question mark on the anomalously low K–Ar date for the reversely magnetised Karau trachyte, which should lie within the range 0.71–0.91 Myr.

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Relationship of blood lead in women and children to domestic water lead

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Humans can be exposed to lead through food, drink, various occupations or hobbies and also some cosmetics[1,2]. The contribution of these different exposures to the total body uptake varies between individuals and groups but it is generally accepted that food and drink are the major sources of body lead[1]. On average, lead from water contributes markedly less to total intake than does lead from food[2]. It has been suggested, however, that when average lead in water rises above 0.1 mg l^{-1} the intake from water begins to match or exceed that from food[2]. We have previously reported[3] that the mean blood lead levels in mothers and children on a housing estate with lead water pipes were over twice as high as those on an adjacent estate using copper pipes. Here we report that the blood lead levels, even when raised, remained very stable when lead exposures were unchanged. The removal of the lead water pipes produced a drop of approximately 50% in mean blood lead levels, reducing them to levels comparable to those on the copper piped estate. No other changes in lead exposure could be found to explain the variations in blood lead levels between the estates, and therefore the possibility of the large contribution of water lead to blood lead should be considered where the conditions described below are known to occur.

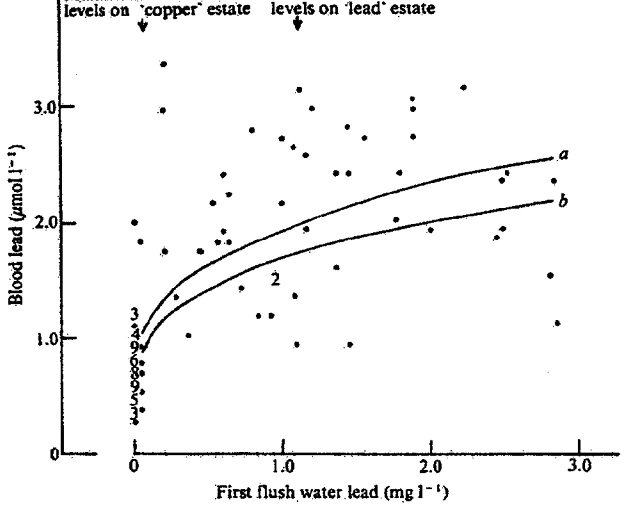

Fig. 1 Relation of blood lead (adult female) to first flush water lead in combined estates. (Numbers are coincidental points; 9 = 9 or more.) Curve *a*, present data; curve *b*, data of Moore *et al.*[7].

The two adjacent council housing estates are situated on the outskirts of a small rural town. The 'lead' estate was built in about 1935 and consists of 60 houses, 55 of which had 4–6 m of external lead piping and 26 of which also had 1–2 m of internal lead piping to the kitchen tap. Lead pipes to the remaining five houses had been replaced with copper before this study. The 'copper' estate comprises 75 houses (built in 1948) and 20 old peoples' maisonettes (built in 1968) and is entirely copper piped. Water for both estates is supplied from a small upland reservoir, and is soft (total hardness 13 mg l^{-1} $CaCO_3$), acidic (*p*H 5.6) and lead free at source.

Water samples (1.2 l polythene bottles; Water Research Centre (WRC) method[4]) were collected from the cold kitchen tap of each house on three occasions at 2-week intervals. The samples were 'daytime' (first water out of the tap at the time of visit), 'running' (after the tap has been running moderately for 5 min after the 'daytime' sample) and 'first flush' (first water out of the tap in the morning before any other water has been run to waste, collected by residents). Samples were acidified (5 ml 1 M HCl) within 12–24 h of collection. Lead estimations were carried out by a Welsh Water Authority (WWA) laboratory that had collaborated with the WRC in an inter-laboratory harmonisation study to establish reliable methods of analysis[4] and quality control[5].

Table 1 Relationships between three methods of water sampling and blood lead in 55 adult females and 39 children in the lead estate, and 60 females and 20 children in the copper estate

	Lead estate				Copper estate			
	Water lead (mg l^{-1}) FF	Day	Run	Blood lead (µmol l^{-1})	Water lead (mg l^{-1}) FF	Day	Run	Blood lead (µmol l^{-1})
Adult females								
Minimum	0.002	0.002	0.002	0.9	0.002	0.002	0.002	0.3
Median	1.075	0.568	0.139	1.9	0.004	0.003	0.003	0.7
Maximum	2.826	1.385	0.354	3.3	0.060	0.030	0.018	2.0
Children								
Minimum	0.002	0.002	0.002	1.0	0.002	0.002	0.002	0.4
Median	1.075	0.552	0.147	1.8	0.003	0.003	0.003	0.8
Maximum	2.826	1.276	0.354	3.2	0.060	0.020	0.018	2.2

Water samples were obtained from all dwellings except one which was vacant and therefore excluded. The proportion of eligible subjects providing blood samples: lead estate, adult females 96%, children 100%; copper estate (only two-thirds eligible subjects approached), adult females 95%, children 100%. Reproducibility of blood lead measurements: within laboratory c.v. 8.3% (75 blind duplicates); between laboratories, c.v. 12.4% (Leeds: London; 50 blind duplicates) and 10.2% (Leeds: Glasgow; 18 blind duplicates). Estimate of variation based on 'within sample' variance as distinct from 'between sample' variance. FF, First flush; Day, random daytime sample; Run, after 5 min running.

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Blood samples (adult: anticubital vein 2.5 ml into EDTA; young children: capillary) were taken from the adult female residents who spent most time in the house and usually from the youngest child. Lead estimations (including blind duplicates) were made by the NHS Supra-Regional Laboratory at Leeds, with sub-samples being analysed at London (Institute of Child Health) and Glasgow (Department of Materia Medica).

The overall water lead and blood lead levels measured are shown in Table 1. Blood lead levels were markedly higher in the lead estate than in the copper estate. This was true for both adults and children, and has been discussed elsewhere[3]. No subject had exposure to lead through occupation. Only one woman has a hobby (in this case, enamelling) which involved the use of lead. However, her blood lead level (1.5 μmol l^{-1}) was below the median level (1.9 μmol l^{-1}) found on the estate on which she lived, suggesting that this hobby did not involve a high exposure to lead.

Detailed analyses (not presented here) of the dependence of blood lead on water lead gave no evidence that any of the water sampling methods—'daytime', 'running' or 'first flush'—was a markedly better predictor of blood lead than the others.

The stability of blood lead within subjects is of interest in this kind of work[6]. We therefore examined this and found that, at least over a period of weeks, blood lead, even when raised, is extremely stable (Table 2).

Table 2 Stability of blood lead (μmol l^{-1}) over time in adult female subjects

Time interval	No. of subjects	Mean of first and second sample	Mean change (s.d.)	c.v. (%)
2 weeks	14	1.6	+0.07 (0.21)	9.7
4 weeks	19	1.8	−0.10 (0.17)	6.6
Over 12 weeks	12	0.8	0.00 (0.15)	13.1

No individual was included in more than one subgroup. Coefficients of variation based on 'within subject' variance. These are very similar to the within laboratory c.v. (see Table 1) which suggests that 'true' blood lead is very stable.

Following the removal of the lead pipes, water lead levels became indistinguishable within a few weeks from those on the copper estate. The fall in blood lead (Table 3) was determined in sub-samples of adult subjects examined up to 9 months after the lead pipes had been removed. The mean decrease after pipe removal was approximately 30% at 3 and 4 months and 50% at 6 and 9 months. The blood lead levels had thus become comparable to those on the copper piped estate in approximately 6 months. Changes in blood lead for a small number of controls on the copper estate were also measured and were negligible. No other changes in lead exposure were apparent during this time and therefore the reduction in water lead may be assumed to have produced the fall in mean blood lead levels observed.

Various empirical models (for example, simple linear, quadratic, square root, cube root) were used for regressing blood lead against water lead in our data. The curvilinear models gave a slightly better fit than the simple linear and Fig. 1 shows the regression line of blood lead on the cube root of first flush water lead. This empirical relationship was suggested by Moore and colleagues[7] from their Scottish data, and the line determined by their regression coefficients is also shown in Fig. 1. The similarity of the curves is interesting as our population sample is quite different from theirs. However, a close similarity between Welsh and Scottish data has also been pointed out previously[8].

The lead piped estate on which this work was based seems to be exceptional in terms of water lead levels. Over 70% of the houses had first flush water lead levels above 0.3 mg l^{-1} compared with less than 1% of the results for Wales in the survey carried out by the Department of Environment[2]. In conjunction with the WWA, we sampled drinking water from over 20 areas in North Wales considered by water boards to have a possible plumbo-solvency problem but no estate was found with lead levels approaching those reported here. It is therefore probable that we are reporting an exceptional case,

Table 3 Mean blood lead levels (μmol l^{-1}) of subgroups of adult females in the lead estate, and the fall in blood lead following removal of the lead pipes

Interval (months)	n*	Initial blood lead (s.d.)	Mean fall after pipe removal (s.d.)	% Mean decrease
3	13	2.2 (0.6)	0.7 (0.3)	32
4	11	1.7 (0.6)	0.6 (0.3)	35
6	10	2.2 (0.5)	1.1 (0.3)	50
9	11	2.3 (0.5)	1.1 (0.3)	48

* No individual included in more than one subgroup.

but water authorities should obviously ensure that no such estates exist within their areas. Where problems exist, removal of lead plumbing is a very effective remedy but other, more economic methods of plumbo-solvency control are being developed[9].

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Reappraisal of energetics of locomotion shows identical cost in bipeds and quadrupeds including ostrich and horse

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Animals use different amounts of energy to move from place to place depending on their size and mode of locomotion[1]. Flyers and swimmers use less energy to move a unit mass a unit distance than do running animals, and small animals use more energy than large ones. For terrestrial animals Taylor *et al.*[2] have defined cost of transport as the slope of the regression line relating weight-specific metabolic power and running speed. Cost of transport, so defined, is a comparative index of the relative energy-cost of locomotion of different animals. Fedak *et al.*[3] had reported that bipeds and quadrupeds have different costs and that, extrapolating from their data, the difference between them would be greatest among large animals. Now, after considering new data from 100-kg ostrich and horse, and reviewing the data collected in the past 5 yr, we find that there are no consistent differences in energy-cost between bipeds and quadrupeds of any size. The apparent differences reported earlier was biased by an unfortunate choice of animals. The new, much more extensive, evidence shows no difference of the scaling of energy requirements for locomotion between bipeds and quadrupeds, but suggests a difference between apparently clumsy and graceful animals.

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