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EFFECT OF SOIL AND DUST LEAD ON LEAD LEVELS IN CHILDREN

I have reviewed the Silver Valley and Omaha Lead Studies as you requested. These studies indicate that the lead concentration of the air, soil, and household dust all have a significant effect on the blood lead level of children. It appears, however, that soil and dust lead have larger effects and that the effect of air lead may be smaller for children, ages 1-5 years, than it is for older children. This suggests that hand-to-mouth transfer is the greatest source of lead exposure for children. This conclusion is supported by the studies of Roels, et al.

Unfortunately, the question, "How much of the lead in the soil and dust is due to fallout from the air?", remains unanswered. Low correlations between air lead and soil lead were observed in both studies (Silver Valley $r = 0.52$, Omaha $r = 0.37$).

A summary of my review of these studies is attached. Please let me know what further work you would like me to do on this subject.

ENGINEERING SERVICE DIVISION

R. D. Snee
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EFFECTS OF AIR LEAD, SOIL LEAD, AND HOUSEHOLD DUST LEAD ON BLOOD LEAD LEVELS IN CHILDREN

Summary

A review of the Silver Valley and Omaha lead studies was made to determine the importance of the affects of air lead, soil lead, and household dust lead on blood lead levels in children. It is concluded that all three variables have significant positive effects with the combined effects of soil lead and household dust lead being larger than the effect of air lead.

Although the two studies do not completely agree, there is evidence to suggest that household dust Pb is the most important source of lead for children ages 1-5 years. It also appears that the effects of soil lead and household dust lead on the blood lead level of older children are approximately equal in magnitude and larger than the effect of air lead.

The studies do not appear to answer the critical question of how much of the lead in the soil and household dust is due to fallout from the air.

Silver Valley Lead Study

This summary of the Silver Valley Lead Study is based on the reports of Yankel, et al (1977), Walter, et al (1980), and Snee (1982). It is concluded that the variables in order of importance are household dustiness, air lead, and soil lead (Table 1). In the 1974 study, the combined effects of household dustiness and soil lead (9.4 + 17.6% increase in blood Pb) is approximately 85 percent larger than that of air lead (14.6% increase in blood Pb).

The household dustiness effect was largest for ages 1-5 years while the soil lead effect was largest for ages 4-7 years. In 1974 the air lead effect was approximately the same for all ages 1-9 years; however, in 1975 no significant air lead effect was observed for children aged 1-3 years.

The correlation between blood lead level and the lead concentration of household paint or household dust was not statistically significant. The latter result, together with the significant correlation between blood lead and household dustiness, suggests that, in this study, the critical variable is the amount of household dust rather than the concentration of lead in the household dust.

Omaha Lead Study

This summary of the Omaha Lead Study is based on the report of Angle and McIntire (1979), the key results of which are summarized in Tables 2 and 3. I have some reservations concerning the data and associated the statistical analysis; however, the results, as reported, suggest the following conclusions:

- The blood lead levels of suburban children (mostly white in this study) are not affected by the air lead, soil lead, and household dust lead levels to which they were exposed (Table 2).
- The blood lead levels of urban children, ages 1-5 years (mostly black in this study), were due to household dust lead concentrations and not to air or soil lead (Table 2).

- The urban children, ages 6-18 years, showed significant correlations between blood lead and air lead, soil lead, and dust lead, with air lead having the smallest effect and the effects of soil and dust lead being larger and of approximately equal magnitude (Table 2).

- A multiple regression analysis of the combined urban and surburban data (Table 3) showed that

  - Air lead had no effect on the blood lead levels of the children, ages 1-5 years, and

  - All three variables had significant effects on the blood lead levels of the children, ages 6-18 years, with the following order of importance; soil lead, dust lead, air lead.

The effects on blood lead of air, soil, and dust lead observed in the Silver Valley and Omaha Lead Studies are summarized in Table 4. The results of the two studies are in general agreement with the exception that the air lead effect in the Omaha Study appears to be on the low side.

Comparison to Roels' Study

The results of the Silver Valley and Omaha Studies suggest that hand-to-mouth transfer is a more important route of lead exposure for children than air lead exposure. This conclusion is also supported by the work of Roels, et al (1980), who found that air lead had no significant effect on children's blood lead level when the lead concentration on the children's hands (PbH) was considered. Roels, et al (page 89), concluded "ingestion of lead from lead-contaminated hands is a much more important factor contributing to PbB (blood lead) than does PbA (air lead)".

Calculation of Percent Increase In Blood Lead

The following relationships were used to calculate the percent increase in blood lead summarized in Tables 1-4.

Semilog Model

$$\log Y = a + b \log X$$

where Y = blood lead
X = source of environmental lead
I = Increase in blood lead when X increases from X_1 to X_2

$$\%I = 100 \, (\exp [b(X_2 - X_1)] - 1)$$

Log-Log Model

$$\log Y = A + B \log X$$

$$\%I = 100[(X_2/X_1)^B - 1]$$

R. D. Snee
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Roels, H. A., et al (1980). Environmental Research, 22, 81-94.

Snee, R. D. (1982). J. Air Pollution Control Assn., 32, 170-175.

Walter S. D., et al (1980). Archives of Environmental Health, 35, 53-58.

Yankel, A. J., et al (1977). J. Air Pollution Control Assn., 27, 763-767.

TABLE 1

SILVER VALLEY LEAD STUDY - EFFECTS OF ENVIRONMENTAL LEAD

Variable	Variable Range	Study Year	Percent Increase in Blood Lead		
				Snee	
			Yankel, et al	All Data	Air Pb ≤ 10 $\mu g/m^3$
Air Lead	1.5-5.0 $\mu g/m^3$	1974	15.4	14.6	14.6
		1975	--	20.0	17.1
Soil Lead	500-1000 ppm	1974	1.6	4.6 NS	3.9 NS
		1975	--	1.4	1.4
	500-2000 ppm	1974	3.2	9.4 NS	7.9 NS
		1975	--	3.0	2.8
	500-5000 ppm	1974	9.9	16.1 NS	13.5 NS
		1975	--	5.0	4.7
Household Dustiness	Clean-Moderately Clean	1974	9.1	9.0 NS	8.0 NS
		1975	--	-2.8	-0.6
	Clean-Dirty	1974	19.0	17.6	16.3
		1975	--	16.9	21.3

NS = Variable has no significant effect on children's blood lead level.

TABLE 2

OMAHA LEAD STUDY - SINGLE VARIABLE REGRESSION RESULTS

Group	No. of Children	Log-Log Slope (b)*		
		Air Pb	Soil Pb	Household Dust Pb
1-18 years	1074	.0269	.1515	.1655
1-5 years	242	-.1331^{NS}	.2033	.2170
6-18 years	832	.0834	.1560	.1921
1-5 years				
Urban	204	-.1150^{NS}	.0417^{NS}	.1979
Suburban	38	-.0451^{NS}	.3074^{NS}	.0384^{NS}
6-18 years				
Urban	620	.0899	.1695	.2258
Suburban	212	-.0171^{NS}	.0231^{NS}	.0151^{NS}

*Model: Log Blood Lead = a + b Log X, where X = Air Pb, Soil Pb, or Household Dust Pb.

NS = Variable has no significant effect on children's blood lead level.

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TABLE 3

OMAHA LEAD STUDY - MULTIPLE REGRESSION RESULTS

Log Blood Pb = b_0 + b_1 Log Air Pb + b_2 Log Soil Pb + b_3 Log Dust Lead

Group	Air (b_1)	Soil (b_2)	Household Dust (b_3)
1-5 years[1]	NS	*	*
6-18 years	0.03	.10	.07
Variable Range	.04-1.66 $\mu g/m^3$	60-900 $\mu g/gm$	100-900 $\mu g/gm$
% Increase in Blood Pb	11.8	31.1	16.6

[1] Values of regression coefficients were not reported.
NS = Variable had no significant effect on children's blood lead level.
*A statistically significant effect on children's blood lead level was observed.

TABLE 4

COMPARISON OF THE RESULTS OF THE
SILVER VALLEY AND OMAHA LEAD STUDIES

Age Group	Study[a]	Percent Increased In Blood Pb		
		Air Lead 1.5-5.0 $\mu g/m^3$	Soil Lead 500-2000 ppm	Household Dust
1-5 years	Silver Valley (1974)	14.9[1]	10.2[2]	22.9[3]
	Omaha	NS	*	*
≥6 years	Silver Valley (1974)	14.3	9.1[2]	12.1[3]
	Omaha	3.7	14.9	16.6

[a] The Silver Valley (1974) results are based on an average of the regression coefficients found in Tables V and VI of Snee (1982).

[1] Air lead effect was 10.0% increase for ages 1-3 in 1975 (Snee 1982, Table VI).

[2] Soil Lead effect was not significant in 1975.

[3] Based on household dustiness variable.

NS = Variable had no significant effect on children's blood lead level.

*A statistically significant effect on children's blood lead level was observed.