"ASSESSMENT OF BLOOD LEAD LEVELS IN THE USA FROM NHANES II DATA",

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ASSESSMENT OF BLOOD LEAD LEVELS IN THE U.S.A. FROM NHANESII DATA

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ABSTRACT

Changing demographics of the subject groups at the 64 sites sampled during NHANESII accounts for over half the apparent 5.61 ug/dl blood lead decrease from 1976 to 1980. Site-specific gasoline lead exposure accounts for 0.51 ug/dl of the blood lead decrease, in agreement with the change expected due to the decrease of 0.32 ug/m^3 in average air lead and the accepted range $1 \leq \alpha \leq 2$ for blood lead response to air lead change.

INTRODUCTION

The U.S. Government's second National Health and Nutritional Examination Survey (NHANESII) was a cross-sectional study designed to assess national health status. Venous blood lead levels (BPb) were measured for 9,936 of the 20,333 examinees. Mobile caravan teams visited 64 sites in the contiguous U.S.A. and Hawaii between 1976 and 1980. A preliminary analysis reported a 36.7% reduction in BPb over the four-year study period and noted that the decrease in BPb reflects the decrease in national use of lead in gasoline production (ref 1).

Because the NHANESII sample was not selected to insure valid within-study time analyses, several categories of demographic variables were evaluated in the present study to examine their effect on the reported BPb decline. Three alternative measures of exposure to lead from gasoline were tested for their utility as indicators of BPb response. Finally, time was introduced to represent all other time-related BPb effects that may be present.

ADJUSTMENT FOR DEMOGRAPHICS

The effect of changing site demographics on the BPb time trend was investigated by classifying each examinee in terms of 6 personal variables (P) describing race, sex, age and family income, 3 residence variables (R) describing degree of urbanization, and 6 caravan itinerary variables (I) describing season of the year and region of the U.S.A. These classification variables assume a value of 1 if the descriptor applies to the examinee, 0 otherwise. Means were computed for each site based on examinee records with a venous BPb, and the 64 site means further analyzed.

Three BPb adjustments were evaluated corresponding to different selection sets of candidate explanatory terms for variation among site mean BPb's. The first set included the 6 P variables and their 15 two-way interactions; the second set added the 3 R variables to the first set; and, the third set added the 6 I variables to the second set. A weighted least squares stepwise regression procedure was applied to each full set of selection candidates. Weighting was by number of BPb values at each site.

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Terms were retained if their significance with BPb satisfied the $p < 0.15$ criterion.

Adjusted site mean BPb's were obtained by adding the weighted site mean BPb to the residuals from the final regression model. Each adjusted set of values, along with the unadjusted BPb's, then was regressed on site mean examination date. Values of BPb were predicted at the first and last site mean examination date in NHANESII to evaluate the influence of differential site demographics.

The results of the time analyses on the unadjusted and adjusted site mean BPb's are given in Table 1. They illustrate the confounding inherent among BPb, site demographics and time during the study period. Each group of demographic variables was able to explain some of the time trend with terms from the third selection set reducing the unadjusted decrease by more than half.

Table 1

Time Trend and Four Year Change of Blood Lead
Unadjusted and Adjusted for Demographics

	Time Trend		Remaining Four Year Decrease	
	ug/dl/yr	Std. Error	BPb, ug/dl	%
Unadjusted	-1.43	0.18	5.61	32.7
Adjusted for P	-1.09	0.18	4.29	26.0
for P and R	-0.74	0.17	2.92	18.4
for P, R and I	-0.57	0.14	2.26	14.5

ADJUSTMENT FOR GASOLINE LEAD AND DEMOGRAPHICS

Gasoline lead (GPb) is the best documented of the identified sources of lead which include food, water, paint and dust. National GPb use has been claimed to explain the decrease in unadjusted BPb (ref 2), and so was evaluated as one GPb exposure variable. National GPb use (tonnes) was computed from data by state on lead content and consumption of gasoline. To reflect site to site variation, a GPb density (tonnes/mi^2) for each site was computed by multiplying the relevant state GP use by the ratio of population in the site counties to state population, and dividing by land area of the site counties. The basis for this definition is the correlation between population and gasoline use (ref 3). Subsite GPb density was calculated similarly but based on each BPb examinee's residence characteristics. Applicable data permitted calculation of all 3 GPb exposures for 55 of the original 64 sites.

Mean BPb's from the 55 sites were adjusted as before for 5 selection sets, each containing all of the P,R and I demographic terms and one of the GPb exposure variables or its logarithm. The adjusted BPb's then were regressed on site mean examination date. These results, along with the significance levels of the GPb exposure terms, are given in Table 2. In all cases inclusion of a GPb term further reduced the BPb decrease from the 2.26 ug/dl unaccounted for by demographics. The remaining trend was consistent for all but national GPb use.

Table 2

Time Trend and Four Year Change of Blood Lead
Adjusted for Demographics and Gasoline Lead Exposure

GPb Exposure Variable	Signif. Level p	Time Trend ug/dl/yr	Time Trend Std. Error	Remaining Four Year Decrease BPb, ug/dl	Remaining Four Year Decrease %
National	$\leq$ 0.0001	-0.14	0.12	0.57	3.8
Site Density	$\leq$ 0.0001	-0.44	0.13	1.75	11.3
Subsite Density	0.0311	-0.47	0.12	1.85	11.9
Log (Site Density)	$\leq$ 0.0001	-0.52	0.13	2.05	13.1
Log (Subsite Density)	0.1076	-0.39	0.13	1.55	10.1

TIME-RELATED BLOOD LEAD EFFECTS

In the absence of credible and suitable data on lead sources besides gasoline, a time variable, reflecting site mean examination date, was adopted as a surrogate for other time-related BPb effects. A stepwise regression procedure was used on each of 5 selection sets again containing the full set of demographic terms, one of the GPb exposure variables and the surrogate, time. First, the model was forced to include both time and the GPb variable used; in companion analyses the selection of all terms was allowed to proceed solely on the basis of the inclusion criterion. As shown in Table 3, under both forced and unforced conditions the time variable was significant for all cases, but only Site GPb Density retained significance. When time is taken into account as a surrogate for unquantified time-related BPb effects, national GPb use is no longer significant. These results suggest other time-related BPb effects are present in NHANESII.

Table 3

Significance Levels of Gasoline Lead Exposure
and Time Terms in Models Including Demographics

GPb Exposure Variable	Forced: GPb Signif. Level	Forced: Time Signif. Level	Unforced: GPb Signif. Level	Unforced: Time Signif. Level
National	0.8850	$\leq$ 0.0001	NS	$\leq$ 0.0001
Site Density	0.0022	$\leq$ 0.0001	0.0022	$\leq$ 0.0001
Subsite Density	0.6276	$\leq$ 0.0001	NS	$\leq$ 0.0001
Log (Site Density)	0.0019	$\leq$ 0.0001	0.0019	$\leq$ 0.0001
Log (Subsite Density)	0.7520	$\leq$ 0.0001	NS	$\leq$ 0.0001

NS = Not Selected, $p > 0.15$

CONCLUSIONS

This analysis has shown that many factors related to personal and residence characteristics and sampling itinerary significantly affect NHANESII BPb values, and can account for 3.35 ug/dl of the apparent decrease between 1976 and 1980. Of the GPb exposure variables only Site GPb Density and its logarithm had a significant effect on BPb in the presence of the time surrogate. The portion of the four-year decrease due to Site GPb Density was determined by the analysis to be 0.5 ug/dl. This is consistent with the observed national average air lead decrease of 0.3 ug/m^3 over the same period (ref 4), and the well-documented air lead/blood lead relationship (ref 5,6). Figure 1 shows the relative contributions to the four-year blood lead decrease.

The unexplained portion of the BPb decrease, 1.75 ug/dl, is reflected by the time variable and may be due to improved sample handling over the course of the NHANESII study, effectiveness of numerous government programs to reduce lead intake through food, paint and water (ref 7), or other unquantified causes.

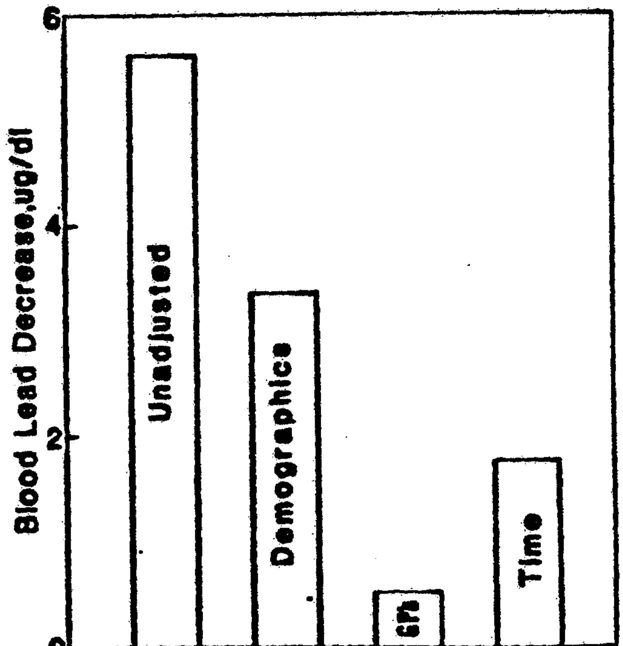

Fig.1 Contributions to Blood Lead Decrease,1976-80

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