

Does welding stainless steel cause cancer?

In his paper on the role of chemical species and exposure characteristics in cancer among persons occupationally exposed to chromium compounds, Langård (1) presents the welding of stainless steel as an activity potentially presenting a carcinogenic risk because of the presence of hexavalent chromium compounds in welding fumes. He supports this position directly from epidemiologic studies by the International Agency for Research on Cancer (IARC) (2) and Sjögren (3, 4). He also refers more indirectly to the studies by Becker (5, 6).

We do not agree with his position or the interpretation he made of the results of the various studies in which the welding of stainless steel (which means potential exposure to hexavalent chromium) was specifically addressed by epidemiologists.

The IARC study is certainly the most relevant and significant one. It was a multinational study carried out in nine European countries on 11 092 mild steel and stainless steel welders. A distinction was made between four categories of welders according to potential exposure to hexavalent chromium (table 1).

Table 2 contains standardized mortality ratios (SMR) on which comparisons can be made in relation to the statement made by Langård. It is surprising that Langård has concluded that the SMR of 157 for the "stainless steel welders ≤ 10 years of employment" was "indicating that stainless steel welders are more likely to die from lung cancer than welders as a whole [p 82]" without having reported any of the other figures available in the Simonato paper in relation to other categories of welders implied in the comparison, that is, 176 for "predominant-

ly stainless steel welders" and, especially, 173 for "mild steel welders"!

Any hypothesis of a role played by hexavalent chromium compounds in an excess of cancers was ruled out by Simonato in his conclusions: "The excess mortality from lung cancer is present among shipyard welders, mild steel welders, and stainless steel welders, but it does not appear to be related to duration of employment or cumulative exposure to total fumes, total Cr, Cr VI, or Ni [p 153]."

The only conclusion which can be drawn from these figures is that the mild steel welders in this cohort were at higher risk of lung cancer than the stainless steel welders were.

The SMR for lung cancer among welders as a whole, when all the relevant studies are considered together, is on the order of 140. The cause of this excess is attributed by most experts first to asbestos and then to smoking. It should be remembered that there were five mesotheliomas observed in the European cohort. These two biases

Table 1. Categories of welders and their potential exposure to hexavalent chromium according to the International Agency for Research in Cancer (2).

Type of welding	Exposure to hexavalent chromium
Mild steel welding	No
Predominantly stainless steel welders	Yes
Stainless steel welding	Yes
Shipyard welders	No

Table 2. Standardized mortality ratios (SMR) in the Simonato et al paper on the European cohort of welders in relation to lung cancer (2).

	Shipyard welders		Mild steel welders		Predominantly stainless steel		Stainless steel ever welders		All welders	
	SMR	Cases of lung cancer	SMR	Cases of lung cancer	SMR	Cases of lung cancer	SMR	Cases of lung cancer	SMR	Cases of lung cancer
> 20 years since first exposure										
Total	107	25	198	25	174	13	152	22	.	.
≥ 10 years of employment ^a	96	10	173	15	176	11	157	13	.	.
Total	126	36	179	40	123	20	128	39	134	116

^a 157 is the key figure of these comments.

are also addressed in the Simonato paper. KH Jöckel, reporting on a case-referent study on lung cancer and welding in Germany concluded: "The present study supports the hypothesis that some, if not all, of the excess of risk observed in the literature may be due to the exposure to asbestos [p 805]" (7). The lack of clear evidence for a role of the "stainless" characteristic of the steel in the excess of lung cancers can also be demonstrated by considering the following three studies made on subcohorts of the IARC/European cohort: the Swedish by Sjögren (3, 4), the German by Becker (5, 6), both quoted by Langård, and the French by Moulin (8), not quoted by Langård.

Sjögren found five cases of lung cancer versus 2.5 expected. This low number of cases is not sufficient for a generalization. Asbestos was also involved.

Becker, in 1985 and 1991, published the following results of a German cohort of 1213 welders of stainless steel:

1985	6 cases	SMR 95
1991	14 cases	SMR 113

with the additional observation of three mesotheliomas attributed to the presence of asbestos. Since no statistically significant excess of lung cancer was found for these stainless steel welders, any role of chromium (or nickel) remains unsupported. Becker himself has written: "Mortality from lung cancer only weakly increased after the removal of the effects of smoking and a part of the increase must clearly be attributed to exposure to asbestos . . . Thus the second follow-up of the study of German welders does not yet allow final conclusions [p 683]."

For a French cohort of 2721 welders (all types of welding) Moulin found an SMR of 124 (19 cases) for all welders, an SMR of 159 (9 cases) for mild steel welders, an SMR of 92 (3 cases) for stainless steel welders, and an SMR of 103 (2 cases) for "predominantly Cr VI." — figures consistent with the aforementioned ones.

Overall, we are supported by the statement by IARC in its monograph no 49 (9) (also cited by Langård as reference 10 in his paper): "A large European cohort study, including three cohorts reported previously, detected statistically significant increases in both the incidence of and mortality from lung cancer but demonstrated no consistent difference in cancer risk among stainless-steel welders as compared to mild-steel welders

or to shipyard welders. In addition, five deaths were due to mesothelioma [p 506]." IARC also placed this industrial activity in group 2B of its categories for carcinogens as follows: "There is limited evidence in humans for the carcinogenicity of welding fumes and gases . . . Welding fumes are possibly carcinogenic to humans (group 2B) [p 507]."

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François Marini MD,¹ Marie-Pascale Ferré MD,²
Hans Gross MD,³ Bernard Mantout MD,⁴ Markku Huvinen
MD,⁵ Daniel Beaufils,² Pierre-Jean Cunat,⁴
Christian Bozec⁶

¹ Alstom-Belfort, France.

² Institut de Soudure, France.

³ Munich, Germany.

⁴ Ugine-Savoie, France.

⁵ Outokumpu Group, Helsinki, Finland.

⁶ Eramet, France.

Author's reply

A group of Finnish, French, and German authors (1) has commented on my suggestions (2) that chromium in the hexavalent state in welding fumes generated during weld-

ing on stainless steel may result in a higher risk of lung cancer than does comparable exposure to fumes during mild steel welding. They are skeptical of my interpreta-

tion of a set of published data concerning stainless steel welders (3–7). My paper was written in 1992; hence I was not in the position to refer to later studies (8, 9).

It is timely that the authors (1) take up the intriguing issue of whether or not welding on stainless steel generates a higher risk of cancer of the respiratory organs than does welding on mild steel under otherwise comparable exposure to modifying factors such as tobacco smoking and asbestos.

As for asbestos, I fully agree with the authors that exposure to this substance is a possible confounder in most studies among welders and that the confounding has also been confirmed in a recent study (10) indicating that asbestos may contribute to the occurrence of lung cancer among mild steel welders (10). The issue of concern is whether exposure to asbestos as a confounder plays different roles in the two groups of welders. So far no firm evidence can be found in published papers on documented differences in exposure to asbestos among the two groups. In fact, a case-referent study (11) performed among 176 lung cancer patients, among whom exposure to asbestos and smoking habits was scrutinized, did not report a clear difference in terms of exposure to asbestos between the two groups of welders. However, this result does not exclude the possibility that there might be a difference.

In regard to smoking, there is no doubt that it may be a confounder in both groups of welders, hence playing a possible differential role as a determinant for lung cancer in the two groups. However, as of today, none of the published studies have presented firm evidence that smoking occurs significantly more often in one of the groups of welders than in the other. One can, however, speculate that stainless steel welding in general is associated with a higher level of education than is mild steel welding and, consequently, that the assumed higher educational level could be associated with less smoking among stainless steel than among mild steel welders. If so, smoking would appear as a “negative” confounder among stainless steel welders and therefore contribute to a less extent to lung cancer than among mild steel welders. For further speculation on the basis of this assumption, a higher carcinogenic potential would be needed of fumes generated from stainless steel welding to cause lung cancer than of fumes from mild steel welding.

As for the possibility of different exposure to hexavalent chromium in the two groups of welders, my co-workers and I have presented evidence that there may be exposure to very high levels of hexavalent chromium among stainless steel welders using the manual metal arc method (MMA), in particular during welding in confined spaces (12, 13). This possibility indicates that exposure to hexavalent chromium could be a separate determinant of lung cancer among stainless steel welders using the

MMA method. However, this finding does not clearly confirm that exposure to hexavalent chromium is a major determinant of lung cancer for that group of welders.

The letter by Marini and his colleagues (1) points to the need for further clarification of the significance of exposure to hexavalent chromium as a determinant of respiratory cancer among stainless steel welders. There is also a need to elucidate whether the different methods of welding (eg, MMA, tungsten inert gas, metal inert gas-metal active gas, and flux core wire) may contribute differently to the risk of cancer in the respiratory organs of welders. Recent results from Norwegian studies on the subject (10, 14) indicate an excess risk of lung cancer among mild steel welders.

Therefore, I can only agree with Marini and his colleagues (1) that the evidence so far is weak that exposure to hexavalent chromium is a strong determinant of lung cancer among stainless steel welders. There is need for a large case-referent study of incident cases of lung cancer among men to clarify this issue. In a such study accurate and (semi)quantifiable information on past exposure to all known lung cancer determinants must be compiled. In addition, there seems to be a need for a renewed follow-up of the cohort that contributed to the IARC study, which can now be expanded in duration of follow-up, as well as in the size of the cohort, as compared with the previous follow-up (3).

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Sverre Langård, MD
Telemark Central Hospital
Department of Occupational and Environmental Medicine
N-3710 Skien
Norway

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Sex ratio of offspring of female physiotherapists exposed to low-level high-frequency electromagnetic radiation

Larsen et al (1) reported that Danish physiotherapists exposed to low levels of electromagnetic radiation produce a highly significant, dose-related excess of daughters. The result needs replicating, but I would like to offer a provisional explanation.

I have gathered substantial quantities of data to support the hypothesis that the sex of mammalian (and among them, human) offspring is partially controlled by the hormone levels of both parents at the time of conception, high levels of gonadotrophin and progesterone being associated with the subsequent births of daughters and high levels of estrogen and testosterone with sons (2).

In mammals, the endocrine responses to acute microwave exposure are similar to the responses to nonspecific stressors such as heat (3). However this sort of response only occurs above a threshold. Below the threshold, exposure seems not to act as a stressor. For instance, rats exposed to low levels of radiation (with no increase in colonic temperature) showed inhibition of the normal circadian elevation of corticosterone (4). Various glucocorticoids suppress basal luteinizing hormone (LH) secretion (5, 6), and indeed a significant increase in LH has been reported in the pituitary of rats exposed to long-term low-level radiation (7). Therefore it seems that such exposure may also result in high gonadotrophin levels in women. If so, the phenomenon would explain the excess of daughters among physiotherapists exposed to low levels of electromagnetic radiation. To test this suggestion, it would certainly be worth assaying the hormone levels of female physiotherapists exposed to low levels of radiation.

Workers in occupational medicine might consider using the sex ratios (proportion of males) of offspring as a criterion of reproductive risk. Unusual sex ratios of offspring are characteristic of several diseases, for example, prostatic cancer (8), hepatitis (9), multiple sclerosis (10), otosclerosis (11), and non-Hodgkin's lymphoma (12). Moreover there is evidence that the reported low sex ratios for offspring of professional male divers (13, 14) and pesticide applicators (15) are caused by high levels of paternal gonadotrophin (16). Since high levels of gonadotrophin in men are associated with subfertility, there are grounds for concern over these occupations. However, an excess of daughters born to women is not equally suggestive of pathology. High levels of gonadotrophin in women are associated, for instance, with the births of dizygotic twins and may be a sign of well-being rather than otherwise. The idea that low-level microwave radiation may be beneficial should at least be considered.

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