

APPENDIX F

**COMPARISON AND CONTRAST OF RISK ESTIMATES FROM
THE HUD MODEL AND THE ROCHESTER MULTIMEDIA MODEL
DEVELOPED IN THE §403 RISK ANALYSIS**

Comparison and Contrast of Risk Estimates from the HUD Model and the Multimedia Models Developed in the §403 Risk Analysis

To determine how blood-lead concentration as predicted by the HUD model differs from that predicted by the Rochester multimedia model, the HUD model results presented in Tables 4 and 5 of Lanphear et al., 1998, were compared to results under the Rochester multimedia model given the same sets of input values considered in these two tables. HUD model results presented in this appendix were taken from these two tables. However, when interpreting how these results compare across the two models in this exercise, one should recall that the HUD model assumes that input environmental-lead levels are “true” levels. This is the result of measurement error adjustments made to this model, which were not made to the Rochester multimedia model. Thus, estimates under the Rochester multimedia model assume that environmental-lead levels input to the model are measurements that result from a risk assessment.

Tables 4 and 5 of Lanphear et al., 1998, reflected HUD model fits for all combinations of the following:

- Floor (wipe) dust-lead loadings of 1, 5, 10, 15, 20, 25, 40, 50, 55, 70, and 100 $\mu\text{g}/\text{ft}^2$
- Soil-lead concentrations of 10, 72, 100, 400, 500, 1000, 1500, 2000, and 4000 ppm.

These same input values were also considered in this exercise. This list includes the proposed §403 hazard standard for soil (2000 ppm) and national median levels (according to Lanphear et al., 1998) for floor dust-lead loading (5 $\mu\text{g}/\text{ft}^2$) and soil-lead concentration (72 ppm). In addition, for the Rochester multimedia model, a floor dust-lead loading of 50 $\mu\text{g}/\text{ft}^2$ (i.e., the proposed §403 hazard standard for floor-dust) and a soil-lead concentration of 400 ppm (i.e., the proposed §403 soil-lead level of concern) were added to the list of input values.

As the Rochester multimedia model requires window sill (wipe) dust-lead loading as input, a value of 27.5 $\mu\text{g}/\text{ft}^2$ was used. This value represents the national median dust-lead loading for window sills, as estimated within the §403 risk analysis using HUD National Survey data, with sampling weights updated to reflect the 1997 housing stock (the §403 risk analysis report) and Blue Nozzle vacuum dust-lead loadings converted to wipe-equivalents using conversion equations found in USEPA, 1997.

According to Lanphear et al., 1998, all HUD model fits assumed that maximum interior paint-lead concentration was set at 1.6 mg/cm^2 and water-lead concentration at 1 ppb; these values represented national median levels. The age of child was specified as 16 months (the mean age across all of the pooled data on which the model was developed), and values of categorical variables were taken to be the average across the population represented by the pooled data. The HUD model fits assumed no exposure to damaged paint, and exterior-lead exposures were estimated from dripline soil samples.

F.1 COMPARING THE ESTIMATED GEOMETRIC MEAN BLOOD-LEAD CONCENTRATIONS

Tables F-1 and F-2 present geometric mean blood-lead concentrations ($\mu\text{g/dL}$) under each combination of the floor dust-lead loading and soil-lead concentration values mentioned above, as predicted by the HUD model and the Rochester Multimedia model, respectively.

Table F-1. Geometric Mean Blood-Lead Concentrations ($\mu\text{g/dL}$), as Predicted by the HUD Model for Specified Values of Environmental-Lead Levels¹

Interior Floor Dust-Lead Loading ($\mu\text{g}/\text{ft}^2$) ²	Soil-Lead Concentration at the Foundation Perimeter (ppm)							
	10	72 ³	100	500	1000	1500	2000	4000
1	2.3	2.8	2.9	3.5	3.8	4.0	4.1	4.4
5 ³	3.2	4.0	4.1	4.9	5.3	5.5	5.7	6.1
10	3.7	4.6	4.7	5.6	6.1	6.3	6.5	7.1
15	4.0	5.0	5.1	6.1	6.6	6.9	7.4	7.7
20	4.2	5.3	5.4	6.5	7.0	7.3	7.6	8.1
25	4.4	5.5	5.7	6.8	7.3	7.7	7.9	8.5
40	4.9	6.1	6.3	7.5	8.1	8.4	8.7	9.4
55	5.2	6.5	6.7	8.0	8.6	9.0	9.3	10.0
70	5.5	6.8	7.0	8.4	9.1	9.5	9.8	10.5
100	5.9	7.3	7.6	9.0	9.7	10.2	10.5	11.3

¹ Taken from Table 4 of Lanphear et al., 1998. Table entries represent blood-lead concentrations for a 16-month old child (i.e., the mean age in HUD's pooled analysis). Water-lead concentration is assumed to be 1.0 ppb, an estimate of the national median as determined in Lanphear et al., 1998, from the pooled data and other sources. Maximum XRF paint-lead measurement is assumed to be 1.6 mg/cm², which is the median level based on data from the HUD National Survey. No exposure to damaged paint was assumed. The effects for other categorical model predictors (i.e., study, race, SES, mouthing behavior) were set to the arithmetic mean effect across the population represented by the study data.

² Assumes wipe dust collection techniques.

³ Estimated median level based on data from the HUD National Survey, as determined in Lanphear et al., 1998. The median wipe dust-lead loading was determined by converting Blue Nozzle vacuum loadings from the HUD National Survey to wipe-equivalent loadings using a conversion equation published in Farfel et al., 1994.

Table F-2. Geometric Mean Blood-Lead Concentrations ($\mu\text{g}/\text{dL}$), as Predicted by the Rochester Multimedia Model for Specified Values of Environmental-Lead Levels¹

Interior Floor Dust-Lead Loading ($\mu\text{g}/\text{ft}^2$) ²	Soil-Lead Concentration at the Drip Line (ppm)								
	10	72 ³	100	400	500	1000	1500	2000	4000
1	2.74	3.43	3.56	4.18	4.28	4.63	4.85	5.02	5.43
5 ³	3.05	3.82	3.96	4.64	4.76	5.15	5.40	5.58	6.04
10	3.19	4.00	4.15	4.86	4.99	5.40	5.65	5.84	6.32
15	3.28	4.11	4.26	4.99	5.12	5.54	5.80	6.00	6.49
20	3.34	4.18	4.34	5.09	5.22	5.65	5.92	6.11	6.61
25	3.39	4.25	4.41	5.16	5.30	5.73	6.00	6.20	6.71
40	3.50	4.38	4.55	5.33	5.46	5.91	6.19	6.40	6.92
50	3.55	4.45	4.61	5.40	5.54	6.00	6.28	6.49	7.03
55	3.57	4.47	4.64	5.44	5.58	6.04	6.32	6.53	7.07
70	3.63	4.55	4.72	5.53	5.67	6.13	6.43	6.64	7.19
100	3.72	4.65	4.83	5.66	5.80	6.28	6.58	6.80	7.36

¹ Window sill (wipe) dust-lead loading is assumed to be $27.5 \mu\text{g}/\text{ft}^2$, the median area-weighted household average determined from HUD National Survey data (after converting Blue Nozzle dust-lead loadings to wipe-equivalent loadings and after updating the sample weights to reflect the 1997 housing stock, using methods developed for the §403 risk analysis). The reported geometric means in this table equal $(0.91 * A + 0.09 * B)$, where A is the predicted geometric mean assuming $\text{PbP} = 0$ (i.e., no deteriorated lead-based paint or paint pica tendencies in the child -- see Section 3.2), and B is the predicted geometric mean assuming $\text{PbP} = 1.5$.

² Assumes wipe dust collection techniques.

³ Estimated median level based on data from the HUD National Survey, as determined in Lanphear et al., 1998. The median wipe dust-lead loading was determined by converting Blue Nozzle vacuum loadings from the HUD National Survey to wipe-equivalent loadings using a conversion equation published in Farfel et al., 1994.

At median environmental-lead levels, the HUD model and Rochester Multimedia model estimates are very similar. The HUD model estimate of $4.0 \mu\text{g}/\text{dL}$ is only 4.7% above the Rochester Multimedia model estimate of $3.82 \mu\text{g}/\text{dL}$. At the proposed §403 standards for floor-dust and soil ($50 \mu\text{g}/\text{ft}^2$ and 2000 ppm, respectively), the HUD model predicts a geometric mean blood-lead concentration of approximately $9.1 \mu\text{g}/\text{dL}$, which is 40% above the Rochester Multimedia model estimate ($6.49 \mu\text{g}/\text{dL}$).

To more easily observe how model estimates change as dust-lead and soil-lead levels vary, Figures F-1a and F-1b portray the information in Tables F-1 and F-2 graphically. For each model, the two figures demonstrate how predicted geometric mean blood-lead concentration

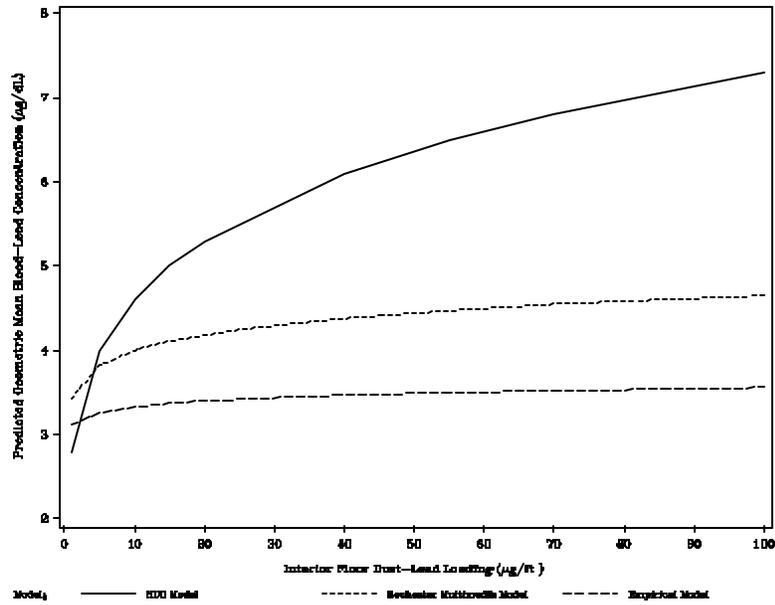


Figure F-1a. Predicted Geometric Mean Blood-Lead Concentration vs. Floor Dust-Lead Loading ($\mu\text{g}/\text{ft}^2$), Assuming Soil-Lead Concentration = 72 ppm
 (see footnotes to Tables F-1 and F-2)

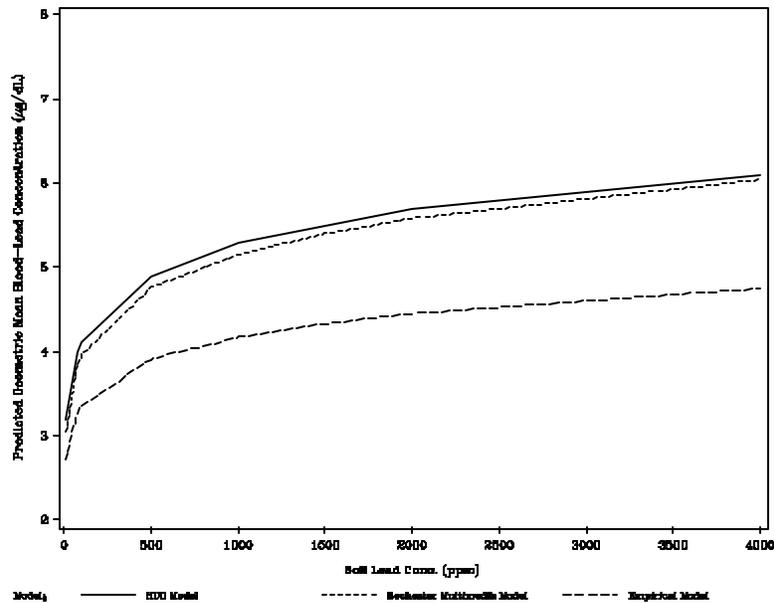


Figure F-1b. Predicted Geometric Mean Blood-Lead Concentration vs. Soil-Lead Concentration (ppm), Assuming Floor Dust-Lead Loading = $5 \mu\text{g}/\text{ft}^2$
 (see footnotes to Tables F-1 and F-2)

increases as either floor dust-lead loading (Figure F-1a) or soil-lead concentration (Figure F-1b) increases. While results for the empirical model (Section 4.2.5 of the §403 risk analysis report) are included in these figures, they should not be considered in the interpretation of results across models. In both figures, environmental-lead levels in media other than that specified on the horizontal axis are set at estimated national median levels, as indicated in the footnotes of Tables F-1 and F-2.

Figure F-1a shows that HUD model estimates become considerably higher than those for the Rochester multimedia model when floor dust-lead loadings increase. As floor dust-lead loading increases from 1 to 100 $\mu\text{g}/\text{ft}^2$ and other environmental media are at their estimated national median levels (e.g., soil-lead concentration = 72 ppm), predicted blood-lead concentrations under the HUD model increase three-fold. In contrast, estimates under the Rochester multimedia model increase by 35%. In the settings represented within Figure 3-1a, the HUD model estimates are similar to or lower than those for the Rochester multimedia model only at very low floor dust-lead loadings (i.e., less than 10 $\mu\text{g}/\text{ft}^2$). However, inferences at such low loadings must be done with extreme caution.

Figure 3-1b shows a different relationship than that seen in Figure 3-1a. In this plot, soil-lead concentration increases from 10 to 4000 ppm, but floor dust-lead loading is fixed at 5 $\mu\text{g}/\text{ft}^2$. In this setting, estimates between the HUD model and the Rochester multimedia model are nearly the same across the range of soil-lead concentrations. However, inferences at such a low floor dust-lead loading must be made with caution in these models.

The extent of difference in the predicted geometric mean blood-lead concentration between the HUD and Rochester multimedia model estimates gets larger as the assumed dust-lead loading increases and as soil-lead concentration decreases. Among the different combinations of dust-lead and soil-lead levels utilized in the model fits, the HUD model estimate differs greatly at the largest dust-lead loading (100 $\mu\text{g}/\text{ft}^2$) and the lowest soil-lead concentration (10 ppm), where this estimate (5.9 $\mu\text{g}/\text{dL}$) is a 59% increase over the Rochester multimedia model estimate (3.72 $\mu\text{g}/\text{dL}$).

F.2 Comparisons of the Estimated Percentage of Children With Blood-Lead Concentrations At or Above 10 $\mu\text{g}/\text{dL}$

When an estimated geometric mean (GM) from the previous sub-section is combined with an assumed geometric standard deviation (GSD) on the distribution of blood-lead concentration, and if this distribution is assumed to be lognormal, then the probability of observing blood-lead concentrations at or above 10 $\mu\text{g}/\text{dL}$ (the lowest blood-lead concentration considered elevated by the Centers for Disease Control and Prevention) is calculated as

$$P[\text{PbB} \geq 10] = 1 - \Phi\left(\frac{\ln(10) - \ln(\text{GM})}{\ln(\text{GSD})}\right)$$

where $\Phi(z)$ is the probability of observing a value less than z under the standard normal distribution. This sub-section presents estimates of this probability (expressed in percentage terms) under the estimated geometric means in Tables F-1 and F-2 and under three different assumptions on the geometric standard deviation (GSD):

- GSD=1.6, used to represent within-house variability in the §403 risk analysis
- GSD=1.72, assumed in Lanphear et al., 1998
- GSD=1.75, calculated from data in the Rochester Lead-in-Dust study

Tables F-3 and F-4 present the estimated percentages under the HUD model and the Rochester Multimedia model, respectively.

When GSD=1.72 and at estimated median environmental-lead levels, Tables F-3 and F-4 indicate that the estimated percentages are similar between the HUD model (4.56%) and the Rochester multimedia model (3.79%). While the similarity was expected given the similar geometric means observed in the previous sub-section, the HUD model estimate is approximately 20% higher than the Rochester multimedia model estimate, which is a higher rate of increase than the 4% increase observed in the estimated geometric mean. Furthermore, these estimates can change considerably with the GSD. For example, under GSD=1.6, the estimates are 45-55% lower (2.56% under the HUD model, 2.03% under the Rochester multimedia model) than their respective values under GSD=1.72.

Figures F-2a and F-2b portray how the estimated percentages of blood-lead concentrations at or above 10 $\mu\text{g}/\text{dL}$ increase as dust-lead and soil-lead levels, respectively, are increased. These estimates coincide with the geometric mean estimates plotted in Figures F-1a and F-1b and are calculated under the same underlying assumptions (i.e., national median levels are assumed for media not specified on the horizontal axis). Each figure contains three plots, one for each assumed GSD value.

Figure 3-2a shows that at an assumed soil-lead concentration of 72 ppm, the HUD model estimates become markedly increased as floor dust-lead loading increases to 100 $\mu\text{g}/\text{ft}^2$. At 100 $\mu\text{g}/\text{ft}^2$, the HUD model estimates from 25% to 29% of children have blood-lead concentrations at or above 10 $\mu\text{g}/\text{dL}$ (under GSD values from 1.6 to 1.75), while these estimates range from 5% to 9% under the Rochester multimedia model.

In contrast, Figure 3-2b shows that at an assumed floor dust-lead loading of 5 $\mu\text{g}/\text{ft}^2$, the HUD model and Rochester multimedia model provides nearly identical estimates of the probability at or above 10 $\mu\text{g}/\text{dL}$, across the entire range of soil-lead concentration (10-4000 ppm). This is due to the similar geometric mean estimates observed in Figure 3-1b. At this floor dust-lead loading and at GSD=1.72, the estimated probabilities range from approximately 1.5% to 18% under both models as the soil-lead concentration increases.

Table F-3. Percentage of Children with Blood-Lead Concentration At or Above 10 $\mu\text{g/dL}$, as Predicted by the HUD Model for Specified Values of Environmental-Lead Levels and Under Different Estimates for GSD¹

Interior Floor Dust-Lead Loading ($\mu\text{g}/\text{ft}^2$) ²	Soil-Lead Concentration at the Yard Perimeter (ppm)							
	10	72 ³	100	500	1000	1500	2000	4000
GSD = 1.6								
1	0.09	0.34	0.42	1.28	1.98	2.56	2.89	4.03
5	0.77	2.56	2.89	6.45	8.84	10.2	11.6	14.6
10	1.72	4.92	5.41	10.9	14.6	16.3	18.0	23.3
15	2.56	7.01	7.60	14.6	18.8	21.5	26.1	28.9
20	3.25	8.84	9.49	18.0	22.4	25.2	28.0	32.7
25	4.03	10.2	11.6	20.6	25.2	28.9	30.8	36.5
40	6.45	14.6	16.3	27.0	32.7	35.5	38.4	44.8
55	8.21	18.0	19.7	31.7	37.4	41.1	43.9	50.0
70	10.2	20.6	22.4	35.5	42.0	45.7	48.3	54.1
100	13.1	25.2	28.0	41.1	47.4	51.7	54.1	60.3
GSD = 1.72								
1	0.34	0.95	1.12	2.64	3.72	4.56	5.01	6.50
5	1.78	4.56	5.01	9.42	12.1	13.5	15.0	18.1
10	3.34	7.61	8.19	14.3	18.1	19.7	21.4	26.4
15	4.56	10.1	10.7	18.1	22.2	24.7	28.9	31.5
20	5.48	12.1	12.8	21.4	25.5	28.1	30.6	34.9
25	6.50	13.5	15.0	23.9	28.1	31.5	33.2	38.2
40	9.42	18.1	19.7	29.8	34.9	37.4	39.9	45.5
55	11.4	21.4	23.0	34.0	39.0	42.3	44.7	50.0
70	13.5	23.9	25.5	37.4	43.1	46.2	48.5	53.6
100	16.5	28.1	30.6	42.3	47.8	51.5	53.6	58.9
GSD = 1.75								
1	0.43	1.15	1.35	3.03	4.19	5.08	5.56	7.12
5	2.09	5.08	5.56	10.1	12.8	14.3	15.8	18.9
10	3.78	8.26	8.86	15.0	18.9	20.5	22.1	27.0
15	5.08	10.8	11.4	18.9	22.9	25.4	29.5	32.0
20	6.06	12.8	13.5	22.1	26.2	28.7	31.2	35.3
25	7.12	14.3	15.8	24.5	28.7	32.0	33.7	38.6
40	10.1	18.9	20.5	30.4	35.3	37.8	40.2	45.6
55	12.1	22.1	23.7	34.5	39.4	42.5	44.8	50.0
70	14.3	24.5	26.2	37.8	43.3	46.3	48.6	53.5
100	17.3	28.7	31.2	42.5	47.8	51.4	53.5	58.6

¹Footnotes are indicated within Table F-1.

Table F-4. Percentage of Children with Blood-Lead Concentration At or Above 10 $\mu\text{g}/\text{dL}$, as Predicted by the Rochester Multimedia Model for Specified Values of Environmental-Lead Levels and Under Different Estimates for GSD¹

Interior Floor Dust-Lead Loading ($\mu\text{g}/\text{ft}^2$) ²	Soil-Lead Concentration at the Drip Line (ppm)								
	10	72 ³	100	400	500	1000	1500	2000	4000
GSD = 1.6									
1	0.30	1.15	1.41	3.16	3.56	5.09	6.20	7.10	9.68
5	0.57	2.03	2.45	5.13	5.72	7.92	9.48	10.71	14.14
10	0.76	2.55	3.06	6.24	6.93	9.46	11.23	12.62	16.44
15	0.88	2.91	3.48	6.97	7.72	10.46	12.35	13.83	17.89
20	0.98	3.19	3.80	7.53	8.32	11.21	13.20	14.75	18.96
25	1.07	3.42	4.07	7.98	8.81	11.82	13.88	15.48	19.82
40	1.27	3.95	4.68	9.01	9.92	13.17	15.39	17.10	21.71
50	1.38	4.23	5.00	9.53	10.47	13.86	16.15	17.91	22.64
55	1.42	4.35	5.13	9.75	10.72	14.15	16.48	18.26	23.05
70	1.55	4.67	5.50	10.35	11.36	14.93	17.33	19.18	24.09
100	1.76	5.18	6.08	11.28	12.35	16.12	18.64	20.57	25.68
GSD = 1.72									
1	0.85	2.44	2.86	5.36	5.89	7.81	9.13	10.16	13.00
5	1.43	3.79	4.40	7.86	8.57	11.08	12.78	14.09	17.60
10	1.76	4.54	5.24	9.17	9.97	12.76	14.63	16.06	19.87
15	1.99	5.03	5.79	10.01	10.86	13.82	15.79	17.29	21.27
20	2.16	5.41	6.21	10.64	11.52	14.61	16.65	18.20	22.30
25	2.31	5.71	6.55	11.14	12.06	15.24	17.33	18.93	23.12
40	2.64	6.40	7.31	12.27	13.25	16.63	18.84	20.52	24.90
50	2.81	6.75	7.69	12.83	13.84	17.31	19.58	21.30	25.77
55	2.88	6.90	7.86	13.07	14.10	17.61	19.90	21.63	26.14
70	3.08	7.30	8.30	13.71	14.76	18.38	20.73	22.50	27.11
100	3.40	7.92	8.99	14.68	15.79	19.56	22.00	23.83	28.56
GSD = 1.75									
1	1.04	2.81	3.26	5.93	6.48	8.47	9.83	10.88	13.75
5	1.69	4.27	4.91	8.52	9.25	11.81	13.53	14.84	18.35
10	2.06	5.06	5.80	9.87	10.68	13.51	15.39	16.82	20.60
15	2.31	5.58	6.38	10.72	11.58	14.58	16.55	18.05	21.99
20	2.51	5.98	6.81	11.36	12.26	15.37	17.41	18.95	23.01
25	2.66	6.29	7.17	11.88	12.80	16.00	18.09	19.67	23.82
40	3.02	7.01	7.95	13.01	14.00	17.38	19.59	21.25	25.57
50	3.21	7.37	8.35	13.58	14.59	18.07	20.32	22.02	26.42
55	3.29	7.53	8.52	13.82	14.85	18.36	20.64	22.35	26.79
70	3.51	7.94	8.98	14.46	15.52	19.13	21.46	23.21	27.74
100	3.84	8.58	9.68	15.44	16.55	20.30	22.71	24.51	29.16

¹ Footnotes are indicated within Table F-2.

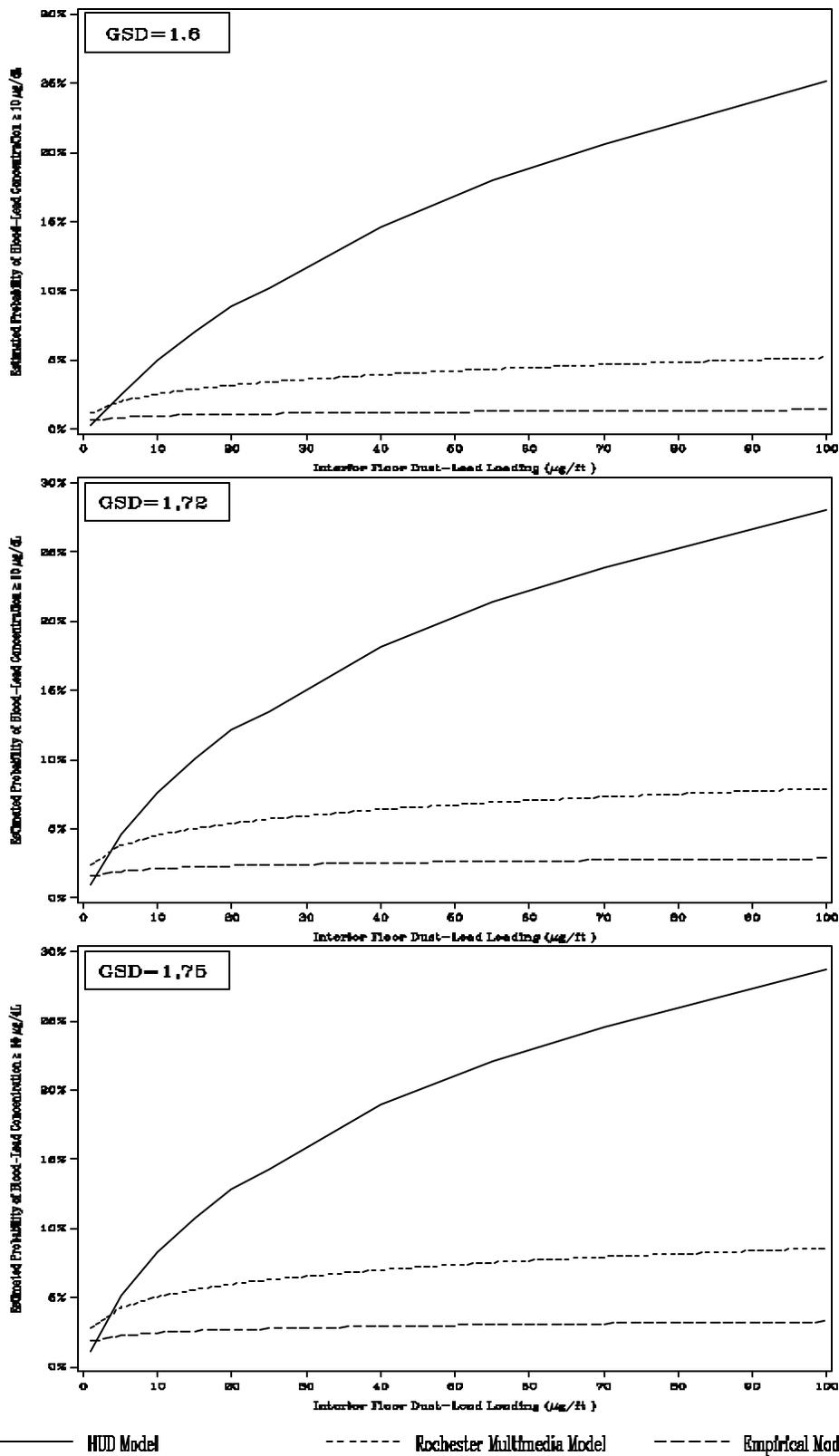
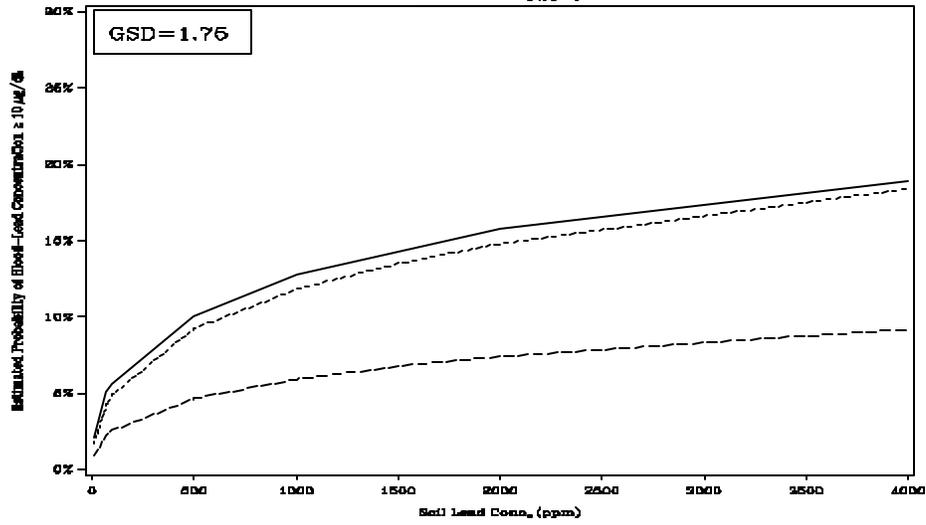
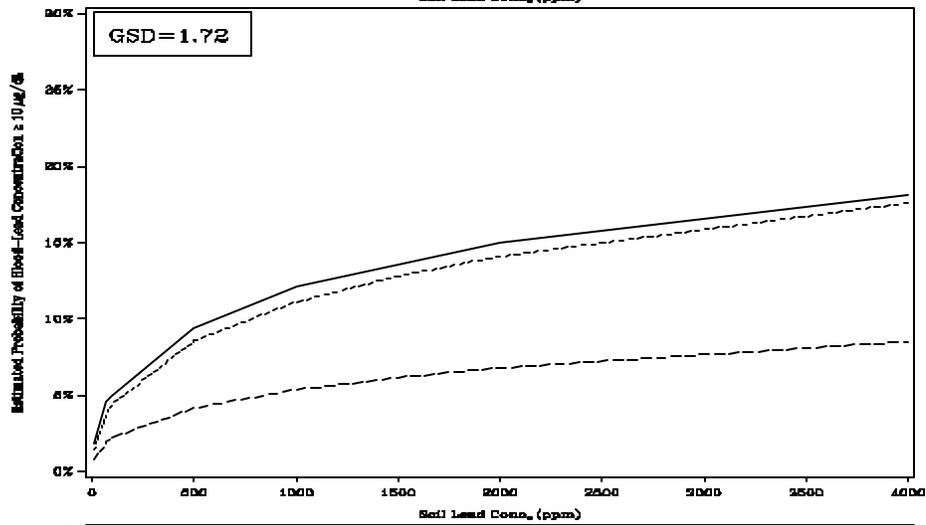
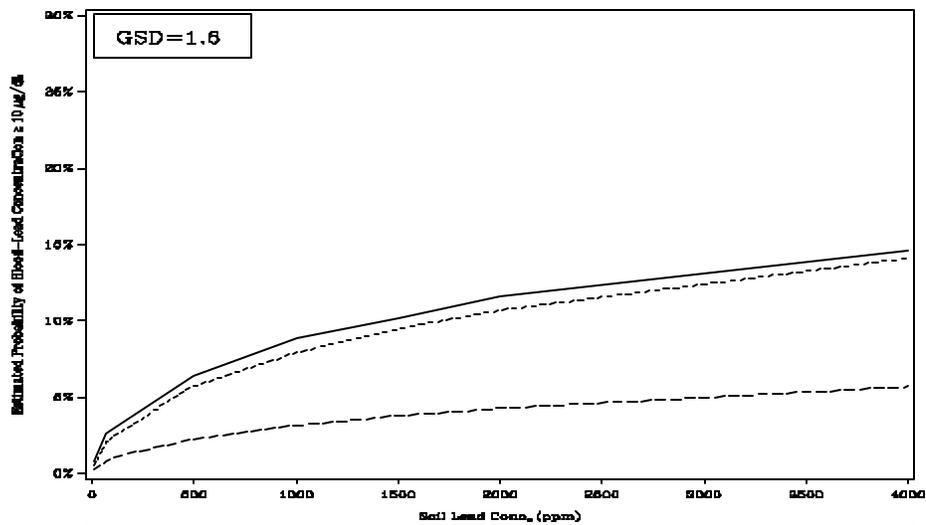


Figure F-2a. Predicted Percentage of Children with Blood-Lead Concentration At or Above 10 µg/dL vs. Floor Dust-Lead Loading (µg/ft²), Assuming Soil-Lead Concentration = 72 ppm (see footnotes to Tables F-1 and F-2)



Model: ——— HUD Model - - - - - Rochester Multimedia Model ····· Empirical Model

Figure F-2b. Predicted Percentage of Children with Blood-Lead Concentration At or Above 10 µg/dL vs. Soil-Lead Concentration (ppm), Assuming Floor Dust-Lead Loading = 5 µg/ft² (see footnotes to Tables F-1 and F-2)

Across Tables F-3 and F-4, the largest deviation in the estimated percentage of children with blood-lead concentration at or above 10 $\mu\text{g}/\text{dL}$ between the HUD model and the Rochester multimedia model exists at the lowest soil-lead concentration (10 ppm) and the highest floor dust-lead concentration (100 $\mu\text{g}/\text{ft}^2$). Here, the HUD model estimate (16.5%) is nearly five times that under the Rochester multimedia model (3.4%) when GSD=1.72.

Table F-5 presents the predicted geometric mean blood-lead concentration and percentage of children with blood-lead concentration at or above 10 $\mu\text{g}/\text{dL}$, at the proposed §403 hazard standards for floors and soil (50 $\mu\text{g}/\text{ft}^2$ and 2000 ppm, respectively). For the Rochester multimedia model, the window sill dust-lead loading is assumed to be 27.5 $\mu\text{g}/\text{ft}^2$ (the estimated national median). At these levels, the GSD assumption has less of an impact on the predicted percentages than was seen at national median levels. However, the HUD model predicts considerably higher percentages than the other.

Table F-5. Predicted Geometric Mean Blood-Lead Concentration and Percentage of Children with Blood-Lead Concentration At or Above 10 $\mu\text{g}/\text{dL}$, at the Proposed §403 Hazard Standards for Floors and Soil (50 $\mu\text{g}/\text{ft}^2$ and 2000 ppm, Respectively) and at a Window Sill Dust-Lead Loading of 27.5 $\mu\text{g}/\text{ft}^2$ (An Estimated Median Level for the Nation)

Model	Predicted Geometric Mean Blood-Lead Concentration ($\mu\text{g}/\text{dL}$)	Predicted Percentage of Children With Blood-Lead Concentrations At or Above 10 $\mu\text{g}/\text{dL}$		
		GSD = 1.6	GSD = 1.72	GSD = 1.75
HUD Model*	9.1	42%	43%	44%
Rochester Multimedia Model	6.49	17.9%	21.3%	22.0%

* Values are interpolated from results presented in Lanphear et al., 1998. This model does not use window sill dust-lead loading at an input value.