Exposure to stainless steel welding fumes and lung cancer: a meta-analysis

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Abstract

Stainless steel welding is associated with exposure to metals including hexavalent chromium and nickel. This study is a meta-analysis of five studies of stainless steel welders and the occurrence of lung cancer. Asbestos exposure and smoking habits have been taken into account. The calculated pooled relative risk estimate was 1·94 with a 95% confidence interval of 1·28–2·93. This result suggests a causal relation between exposure to stainless steel welding and lung cancer.

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Stainless steel welding is associated with exposure to metals including chromium and nickel. Manual metal arc welding of stainless steel generates hexavalent chromium. Between 50% and 90% of the chromium generated is hexavalent. The welding fumes from metal inert gas (MIG) welding contains < 20% chromium in the hexavalent state. Increased concentrations of chromium and nickel are seen in blood and urine, especially in manual metal arc stainless steel welders.[1]

Several epidemiological studies of welders have shown an increased risk of lung cancer among these workers. The excess mortality ranged between 30% and 50%.[2,3] The cause of this excess has not been clear but chromium, nickel, as well as exposure to asbestos have been discussed. Confounding exposure from smoking might also have played an important part.

The purpose of this paper was to review the studies of lung cancer among welders exposed to stainless steel welding fumes, which were identified in a search of the scientific literature in MEDLINE and NIOSHTIC between 1984 and 1993. Only investigations taking smoking and asbestos exposure into account were included in a meta-analysis. Other investigations were excluded.

Methods

STUDIES INCLUDED

A Canadian case-referent study of lung cancer, based on men aged 35–70 and resident in the area of Montreal, focused on nickel exposure. The study showed an association between lung cancer and welders exposed to nickel. All the welders exposed to nickel who had lung cancer were also exposed to chromium. The odds ratio (OR) was 3·3 with the corresponding 95% confidence interval (95% CI) 1·2–9·2. Adjustments were made for age, ethnic group, social class, and smoking habits. Other possible confounders such as asbestos exposure were coded on an extensive checklist. Asbestos exposure was not sufficiently correlated with nickel exposure and with lung cancer to have artificially created such a large OR between nickel and lung cancer.[4]

In a case-referent study nested in a cohort of Danish welders the OR for lung cancer associated with ever stainless steel welding was 1·57 (95% CI 0·85–2·89) after adjusting for smoking and asbestos exposure. Exposure to stainless steel welding fumes for at least two decades increased the OR to 1·93 (95% CI 0·74–5·06).[5]

A cohort of 2721 French welders were compared with 6683 non-welding manual workers and with the general French population. The mortality of the two cohorts was studied from 1975 to 1988. Smoking was more prevalent among the welders and this was assumed to lead to a 6% excess of lung cancer *v* the non-welding referents. Asbestos exposure was probably higher in shipyards than in other factories and asbestos exposure was not assumed to be responsible for lung cancers among non-shipyard welders. The cohort of non-shipyard welders included a subcohort of welders exposed to stainless steel welding fumes. Welders were included in this subcohort if more than 70% of their welding activities, for at least one year, comprised manual metal arc welding of stainless steel or armoured steel with stainless steel coated electrodes or oxyacetylene welding or cutting of stainless steel. The number of lung cancers found within this subcohort of predominantly stainless steel welders was 2 *v* 1·95 expected (standardised mortality ratio (SMR = 1·03) from the general French population.[6] Assuming the smoking habits among the subcohort of the stainless steel welders to be the same as the main cohort of welders and the habits among the non-welding referents to be the same as the general French population, the calculated SMR would be 0·97.

In a Norwegian case-referent study of lung cancer an increased OR was found for welders exposed to stainless steel welding fumes when smoking habits were taken into account, OR = 3·3 (95% CI 1·2–9·3).[7] When both asbestos exposure and smoking were included in the logistic regression equation the association was weaker, OR = 2·56 (95% CI 0·85–7·54).

A cohort of 234 Swedish welders working

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Table 1 Standardised mortality ratios (SMRs) or odds ratios (ORs) and their 95% CIs for studies included

Origin	SMR or OR	95% CI
Canada	3·3	1·2—9·2
Denmark	1·57	0·85—2·89
France	0·97	0·12—3·51
Norway	2·56	0·85—7·54
Sweden	2·04	0·66—4·76

mainly in stainless steel for at least five years between 1950 and 1965 was followed up until 1984. The welders were included in the cohort only if representatives from the companies stated that asbestos had never been used in a dust generating way. Smoking habits were not taken into account. Five lung cancers were observed *v* 2·01 expected (SMR = 2·49, 95% CI 0·80–5·81).[8] If we assume smoking to be 10% more prevalent among the welders, which is a conservative estimate, the expected number of lung cancers would be 2·45 and the corresponding SMR 2·04 (95% CI, 0·66–4·76). This calculation is based on the adjustments for smoking habits that have been proposed by Axelson.[9]

Table 1 shows all the data from which the calculations have been made.

EXCLUDED STUDIES

In a German study of 1221 welders exposed to chromium and nickel an increased number of deaths from lung cancer was observed (14 *v* 12·4 expected.[10] Three cases of mesothelioma among the welders clearly indicated an exposure to asbestos.

A case-referent study of lung cancer in Los Angeles county welders showed a slightly increased risk for welders working with manual metal arc welding on stainless steel (OR = 1·3 (95% CI 0·6–2·3)). Practically all welders smoked. Lung cancer was also associated with asbestos exposure (OR = 1·4). Unfortunately there was no adjustment for asbestos exposure to scrutinise the association between exposure to stainless steel welding fumes and lung cancer.[11]

The large European cohort study[2] is excluded as some of the subcohorts are included in this meta-analysis.

META-ANALYSIS

The meta-analysis was based on five studies. The pooled estimate of relative risk with weights from the inverted variances in each study was computed. The variances were estimated from the presented 95% CIs.[12] A 95% CI of the pooled estimate was calculated assuming a roughly normal distribution.[12]

Result

The calculated pooled relative risk was 1·94 (95% CI 1·28—2·93).

Discussion

The result of the meta-analysis clearly indicates a relation between stainless steel welding fumes and the occurrence of lung cancer, when the two most important confounders namely smoking habits and asbestos exposure have been taken into account.

The International Agency for Research on Cancer (IARC) stated in 1990 that there is sufficient evidence in humans for the carcinogenicity of hexavalent chromium compounds as encountered in the chromate production, chromate pigment production, and chromium plating industry.[1] The concentrations of hexavalent chromium in stainless steel welding fumes is about 0·1–0·3 mg/m^3 on average, and this is similar to the concentrations found in various branches of the chromate industry.[13] The concentration of nickel, however, although about 0·05–0·2 mg/m^3 on average, is extremely low compared with the absolute concentrations estimated to have prevailed in the nickel producing industry when exposures were thought to have contributed to the increased risk of respiratory cancers.[13]

A case-referent study of nasal and sinonasal cancer showed an increased incidence of this tumour among stainless steel welders (OR = 3·3 (95% CI 1·1–9·4).[14]

In 1990 IARC stated that there is limited evidence in humans for the carcinogenicity of welding fumes and gases.[1] Since then more studies have been published about stainless steel welding fumes and lung cancer.[5,6] We think it is time to reconsider the IARC statement from 1990 and to separate stainless steel welding fumes from other welding fumes.

Whether exposure to welding fumes from mild steel, containing low concentrations of chromium and nickel, can cause cancer is a different issue. This question should be considered by future studies that control exposures to asbestos, chromium, nickel, and cigarette smoke, for example.

1 International Agency for Research on Cancer. Chromium, nickel and welding *IARC Monogr Eval Carcinog Risks Hum*. Lyon: IARC, 1990.
2 Simonato L, Fletcher AC, Andersen A, Anderson K, Becker N, Chang-Claude J, *et al*. A historical prospective study of European stainless steel, mild steel, and shipyard welders. *Br J Ind Med* 1991;48:145–54.
3 Stern RM. Assessment of risk of lung cancer for welders. *Arch Environ Health* 1983;38:148–55.
4 Gerin M, Siemiatycki J, Richardson L, Pellerin J, Lakhani R, Dewar R. Nickel and cancer associations from a multicancer occupation exposure case-referent study: preliminary findings. *IARC Sci Publ* 1984;53:105–15.
5 Hansen KS, Lauritsen J. Lung cancer mortality in stainless steel and mild steel welders—A nested case-referent study. *Am J Ind Med* 1994 (in press).
6 Moulin JJ, Wild P, Haguenoer JM, Faucon D, De Gaudemaris R, Mur JM, *et al*. A mortality study among mild steel and stainless steel welders. *Br J Ind Med* 1993;50:234–43.
7 Kjuus H, Skjaerven R, Langård S, Lien JT, Aamodt T. A case-referent study of lung cancer, occupational exposures and smoking. I. Comparison of title-based and exposure-based occupational information. *Scand J Work Environ Health* 1986;12:193–202.
8 Sjögren B, Gustavsson A, Hedström L. Mortality in two cohorts of welders exposed to high- and low-levels of hexavalent chromium. *Scand J Work Environ Health* 1987;13:247–51.
9 Axelson O. Aspects on confounding in occupational health epidemiology. *Scand J Work Environ Health* 1978;4:85–9.
10 Becker N, Chang-Claude J, Frentzel-Beyme R. Risk of cancer for arc welders in the Federal Republic of Germany: results of a second follow up (1983–8). *Br J Ind Med* 1991;48:675–83.
11 Hull CJ, Doyle E, Peters JM, Garabrant DH, Bernstein L, Preston-Martin S. Case-control study of lung cancer in Los Angeles county welders. *Am J Ind Med* 1989;16:103–12.
12 Ahlbom A. *Biostatistics for epidemiologists*. Florida: Lewis, 1993.
13 Langård S, Stern RM. Nickel in welding fumes—A cancer hazard to welders? A review of epidemiological studies on cancer in welders. *IARC Sci Publ* 1984;53:95–103.
14 Hernberg S, Westerholm P, Schultz-Larsen K, Degerth R, Kuosma E, Englund A, *et al*. Nasal and sinonasal cancer. Connection with occupational exposures in Denmark, Finland and Sweden. *Scand J Work Environ Health* 1983;9:315–26.