Lead levels on traffic-less islands

PETER C ELWOOD,¹ ROGER BLANEY,² ROBERT C ROBB,³ ANTHONY J ESSEX-CATER,⁴ BRIAN E DAVIES,⁵ AND COLIN TOOTHILL⁶

From the MRC Epidemiology Unit (South Wales),¹ Cardiff; Department of Community Medicine,² Queen's University, Belfast; Medical Officer, Sark, CI;³ Medical Officer of Health, Jersey, CI;⁴ Department of Geography,⁵ University of Wales, Aberystwyth; and Supra Regional Assay Service Laboratory,⁶ Leeds

SUMMARY Surveys were conducted on three traffic-less islands: Tory and Aran, off the coast of Ireland, and Sark, one of the Channel Islands off the coast of France. Identical methods were used in surveys in three other areas, all of which have heavy gasoline driven traffic. These were Jersey, another of the Channel Islands, Ebbw Vale—a mixed industrial area, and Cardiff—the capital city of Wales. Environmental lead levels were very low in two of the traffic-less islands, but on the third, house dust lead levels were comparable with levels found throughout Wales. Blood lead levels on one of the islands were similar to those which have been reported for unacculturated remote tribes, but on the other two traffic-less islands blood lead levels were comparable with those of areas on the mainland of Wales.

Surveys were conducted on three traffic-less islands. Inishmaan (Pop. 265), the middle of the three Aran Islands, is about 6 × 3 km and lies 48 km from Galway, off the west coast of Ireland. Farming, fishing, and a cottage knitting industry make the island virtually self sufficient. Tory (Pop. 115) is 6 × 2 km and lies 13 km off the north coast of Ireland. It has a little farming and fishing, but much of the food is brought over from the mainland. Sark (Pop. about 500) is one of the Channel Islands (CI), lying 100 km off the south coast of England and 35 km west of France. Of the three islands the way of life on Sark differs least from that of the mainland, while Aran and Tory are relatively unacculturated. None of these islands has ever had motor traffic. Aran has a few motor cycles, and for a very brief period a few years ago a nurse drove a car. Tory had a gasoline driven minibus for about a year. Sark has no motor vehicles, only bicycles, horse drawn vehicles, and diesel tractors.

In order to give a contrast with these traffic free islands, two identical surveys were conducted using identical methods. One of these was on Jersey (Resident Pop. 76 000), one of the main Channel Islands. This island is about 11 × km and has an intricate network of roads carrying heavy gasoline driven traffic. The second survey was in three northern electoral wards in Ebbw Vale and Tredegar at the north end of the Welsh industrial valleys. This area was chosen to represent a typical industrial and

residential area outside a major urban centre. Data from a third contrast area, Cardiff (Pop. 279 000), the capital city of Wales, are also presented. This had been surveyed as part of a study of five areas in Wales.¹

Method

The survey on Tory was conducted in October 1982. Participation of all the adult residents was invited and 63 (71%) co-operated. Aran was visited in April 1983, and all subjects aged between 19 and 55 years were asked to cooperate: 97 (94%) did so. On Sark, the resident Medical Officer (Dr R C Robb) obtained the cooperation of 71 adult subjects in January 1984. On Jersey, the Medical Officer of Health (Dr A J Essex-Cater) based the Survey on 50 male and 50 female office workers in February 1984. In Ebbw Vale and Tredegar a random sample of men was chosen from the electoral roll and these, and their wives, were visited in March 1984. Ninety four per cent cooperated. In Cardiff a random sample of women had been drawn from the electoral roll and visited in February 1983.¹

A sample of venous blood was taken from every subject. Environmental samples were taken as follows. Indoor air samples (2 litres per minute for 14 days) were taken at a single site on each of the three traffic-less islands. In Ebbw Vale, Jersey, and Cardiff samples were taken in the main living rooms of

Lead levels on traffic-less islands

random samples of subjects. Samples of soil were taken from the top 10 cm of earth in the gardens of random samples of subjects. A sample of dust from the household vacuum cleaner was requested or, if there was no such machine, the floor of the main living room of the dwelling was swept. The dust was dried and sieved (<1 mm) and lead was extracted with hot concentrated nitric acid. Water samples ("kettle samples") were taken at the time of the visit from the well supplying the dwelling or from the cold kitchen tap if there was a piped water supply. Only in Ebbw Vale and Cardiff were samples obtained from the dwelling of every subject; on the islands random subsamples of subjects were asked to cooperate.

Lead estimations were all by atomic absorption flame spectrophotometry. Our quality control procedure for blood lead includes the sending of occasional batches of 10–30 duplicate samples to the Supra Regional Assay Service Lead Laboratory in Southampton (Dr H T Delves). The difference between this laboratory and ours has always been trivial, and during the present surveys the mean difference in 29 duplicate estimates was $0.2 \mu\text{g/dl}$ or 3% of the mean level.

Results

The table summarises the results. Because of marked skewness in the distributions of environmental lead levels these were transformed, soil and dust to logarithms, water to cube roots. Indoor air lead levels

were very low on the islands. Indeed the figures shown are estimates based on samples, most of which had lead levels below the limit of detection (equivalent to about $0.006 \mu\text{g/m}^3$). Soil lead levels were low on the three traffic-less islands while the levels on Jersey were somewhat higher than in the Welsh areas. House dust levels were very low indeed on Aran and Tory, but on Sark, despite the absence of traffic, dust lead levels were comparable to those in the Welsh urban area. Water lead levels were low in all the areas, but we have shown elsewhere that even levels of water lead which are well below the recommended limits can make a significant contribution to blood.¹ There is a very marked range in the mean blood lead levels but these do not show a consistent pattern in relation either to industrialisation or to the degree of "remoteness". Thus blood lead levels on Sark are comparable with levels in Cardiff, and levels on Tory with those in Ebbw Vale. Nor is there consistency in the ranking of the mean blood lead levels and the levels in the environmental sources because of the inconsistencies which have been noted in the latter.

Discussion

There is little consensus among published reports regarding the levels of lead in the blood of remote unacculturated populations. In some of the very early studies in New Guinea, Brazil, and Africa, levels comparable with those of subjects in the USA were

Environmental and venous blood lead levels of representative population samples. For environmental sources means and 95% ranges derived from transformed data are shown, with numbers of samples in parentheses. For blood, means and standard deviations of untransformed data are shown, with numbers of subjects in parentheses

	Aran	Tory	Sark	Jersey	Ebbw Vale	Cardiff
Indoor air ($\mu\text{g/m}^3$)	0.009 (5)	0.011 (2)	0.021 (5)	0.027 (5)	0.040 (3)	0.272 (34)
Soil ($\mu\text{g/g}$)	62 55–68 (15)	87 83–92 (21)	59 27–128 (20)	431 31–5969 (14)	—	180 11–2883 (27)
Dust ($\mu\text{g/g}$)	36 6–231 (54)	41 9–178 (34)	203 53–773 (19)	284 58–1399 (14)	221 44–1103 (15)	209 44–998 (51)
Water ($\mu\text{g/l}$)	6 1–16 (12)	9 4–16 (20)	8 1–25 (19)	3 1–54 (14)	3 1–7 (36)	14 0–88 (54)
Blood ($\mu\text{g/l}$)						
Men	5.6 SD 2.1 (61)	9.0 SD 3.5 (39)	15.7 SD 7.7 (34)	13.1 SD 3.4 (52)	9.5 SD 2.4 (36)	—
Women	4.7 SD 1.4 (35)	7.0 SD 2.9 (23)	10.1 SD 2.8 (37)	11.0 SD 4.3 (48)	6.3 SD 2.5 (30)	13.3 SD 4.7 (56)

found, but these have been criticised on the grounds of lack of quality control and possible contamination.² However, more recent studies in Eskimos,³ in which quality control seems to have been adequate, have reported mean blood lead levels similar to those found in European industrialised areas (11 to 16 µg/dl in subgroups of 14–50 Eskimos).

On the other hand, low blood lead levels have been described in residents in the Anapurna foothills in Nepal.² Mean levels, based on capillary blood collected on to filter paper, were 3.8 and 2.9 µg/dl in 30 males and 30 females respectively. A study of 72 male and 28 female children aged 7–10 years in a remote area of Papua New Guinea also yielded low levels: 5.2, SD 2.5 and 5.0, SD 2.6 µg/dl.⁴ Additionally, exceedingly low levels, which appear to be quite unique in the literature, have been described in a group of 90 Yanomama Indians, a remote primitive tribe in South America. The mean blood lead level was 0.83, SD 0.59 µg/dl.⁵

The lowest blood lead levels found in our series of surveys were on Aran, the most remote of the islands. The mean levels there (5.6 in men, 4.8 µg/dl in women) are comparable with those in the children in Papua New Guinea and are only about 50% higher than those reported from Nepal. The levels on Tory, which is neither quite as remote nor as self sufficient as Aran, are about 50% higher (8.9 and 7.0 µg/dl). On the other hand, our series of mean blood lead levels from the various areas show a somewhat surprising pattern. The levels in Ebbw Vale, an industrial area, are closely similar to those in Tory, while Sark, a traffic-less island, had mean blood lead levels which are similar to those on Jersey and in Cardiff.

The pattern in the mean blood lead levels is not a simple reflection of the lead levels in the environmental sources we measured. The high concentration of lead in Jersey soil samples cannot be explained. While there is a general similarity between the rank order of the blood lead levels in the women (Aran < Ebbw Vale < Tory < Sark < Jersey < Cardiff) and that for dust lead, Cardiff is clearly

anomalous. Again, while the air lead concentrations are lower on the traffic free islands, compared with Jersey and the mainland, yet the rank order of the mean blood lead levels does not correspond. Smoking and drinking are likely to explain little, if any, of the observed differences in blood levels, and this is certainly true in women, very few of whom in any of the areas are likely to have smoked or drunk heavily. Perhaps the one difference which we can explain fairly confidently is the higher blood lead levels on Tory than on Aran: on Tory there is a fairly high consumption of canned foods.

In conclusion, neither geographic remoteness nor lack of exposure to ambient lead appear to explain the pattern shown in the blood lead levels in these population samples.

We express our grateful thanks to Nurse Máire de Bháil on Tory, and to Nurse Máire Mhic Giolla Phádraig on Aran, for their help in all aspects of the field work.

Correspondence to: Dr P C Elwood, MRC Epidemiology Unit, 4 Richmond Road, Cardiff CF2 3AS

References

- ¹Elwood PC, Gallacher JEJ, Phillips KM, Davies BE, Toothill C. Greater contribution to blood lead from water than from air. *Nature* 1984; **310**: 138–40.
- ²Piomelli S, Corash L, Corash MB, Seaman C, Mushak P, Glover B, Padget R. Blood lead concentrations in a remote Himalayan population. *Science* 1980; **210**: 1135–6.
- ³Hansen JC, Kromann N, Wulf HC, Albøge K. Human exposure to heavy metals in East Greenland: II. Lead. *Science of the Total Environment* 1983; **26**: 245–54.
- ⁴Poole C, Smythe LE. Blood lead levels in Papua New Guinea children living in a remote area. *Science of the Total Environment* 1980; **15**: 17–24.
- ⁵Hecker LH, Allen HE, Dinman BD, Neel J. Heavy metals levels in acculturated and unacculturated populations. *Archiv Environ Health* 1974; **29**: 181–5.