Effects of alcohol and smoking on blood lead in middle-aged British men

A G SHAPER, S J POCCOCK, MARY WALKER, C J WALE, BARBARA CLAYTON, H T DELVES, LESLEY HINKS

Abstract

A survey of middle-aged men in 24 British towns showed a strong association between blood lead concentrations, alcohol consumption, and cigarette smoking. The association with alcohol persisted after age, social class, body mass index, cigarette smoking, water lead concentrations, and the town of residence had been taken into account. There was an independent but less pronounced association between cigarette smoking and blood lead concentrations after adjustment for the other factors. The possible mechanisms include a decreased excretion of lead due to alcohol-induced hepatic dysfunction and an increased lead intake from cigarette smoking.

These findings have implications for widespread measurement of blood lead concentrations in adults in the community and for all studies attempting to relate blood lead concentrations to environmental exposure.

Introduction

The British Regional Heart Study seeks to explain the substantial geographical variations in cardiovascular mortality in Great Britain by evaluating the role of environmental, socioeconomic, and personal risk factors. The role of water quality is of particular interest, and analysis of data collected in the study has recently shown that cardiovascular mortality is about 10% higher in areas with very soft water than in areas with medium-hard water, after appropriate adjustments have been made for other factors such as climate and socioeconomic circumstances. The mechanism by which soft water is associated with a higher cardiovascular mortality is uncertain but one of the possibilities considered was the increased water lead concentrations seen in many soft, acid waters. The Regional Heart Study includes a clinical survey of middle-aged men in 24 British towns, carried out to determine the distribution of established or possible risk factors for cardiovascular disease, to examine their interrelationships and to initiate a long-term prospective study of cardiovascular disease based on these findings. The survey has included the measurement of blood lead concentrations, and this report describes some relationships observed between blood lead concentration, cigarette smoking, and alcohol consumption in these middle-aged men.

Subjects and methods

The British Regional Heart Study covers 7735 men aged 40-59 years randomly selected from the age-sex registers of representative general practices in 24 British towns. The criteria for selecting the towns, the general practices, and the subjects as well as the methods of data collection have been presented in a separate report. In brief,
the 24 towns were primarily selected from those with populations of 50,000 to 100,000 (1971 census). They were chosen to represent the full range of cardiovascular disease mortality and included towns in all the major standard regions. The general practice selected in each town was required to have a social class distribution that reflected the social class distribution of the men of that town. Trained research nurses gave each man an extensive standard questionnaire that included questions on occupational history, smoking habits, and alcohol consumption.

Smoking habits were recorded as follows: never smoked, ex-cigarette smoker, pipe/cigar only, pipe/cigar smokers who were ex-cigarette smokers, and current cigarette smokers at four levels (1-19, 20, 21-39, >40/day). Alcohol consumption was recorded using questions on frequency, quantity, and type similar to those used in the General Household Survey. Eight drinking categories were used: non-drinkers, men drinking on special occasions or 1-2/month, men drinking at weekends (1-2, 3-6, or >6 drinks per day), and men drinking daily or on most days (1-2, 3-6, and >6 drinks per day). A "drink" was defined as half a pint of beer, a glass of wine, or a tot of spirits. To determine social class the longest held occupation of each man was coded and the men were then classified within one of the six social classes of the Office of Population Censuses and Surveys.

Blood lead analyses were carried out on 7378 men (95%) using flame microsampling atomic absorption spectroscopy with minor modifications to the original procedure: sample volumes were reduced to 6 µl; the wavelength was 217.0 nm; Al₂O₃ absorption tubes were used; and the absorption signals were integrated. The missing samples were mainly accounted for by clotting problems in the specimens. To ensure comparability of blood-lead results over the two years of this study, a strict internal quality control protocol was maintained and the quality of the analyses was assessed by participation in national and international quality assurance programmes. Since blood lead concentrations follow a log-normal distribution, the results were expressed in terms of geometric means.

**Results and comment**

Fig 1 shows the geometric mean blood lead concentrations with 95% confidence limits for men in each drinking category. Men drinking three or more drinks daily or on most days showed a pronounced increase in mean blood lead concentrations. For the men drinking more than six drinks daily (11% of all men) the mean blood lead was 30% higher than that seen in non-drinkers and occasional drinkers. There was also evidence of smaller increases in blood lead concentration for light daily drinkers and for moderate and heavy weekend drinkers.

![Graph showing blood lead concentration in middle-aged British men by alcohol consumption](image)

**Fig 1**—Blood lead concentration in middle-aged British men by alcohol consumption. ○ = Geometric mean and 95% confidence limits. ● = Geometric mean adjusted for smoking status, social class, and town of residence. (Occasional = special occasion or 1-2/month.)

Conversion: SI to traditional units—Lead: 1 µmol/l ≥ 20-1 µg/100 ml.

Fig 2 shows the mean blood lead concentrations by smoking categories. Those who had never smoked and those smoking only pipes or cigars showed the lowest blood lead concentrations. There was a small but significant increase in blood lead concentration in ex-cigarette smokers and in ex-cigarette smokers currently smoking pipes and cigars. For all categories of cigarette smoking the mean blood lead concentration was increased, and in heavy smokers (>40/day) it was 25% higher than in those who had never smoked. The combined effects of smoking and drinking were shown by comparing 229 men who smoked more than 20 cigarettes a day and drank more than 6 drinks a day with 423 men who had never smoked and drank who were occasional drinkers. The mean blood lead concentrations were 0·85 and 0·59 µmol/l (17·6 and 12·2 µg/100 ml) respectively, reflecting an increase of some 44% that was apparently produced by heavy smoking and drinking.

It is important to allow for other environmental and personal factors which might affect the blood lead concentration. Manual workers had a higher geometric mean blood lead concentration than non-manual workers (0·70 and 0·67 µmol/l (14·5 and 13·9 µg/100 ml) respectively) and there were considerable differences between towns in geometric mean blood lead concentrations (range 0·51 to 0·94 µmol/l (10·6-19·6 µg/100 ml)). We therefore used analysis of covariance to adjust the mean blood lead concentration in the several drinking groups for smoking status, social class, and the town of residence. The resulting adjusted mean blood lead values are also shown in fig 1. Similarly, for each smoking group the mean blood lead level was adjusted for drinking status, social class, and town of residence (fig 2).

These adjustments confirmed the simple (univariate) association between alcohol intake and blood lead concentration. Furthermore, this association was shown separately for each smoking category, each social class, and each town. The same applied to the association between cigarette smoking and blood lead concentration. Adjustment did, however, make some difference to the pattern of association. For example, fig 1 shows that those men drinking one or two drinks daily had an increased adjusted mean blood lead concentration. This was probably because drinking at this level is more common in areas of higher social class with more non-smokers and in towns with lower blood lead concentrations. In fig 2 the adjusted blood lead concentration was reduced in men smoking 40 or more cigarettes a day. This was probably because this group contained more heavy drinkers, more manual workers, and more towns with higher blood lead concentrations. The overall effect of the adjustments was to show that the association between smoking and drinking with blood lead could not be explained away by these other factors.

During the clinical survey tap water samples were collected from the homes of 941 men (12%), and lead concentrations were measured by the Water Research Centre, Medmenham. Fifty-three (5·6%) of the "first-draw" samples and 28 (3%) of the daytime samples contained more than 100 µg/l, the WHO recommended limit for lead in water.
and 12 (13%) first-draw samples were above the WHO first-draw limit of 300 μg/l. There is a well-established relationship between water lead and blood lead concentrations, and we therefore had to consider whether the associations seen with alcohol and smoking could have been attributed to variations in water lead concentration. In those men living in houses with low levels of water lead (<10 μg/l first draw) there was still a strong association between alcohol intake and blood lead concentration. In the smaller group of men living in houses with higher water lead levels, the same pattern of relationship between alcohol intake and blood lead concentration existed. These findings suggest that the relation between alcohol intake and blood lead concentration was independent of water lead levels. Similarly, the effect of cigarette smoking on blood lead concentration was independent of water lead levels. Age and body mass index (weight/height²) showed no association with blood lead.

The European Community directive 77/312 requires that in certain statutory surveys not more than 0.3% of the varying groups surveyed should have blood lead concentrations above 35 μg/100 ml (1.7 μmol/l). In this study 74 men (10%) had blood lead levels greater than 1.7 μmol/l. In men drinking more than six drinks daily 21% (17/804) had blood lead concentrations of over 1.7 μmol/l compared with 0.8% (2/1792) of those drinking occasionally or not at all.

Discussion

There is considerable interest in the measurement of blood lead concentrations in the community, as evidence has been brought forward to support relationships between the body burden of lead and various health problems. This evidence concerns in particular the intellectual functioning and behaviour patterns of children, but it has also been suggested that increased intakes of lead may be associated with renal disease and hypertension. A recent European Community directive requires that all member states undertake screening campaigns for lead in various population groups and provides reference levels which must be applied to the results of such surveys. Blood lead concentrations in the varying groups surveyed, the blood lead concentrations in the varying groups studied being determined in the main by dietary intake (including drinking water) and also by environmental sources such as lead in air derived from petrol. The relative contributions of these sources is disputed but a recent review concluded that lead emitted by traffic and directly inhaled was not a major source of pollution. Nevertheless, the indirect contribution of such lead (via food and dust) remains to be adequately assessed.

Our findings suggest that both alcohol and cigarette smoking are making significant independent contributions to blood lead concentrations in middle-aged men in British towns, and there are several ways in which this might be explained. A direct increase in lead intake from cigarettes and alcohol may be responsible. Cigarettes contain varying amounts of lead and smoking 20 a day has been estimated to result in the inhalation of 1-5 μg of lead. Nevertheless, the lead contribution from cigarette smoking is not considered to be great enough to increase the blood lead concentration above that found in non-smokers. In some industrial studies higher blood lead concentrations in smokers have been attributed to the transfer of lead from the fingers to the cigarette. Our study shows that cigarette smoking does make a significant independent contribution to the blood lead concentration but less than that associated with alcohol intake. The increased blood lead values in ex-cigarette smokers seem unusual but may be accounted for by the well-known propensity of many cigarette smokers to claim that they have given up smoking when they have not in fact done so.

The very limited information available in the United Kingdom on the lead content of alcoholic drinks indicates that wine has a mean lead content of 0.12 mg/kg and spirits, beer, and cider a mean content of 0.02 mg/kg. The recommended limit for lead in all alcoholic drinks is 0.2 mg/kg. More than half (56%) of the men in the Regional Heart Study drank only beer, a further 13% drank beer and spirits, and 11% drank spirits only. Seven per cent drank only wine or sherry, or both. When the blood lead data in this study were examined separately for men who drank beer only, those drinking spirits, and those drinking wine or sherry only, the pattern of relationships seen in fig 1 was similar for all three groups. This suggests that the increased blood lead concentration seen with increasing alcohol intake is not due to a specific beverage, for example, wine, and is thus probably not due to an increased intake of lead.

Alcohol in the diet may lead to increased absorption of lead from the bowel. There is no direct evidence for this in man, and animal studies suggest either that such an effect is very limited or that alcohol actually diminishes the absorption of lead from the gut. The metabolism of lead and calcium are closely related and calcium appears to reduce the intestinal absorption of lead. In Britain there are both individual and regional differences in the dietary intakes of calcium. There are also considerable variations between regions and towns in the content of lead in the drinking water, and it has been suggested that the availability of lead in hard water is low. In subjects receiving similar concentrations of lead in drinking water the blood lead concentrations are apparently lower in those living in hard water areas compared with those living in soft water areas. Since we have no information on total calcium intakes in individuals, we can approach this question only indirectly. In each of the 24 towns studied, towns presumably differing in their overall dietary patterns and calcium intakes, there was no evidence to suggest that the relation between calcium intake and blood lead concentration was independent of blood lead levels. Nevertheless, the indirect contribution of such lead (via food and dust) remains to be adequately assessed.

The possibility of a relationship between blood lead concentration and the amount of alcohol ingested has not previously been carefully examined, and most studies have been performed in industrial workers and have been only indirectly concerned with alcohol intake or relate to alcoholics with or without hepatic cirrhosis. Our findings suggest that alcohol may significantly change blood lead concentrations, particularly in adults drinking moderately or heavily every day. This phenomenon, together with the independent contribution to blood lead concentration from cigarette smoking, must be taken into account in assessing environmental exposure to lead. There is always the possibility that some confounding variable, other than those such as social class, concentrations of lead in drinking water, and the town of residence, has not been measured. Such an alternative explanation seems unlikely, given the strength of...
the associations for both alcohol and cigarette smoking and the consistency with which the same pattern was seen in each of the 24 towns in this study.

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Requests for reprints should be addressed to Professor A G Shaper.

ADDENDUM—Another Danish study in 40-year-old men and women substantially supports our British findings. Blood lead concentration increased with increasing alcohol consumption, independently of smoking habits. The independent effects of smoking were less significant.11

References
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