantled, shipbreakers imported aging ships from other countries to continue the steel recovery business; shipbreaking teams were able to dismantle a 30,000-ton tanker in as short a time as six weeks. In the 1960s, Taiwan became the world's largest shipbreaker with approximately 65 % of the obsolete ships in the world recovered in Taiwan, accounting for three million tons of ships annually.

Since Kaohsiung has the largest harbor in Taiwan, it was also the island's shipbreaking center with most of the workers from local areas including Kaohsiung County, Kaohsiung City and Pintung County. Although they were among the lower educated citizens in the population, they were skilled at dismantling ships efficiently and economically. These shipbreakers were at a higher risk from injury and exposure to substances generated from the shipbreaking activities. During Taiwan's economic development in the 1980s, the government came to discourage and finally ban the shipbreaking industry for the purpose of disease and accident prevention.

Methods

The study cohort was limited to the registered members of Kaohsiung Shipbreaking Workers Union, as of 1985, when the government in Taiwan started to ban the shipbreaking industry. Registration was established once an individual was employed in the shipbreaking industry for the purpose of joining in the government supported Labor Insurance System. The information available from the register included name, address, birth date, citizenship identification number (ID), and job title during the employment period. Death certificates in Taiwan have been registered and computerized since January 1, 1971, but the death information could not be extracted with the ID until January 1, 1985. This study used the existing computerized records of shipbreaking workers obtained from the Kaohsiung Union and the mortality files obtained from the Department of Health. Each individual's citizenship ID and birth date were used to link these two files. Death records from January 1985 to December 1997 were searched in a follow-up manner. In general, the work forces involved in the shipbreaking industry consisted of flame cutters, lifters, odd-jobbers and supervisors.

The major workforce in the shipbreaking industry consisted of flame cutters, using oxygen acetylene arc torches to cut the steel from the ship. Lifters separated and sorted the steel pieces with lifting equipment. Odd-jobbers cleared the cabin and dismantled the asbestos materials, glass-fibre and inflammables, etc. The remaining occupations included supervisors (experienced workers), knockers (to knock or dismantle), administrators, drivers and discriminators (to discriminate the separated steel pieces for marketing). The flame cutters and lifters were assumed to be at higher risk of injury due to the physical nature of their jobs.

We classified underlying causes of death in accordance with vital statistics of the Department of Health, Taiwan that were in accordance with the rules and conventions outlined in the International Classification of Diseases, Ninth Revision (ICD-9)[15]. The underlined causes of death included in the analyses were for neoplasms, the circulatory system, respiratory system, digestive system, and external causes of injury and poisoning. We also focused our interest on a few specific causes of neoplasms and injuries. Workers who survived between January 1, 1985 and December 31, 1997 contributed the person-years time. Those known to have deceased before the cutoff date contributed the person-year time between January 1, 1985 and their date of death.

We computed the age-adjusted standardized mortality ratio (SMR), the ratio of observed to expected number of deaths estimated from the mortality rate of the reference population. The populations of Kaohsiung County, Kaohsiung City and Pintung County were used as a reference group because most workers were hired from these three areas. The observed and expected numbers of deaths were summed across strata. SMR was measured first by the worker's job title to identify more deaths reported for some causes and external causes of injury and poisoning. Age-specific SMR measurements were then conducted for these causes. Further analysis used age-adjusted logistic regression models to observe the relative risks for selected causes of death among groups including flame cutters, lifters, odd-jobbers and supervisors/others. The odds ratio (OR) and 95% confidence interval (CI) were calculated using the job group with the lowest mortality as the reference group in each regression model.

Results

The sample used for analysis included 4,186 (83.8%) men identified with complete data from an eligible list of 4,994 individuals in the Kaohsiung Shipbreaking Workers Union covered in the Labor Insurance System in 1985. Female workers (n=808) were excluded from this study because of the relatively smaller population size and low mortality (n=31). The number of male workers at risk and the number of follow-up person-years, and mortality are summarized in Table 1 by workers' job

Table 1. Baseline data for male shipbreaking workers in 1985, follow-up person-years at risk, and mortality until 1997 by job title

	Flame Cutters	Lifters	Odd-jobbers	Supervisors/Others	Total
Number	2,850	871	240	225	4,186
Follow-up person-years	35,943	10,775	2,856	2,789	52,363
Average age in 1985	33.0	36.2	45.9	41.8	34.9
Range	17–63	17–64	18–65	23–66	17–66
Average age at death	43.6	44.9	55.0	53.7	45.9
Range	23–71	21–66	26–71	38–67	21–71
Death					
No.	189	87	42	18	336
Rate (%)	6.6	10.0	17.5	8.0	8.0
Rate per 10,000 person-year	52.6	80.7	147.1	64.5	64.2

ps: Supervisors/others include knockers, administrators, drivers and discriminators.

Table 2. Cause-specific standardized mortality ratio (SMR) for male shipbreaking workers by job title

Causes of death (ICD code)	Observed No.	SMR	(95%CI)
All causes (000–999)	336	1.11 *	(1.00–1.23)
Infectious and parasitic diseases (001–139)	11	1.04	(0.58–1.88)
Neoplasms (140–239)	65	0.89	(0.69–1.13)
Circulatory system (390–459)	47	0.80	(0.60–1.07)
Respiratory system (460–519)	9	0.65	(0.34–1.26)
Digestive system (520–579)	40	1.12	(0.82–1.52)
External causes of injury and poisoning (E800-E988)	124	1.75 ***	(1.47–2.09)
Others	40	1.03	(0.75–1.40)

ps: 1) The expected numbers were calculated using southern Taiwan (Kaohsiung County, Kaohsiung City and Pintung County) death rates, with adjustment for age.
2) others: all the causes of death except infectious and parasitic diseases, neoplasms, circulatory, respiratory, digestive system, injury and poisoning death.
3) *P<0.05, **P<0.01, ***P<0.001

title in 1985. The male cohort consisted of 2,850 flame cutters (68.1%), 871 lifters (20.8%), 240 odd-jobbers (5.7%) and 225 (5.4%) supervisors/other workers, with observed person-years ranging from 2,789 person-years for supervisors to 35,943 person-years for flame cutters in the follow-up period. Flame cutters and lifters were younger, averaging 33.0 yr and 36.2, respectively in 1985, and odd-jobbers and supervisors/others were older, averaging 45.9 yr and 41.8 yr, respectively. The average age at deaths range from 43.6 yr for flame cutters to 55.0 yr for odd-jobbers. The odd-jobbers had the highest mortality rate (147.1 per 10,000 person-years), about 3 times higher than for flame cutters (52.6 per 10,000 person-years) during the follow-up period, 1985–1997.

Compared to the reference population mortality rate, overall deaths from all causes that all shipbreaking workers experienced was slightly but significantly higher than expected (SMR=1.11, 95% CI=1.00–1.23) (Table2). Cause-specific mortality showed that there was insignificantly lower mortality from neoplasms, diseases of the circulatory and respiratory systems, and insignificantly higher mortality from diseases of the digestive system. Deaths from external causes of injury and poisoning were higher than expected (SMR=1.75, 95% CI=1.47–2.09).

Further age-specific analysis showed that most cancer SMR values were not significant for the study population, except for nasopharynx cancer (SMR=5.2, 95% CI=1.7–16.2) and pleura mesothelioma (SMR=104.1, 95% CI=14–739) for the 20–39-yr-old workers (Table 3). The SMR values for accidental falls and industrial accidents were highly significant for all age groups. The highest SMR for accidental falls was found for the youngest group (SMR=5.6, 95%CI=3.1–10.1), and the highest SMR for

Table 3. Age-specific observed deaths and standardized mortality ratios (SMR) from cancer and external causes of injury and poisoning by underlying cause for male shipbreaking workers

	Age (person-years)														
	20–39 yr old (37,857)			40–49 yr old (9,259)			50–59 yr old (4,141)			60+ yr old (461)			All (51,718)		
Cause of Death (ICD code)	Obs	SMR	95% CI	Obs	SMR	95% CI	Obs	SMR	95% CI	Obs	SMR	95% CI	Obs	SMR	95% CI
Cancer															
Nasopharynx (147)	3	5.2*	(1.7–16.2)	2	1.1	(0.3–4.3)	2	1.4	(0.4–5.7)	0			7	1.5	(0.7–3.2)
Tongue, Mouth, Lip, Oral Cavity and Pharynx (141, 145, 149)	1	1.9	(0.3–13.4)	4	1.8	(0.7–4.7)	1	0.8	(0.1–5.4)	1	2.6	(0.4–18.3)	7	1.3	(0.6–2.8)
Colorectum (153, 154)	1	2.2	(0.3–16.0)	0			3	2.6	(0.9–8.2)	2	1.3	(0.3–5.1)	6	1.4	(0.7–3.2)
Liver, Primary (155)	2	0.9	(0.2–3.7)	10	1.4	(0.8–2.6)	4	0.6	(0.2–1.5)	4	0.9	(0.4–2.5)	20	0.9	(0.6–1.4)
Trachea, Bronchus and lung (162)	0			3	1.6	(0.5–5.1)	3	1.1	(0.3–3.3)	6	1.3	(0.6–2.9)	12	1.3	(0.7–2.3)
Pleura (163)	1	104.1*	(14–739)	0			0			0			1	27.2*	(4–193)
External causes of injury and poisoning (E800-E988)															
Traffic (810–819, 830–838)	25	1.6*	(1.1–2.4)	14	1.5	(0.9–2.5)	6	1.1	(0.5–2.4)	4	1.2	(0.5–3.2)	49	1.5	(1.1–2.0)
Chemical poisoning (850–869)	6	3.8*	(1.7–8.5)	0			0			1	3.7	(0.5–26.0)	7	2.1	(1.0–4.4)
Accidental Falls (880–888)	11	5.6*	(3.1–10.1)	5	2.5*	(1.0–6.0)	6	4.9*	(2.2–10.9)	0			22	3.5*	(2.3–5.3)
Submersion, suffocation and foreign bodies (910–915)	6	2.2*	(1.0–4.9)	2	1.2	(0.3–4.7)	0			0			8	1.4	(0.7–2.9)
Industrial accidents (916–928)	13	3.1*	(1.8–5.3)	12	4.5*	(2.5–7.9)	5	3.5*	(1.5–8.4)	7	9.9*	(4.7–20.8)	32	3.6*	(2.5–5.0)
Suicide/Homicide (950–969)	4	1.0	(0.4–2.7)	0			1	0.8	(0.1–5.9)	0			5	0.6	(0.2–1.4)
Injury undetermined (980–989)	0			1	2.7	(0.4–19.4)	0			0			1	1.0	(0.1–6.8)

ps: CI: Confidence Interval, *: p<0.05

Table 4. Age-adjusted risks of death from selected causes measured by logistic regression for male shipbreaking workers

Cause of death (ICD code)	Flame Cutters	Lifters	Odd-jobbers	supervisors/others
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
All causes (000–999)	1.3 (1.0–2.9)	1.7* (1.1–3.3)	1.9 (0.6–1.8)	1.0
Neoplasms (140–239)	1.9 (0.9–3.8)	1.0	1.1 (0.4–3.0)	1.6 (0.6–4.4)
Nasopharynx (147)	1.0	1.2 (0.2–6.5)	–	–
Tongue, Mouth, Lip, Oral Cavity and Pharynx (141, 145, 149)	2.1 (0.2–18.3)	–	–	1.0
Colonrectum (153, 154)	1.0	–	1.2 (0.2–9.5)	1.0 (0.1–11.8)
Liver, Primary (155)	5.5 (0.7–42.1)	1.0	6.0 (0.6–60.3)	5.3 (0.5–59.3)
Trachea, Bronchus and lung (162)	2.5 (0.3–22.5)	1.8 (0.2–18.0)	1.1 (0.1–12.4)	1.0
Circulatory system (390–459)	1.7 (0.5–5.9)	1.9 (0.5–6.8)	1.7 (0.4–6.6)	1.0
Respiratory system (460–519)	1.0	–	2.1 (0.4–12.2)	1.1 (0.1–10.3)
Digestive system (520–579)	1.0	2.3* (1.1–4.8)	1.9 (0.6–6.2)	2.1 (0.7–6.6)
External causes of injury and poisoning (E800–E988)	1.9 (0.6–6.1)	3.2 (1.0–10.4)	5.5** (1.6–19.1)	1.0
Traffic (810–819, 830–838)	2.2 (0.3–16.7)	3.2 (0.4–25.0)	8.3* (1.0–27.1)	1.0
Chemical poisoning (850–869)	1.0	1.9 (0.3–10.5)	5.3 (0.5–53.6)	–
Accidental falls (880–888)	1.0	5.1*** (2.1–12.8)	3.5 (0.7–18.3)	–
Submersion, suffocation and foreign bodies (910–915)	1.0	1.6 (0.3–8.3)	5.2 (0.6–46.5)	–
Industrial accidents (916–928)	1.1 (0.2–5.0)	1.2 (0.2–5.7)	1.3 (0.2–8.0)	1.0

ps: OR: Odds Ratio; CI: Confidence Interval; *p<0.05, **p<0.01, ***p<0.001

industrial accidents was for the oldest group (SMR=9.9, 95%CI=4.7–20.8). The 20–39-yr-old workers were also at a significant risk of traffic accidents (SMR=1.6, 95% CI=1.1–2.4) and chemical poisoning (SMR=3.8, 95% CI=1.7–8.5).

Table 4 shows comparisons of age-adjusted risks from selected deaths among flame cutters, lifters, odd-jobbers and supervisors/others by means of logistic regression analyses. Odd-jobbers were significantly at the highest risk of death from all external causes of injury and poisoning (OR=5.5, $p<0.01$) , particularly from traffic accidents (OR=8.3, $p<0.05$) . Lifters were at higher risk of death from all causes (OR=1.7, $p<0.05$), digestive system diseases (OR=2.3, $p<0.05$), and particularly from accidental falls (OR=5.1, $p<0.001$). Flame cutters were at higher risk of death from neoplasms (OR=1.9) but not singificant.

Discussion

Shipyard work and arc welding exposure have been considered to be contributing factors in increased risk of respiratory symptoms and mortality[16–19]. To the best of the authors' knowledge, there are few investigations on the health effects experienced by shipbreaking workers. The current study was the first investigation of the health outcomes for a cohort of workers after the shipbreaking jobs had ceased for a period of 13 yr. The study subjects were from the reference population, and we accessed the death data for both the subjects and reference population in a similar way. In particular, the mortality patterns were investigated for the years after exposure to special job conditions had ceased.

Because of the working conditions and the worker characteristics, we expected health outcomes for the cohort of shipbreaking union workers, even after leaving the job, to be distinct from the general population. These jobs involved removing steel from old ships with cutting torches at high temperature. Workers in the Kaohsiung shipbreaking industry received minimum protection equipment at work except for facecloths. Flame cutters could wear masks with dark colored glasses while working with torches. They were also at the risk of asbestos exposure while dismantling insulation containing asbestos. These workers were therefore potentially at higher risk of disease, particularly malignant respiratory diseases and injuries due to the working conditions.

In the evaluation of all-causes mortality for the study subjects in the follow-up period, we found higher observed numbers than expected; the difference is small but significant. These excess deaths, which consisted of 37% of all deaths, were mainly attributed to external causes of injury and poisoning. The study population had lower observed numbers than expected in mortality from cancer, circulatory diseases, and non-malignant respiratory diseases, but the analysis of deaths caused by cancer was limited by inability to adjust for smoking. Although approximately, 60% of men in the general population in Taiwan were smokers during the study period[20]. The smoking prevalence could be even higher in the study population than in the general population. The analysis of mortality from injury was also limited by the inability to adjust for socioeconomic status and forms of risk behavior. We believe the study subjects are most likely from a selected group of lower socioeconomic status willing to take jobs with higher odds of adverse health effect.

In this study, the expected numbers for mortality from all cancer sites for whole study subjects were lower than the observed numbers. Their SMR value (0.89) was lower than welders had experienced in Germany (SMR=1.09)[4], Norway (SIR=1.13)[21] and Sweden (RR=1.37)[22], but similar to that in France (SMR=0.93)[19]. Higher lung cancer risk was found among welders in other studies[16–19]. Sjögren, *et al.*[17] concluded in a meta-analysis that exposure to stainless steel welding fume leads to a higher risk of lung cancer. For 13 yr of follow-up, the evidence is not strong enough yet to indicate that previous shipbreaking work increases the risk of contracting these diseases in this study.

Although there was a higher mortality rate from respiratory cancer, the difference was not at significant, based on overall SMR estimations. The SMR (1.41) of trachea, bronchus and lung cancer for the present studied flame cutters was higher than that for French stainless steel welders (SMR=1.24) and Swedish shipyard workers (SIR=1.12)[23] but lower than the risk from lung cancer deaths for welders in Norway (SIR=1.69)[2]. Nevertheless, SMR from lung cancer shows that cancers of the respiratory system may occur at a younger age in our study subjects, than in the local general population. In fact, 25% of deaths were from trachea, bronchus and lung cancer among this study population aged 40–49 yr, whereas the rate for the same age group of the local general population was only 5.6%.

Most studies on the workers' health effect have demonstrated that the healthy worker effect may reduce the occurrence of cancer, in particular lung cancer[24]. In this study, regardless of no known exposure in the follow-up period, flame cutters had a similar risk of respiratory cancer to lifters, odd-jobbers and others. It is possible that the follow-up period may not be long enough to observe a latent effect.

From the current study, however, ending exposure to asbestos evidently did not reduce the risk of mesothelioma. Several studies on asbestos disease in shipyard workers[25–28] have shown that the occurrence of mesothelioma requires a long latency period, averaging 33 yr[26, 27, 29]. Persons with short latency intervals contribute little information about the risk of mesotheliomas. The current study revealed that a flame

cutter died of pleural mesothelioma at 36 years old, which might have resulted from exposure prior to 1971. This case contributed a SMR of 104.1 for the flame cutters in the youngest group. We are not so sure whether this pleural mesothelioma death is due to chance or to selection bias. A longer follow-up may result in more cases of asbestos induced cancer.

We also found that the three deaths from nasopharynx neoplasm were in the youngest group aged 20–39. In fact, they were flame cutters, accounting for an age-job-specific mortality rate of 211.3 per 100,000 person-years or a SMR of 5.2. The mortality rate from this disease for the general population of similar ages in 1995 was 5.42 per 100,000. This age-job-specific cluster indicates that flame cutters are at a higher risk of dying from nasopharynx neoplasm, at least 30 yr earlier than the reference population, which has the highest mortality rate from the disease in those 60–65 yr old. It is likely that the deaths from nasopharynx neoplasm are not due to chance.

The most important finding in this study is the large number of deaths from external causes of injuries and poisoning. We believe that these workers take higher risk jobs because of their previous shipbreaking experience and the attraction of high pay in high-risk jobs. These high-risk occupations include work in shipyards, construction, mining and exploration. They were therefore more likely to have a higher risk of death from injuries, in the follow-up period, particularly from accidental falls, industrial accidents and traffic accidents. Our data show that lifters were 5.1 times more likely than flame cutters to die subsequently from accidental falls. Odd-jobbers, on the other hand, were older, but at the highest risk of death from overall external causes of injury and poisoning among the four job groups.

In fact, SMRs of accidental falls and industrial accidents were significant across all age groups, with the oldest workers at the highest risk of industrial accidents, approximately 10 timers higher than the general population of the same age. This finding implies that older workers are not appropriately employed in high risk industries. On the other hand, it may show that employers fail to provide worker protection. Industrial development has been needed in Taiwan, but unfortunately corporations may not have attempted to comply with the regulations to protect the health of workers.

In conclusion, regardless of a possible healthy worker effect, the study population experienced an overall higher mortality of 11 % after leaving the shipbreaking industry. In particular, the higher mortality from accidents may be attributed to continuation in jobs with a higher risk of falls and other types of accidents. Younger flame cutters are also at higher risk of dying from nasopharynx neoplasm and plural mesothelioma. A longer follow-up period may show the residual effect from exposure to metal fume and asbestos.

Acknowledgments: This study was supported by the American Bureau for Medical Advancement in China (ABMAC) and Department of Health for scientific and industrial epidemiology research.

References

1) L Simonato, AC Fletcher, A Andersen, K Anderson, N Becker, J Chang-Claude, G Ferro, M Gerin, CN Gray and KS Hansen: A historical prospective study of European stainless steel, mild steel, and shipyard welders. Br J Ind Med 48, 145–154 (1991)
2) A Melkild, S Langard, A Andersen and JN Tonnessen: Incidence of cancer among welders and other workers in a Norwegian shipyard. Scand J Work Environ Health 15, 387–394 (1989)
3) N Becker, J Chang-Claude and R Frentzel-Beyme: Cancer risk of arc welders exposed to fumes containing chromium and nickel. Scand J Work Environ Health 1985 11, 75–82
4) N Becker, J Chang-Claude and R Frentzel-Beyme: Risk of caner for arc welders in the Federal Republic of Germany: results of a second follow up (1983–88). Br J Ind Med 48, 675–683 (1991)
5) JJ Beaumont and NS Weiss: Lung cancer among welders. J Occup Med 23, 839–844 (1981)
6) Sjögren B, Gustavsson A and Hedstrom L: Mortality in two cohorts of welders exposed to high- and low-levels of hexavalent chromium. Scand J Work Environ Health 13, 247–251 (1987)
7) S Tola, P-L Kalliomäki, E Pukkala, S Asp and ML Korkala: Incidence of cancer among welders, platers, machine shops. Br J Ind Med 45, 209–218 (1988)
8) K Steenland, J Beaumont and L Elliot: Lung cancer in mild steel welders. Am J Epidemiol 133, 220–229 (1991)
9) CJ Hull, E Doyle, JM Peters, DH Garabrant, L Bernstein and S Preston-Martin: Case-control study of lung cancer in Los Angeles county welders. Am J Ind Med 16, 103–112 (1989)
10) ML Lerchen, CL Wiggins and JM Samet: Lung cancer and occupation in New Mexico. J Natl Cancer Inst 79, 639–645 (1987)
11) B Sjögren: A retrospective cohort study of mortality among stainless steel welders. Scand J Work Environ Health 6, 197–200 (1980)
12) JE Dunn and JM Weir: A prospective study of mortality of several occupational group: special emphasis on lung cancer. Arch Environ Health 17, 71–76 (1968)
13) Peto J. Cancer morbidity and mortality studies of welders. In: Stern RM, Berlin A, Fletcher AC, Jarvisalo J, ed. Proceedings of the international conference on health hazards and biological effects of welding fumes and gases, Copenhagen, 18–21 February, 1985. Amsterdam: Excerpta Medica, 1986: 423–434.
14) Liu YM, Fu DX, Zheng XC. The Study on Safety in the Shipbreaking Industry. Labor Safety Inspection Administration, Bureau of Labor's Affairs, Kaohsiung

City Government; 1986; 1–19.
15) International Classification of Diseases, Ninth Revision. Clinical Modification. 2nd ed. Washington DC: U.S. Govr Print Office; 1980 DHHS Pub. No. PHS 80–1260.The health and vital statistics republic of china.
16) S Langård: Nickel-related cancer in welders. Sci Total Environ 148, 303–309 (1994)
17) B Sjögren, KS Hansen, H Kjuus and PG Persson: Exposure to stainless steel welding fumes and lung cancer: a meta-analysis. Occup Environ Med 51, 335–336 (1994)
18) GHG McMillan and RJ Pethybridge: The health of welders in Naval dockyards: proportional mortality study of welders and two control groups. J Soc Occup Med 33, 75–84 (1983)
19) JJ Moulin, P Wild, JM Hanguenoer, D Faucon, R De Graudemaris, JM Mur, M Mereau, Y Gary, JP Toamain and Y Birembaut: A mortality study among mild steel and stainless steel welders. Br J Ind Med 50, 234–243 (1993)
20) LL Yen, LY Pan, HW Ye: The smoking status in adults in Taiwan area: prevalence rates and risk factors. J Chinese Public Health 13, 371–380 (1994)
21) TE Danielsen, S Langård, A Anderson and O Knudsen: Incidence of cancer among welders of mild steel and other shipyard workers. Br J Ind Med 50, 1097–1103 (1993)
22) P Gustavsson, R Jakobsson, H Johansson, F Lewin, S Norell and LE Rutkvist: Occupational exposures and squamous cell carcinoma of the oral cavity, pharynx, larynx, and oesophagus: a case-control study in Sweden. Occup Environ Med 55, 393–400 (1998)
23) Å Sand'en and B Järvholm: Cancer morbidity in Swedish shipyard workers 1978–1983. Int Arch Occup Environ Health 59, 455–462 (1987)
24) BCK Choi: Definition, sources, magnitude, effect modifiers, and strategies of reduction of the healthy worker effect. J Occup Med 34, 979–988 (1992)
25) LN Kolonel, CN Yoshizawa, T Hirohata and BC Myers: Cancer occurrence in shipyard workers exposed to asbestos in Hawaii. Cancer Res 45, 3924–3928 (1985)
26) IJ Selikoff, R Lilis and WJ Nicholson: Asbestos disease in United States shipyards. Ann NY Acad Sci 330, 295–311 (1979)
27) KPS Lumley: A proportional study of cancer registrations of dockyard workers. Br J Ind Med 33, 108–114 (1976)
28) M Newhouse, D Oakes and AJ Woolley: Mortality of welders and other craftsmen at a shipyard in NE England. Br J Ind Med 42, 406–410 (1985)
29) Å Sand'en, B Järvholm and G Thiringer: The risk of lung cancer and mesothelioma after cessation of asbestos exposure: a prospective cohort study of shipyard workers. Eur Respir J 5, 281–285 (1992)