

SUPPLEMENTAL MATERIAL

Economic Costs of Childhood Lead Exposure in Low- and Middle-Income Countries

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Methods

Calculation of weighted means and standard deviations

For countries in which more than one study reporting blood lead concentration was available, after estimating BLL in 2008 using our regression model, we combined these estimates to derive a single, sample-size-weighted geometric mean, according to the method previously described by Fewtrell (Fewtrell et al. 2003; Fewtrell et al. 2004).

First, we weighted the data for sample size, by transforming BLL reported in each study into the natural logarithm and then multiplying by the sample size. These values were summed and divided by the total sample size, and from the natural antilogarithm of this average we then obtained the weighted BLL mean. With respect to standard deviations from different studies, these were combined using the same method but calculated as the variance (Fewtrell et al. 2003; Fewtrell et al. 2004). Below is a working example with BLL from Argentina.

Weighted Mean

Country	Sample size (N)	Mean BLL (A)	ln(A)	ln(A) * N
Argentina	74	3.3	1.19	88.35
Argentina	203	3.2	1.16	236.12
SUM	277			324.47
Log mean	1.17			
Weighted mean	3.23			

Weighted Standard Deviation

Country	Sample size (N)	SD	SD ²	ln(SD ²)	ln(SD ²)*N
Argentina	74	2.1	4.41	1.48	109.81
Argentina	203	1.56	2.4336	0.89	180.54
SUM	277				290.35
N/ln(SD ²)*N	1.05				
Square root	1.02				
Weighted SD	2.78				

Table S1. Sources of Blood Lead Data

Country	Subregion	Year of study	Mean BLL [µg/dl]	Standard Deviation [µg/dl]	Sample Size	Sex	Age or age group	Author source
Kenya	Eastern Africa	2008	5.99	2.42	387	Both	6-59months	Olewe et al
Kenya	Eastern Africa	2008	5.9	4.9	120	Both	≤20yrs	Njoroge et al
Uganda	Eastern Africa	2010	7.15	5.29	163	Both	4-8yrs	Graber et al
Egypt	Northern Africa	2000	22.13	8.56	30	Both	6-12yrs	Omar et al
Egypt	Northern Africa	2000	14.2	3.65	30	Both	6-12yrs	Omar et al
Egypt	Northern Africa	2002	4.81	2.97	79	Both	3-15yrs	Sharaf et al
Morocco	Northern Africa	2008	7.1		39	Both	7-14yrs	Hruba et al
Botswana	Southern Africa	2007	8.8	5.6	213	Both	1-6yrs	Mbongwe et al
South Africa	Southern Africa	2007	7.9	4.3	1581	Both	5-12yrs	Mathee et al
South Africa	Southern Africa	2003	5.7		1546	Both	13yrs	Naicker et al
South Africa	Southern Africa	2002	6.4		429	Both	7yrs	Mathee et al
South Africa	Southern Africa	2003	5.5	2.33	98	Both	5-12yrs	Norman et al
South Africa	Southern Africa	2000	7.5	3.31	1166	Both	0-4yrs	Norman et al
South Africa	Southern Africa	2000	13.2	3.5	68	Both	6-10yrs	Von Schirnding et al
Nigeria	Western Africa	2007	9.4	4.2	306	Both	1-6yrs	Ogunseitan et al
Nigeria	Western Africa	2007	8.9	4.8	653	Both	2-9yrs	Nriagu et al
Nigeria	Western Africa	2004	11.2		64	Both	0-5yrs	Wright et al
China	Eastern Asia	2008	8.07		94,778	Both	0-14yrs	He et al
China	Eastern Asia	2005	6.35	2.66	1575	Both	3-5yrs	Liu et al
China	Eastern Asia	2004	6.38		938	Both	0-7yrs	Jiang et al
China	Eastern Asia	2006	4.67		44,045	Both	0-6yrs	Zhang et al
China	Eastern Asia	2007	6.4	2.6	846	Both	10-18yrs	Zhou et al
China	Eastern Asia	2001	9.68		2,262	Both	0-6	Chen et al
China	Eastern Asia	2007	7.12	4.68	61	Both	<15yrs	Lin et al
Bangladesh	Southern Asia	2000	15		779	Both	4-12yrs	Kaiser et al
Bangladesh	Southern Asia	2008	2.47	3.32	57	Both	6 months to 12 yrs	Mitra et al
Bangladesh	Southern Asia	2008	7.24	6.31	183	Both	6 months to 12 yrs	Mitra et al
Bangladesh	Southern Asia	2009	12.13		919	Both	7 months to 12 yrs	Mitra et al
India	Southern Asia	2009	11.8		195	Both	9-14yrs	Srinivasa et al
India	Southern Asia	2006	9.32	6.21	200	Both	3-12yrs	Ahamed et al
India	Southern Asia	2003	8.36	5.23	754	Both	<12yrs	Nichani et al
India	Southern Asia	2006	11.47	5.33	756	Both	3-7yrs	Roy et al
India	Southern Asia	2009	7.47		100	Both	3-5yrs	Chaudhary et al

Country	Subegion	Year of study	Mean BLL [µg/dl]	Standard Deviation [µg/dl]	Sample Size	Sex	Age or age group	Author source
Pakistan	Southern Asia	2000	15.6		400	Both	36-60months	Rahbar et al
Pakistan	Southern Asia	2000	16.08	6.29	138	Both	6-10yrs	Rahman et al
Pakistan	Southern Asia	2000	6.48	2.71	123	Both	1-6yrs	Khan et al
Sri Lanka	Southern Asia	2003	4.33	1.81	40	Both	1-15yrs	Senanayake et al
Indonesia	South-Eastern Asia	2001	8.6		423	Both	6-12yrs	Albalak et al
Philippines	South-Eastern Asia	2004	6.9	7.7	2861	Both	6-59months	Riddell et al
Thailand	South-Eastern Asia	2010	7.71	4.62	213	Both	3-7 yrs	Neesanan et al
Thailand	South-Eastern Asia	2004	5.65	3.05	296	Both		Chomchai et al
Jordan	Western Asia	2000	3.22		382	Both	2-6yrs	Safi et al
Occupied Palestinian Territory	Western Asia	2000	4.2	3.36	344	Both	2-6yrs	Safi et al
Turkey	Western Asia	2002	3.56	1.7	180	Both	1-17yrs	Kirel et al
Turkey	Western Asia	2000	8.4		760	Both	11-13yrs	Ozden et al
Turkey	Western Asia	2001	3.67	3.88	587	Both	2-16yrs	Kismet et al
Yemen	Western Asia	2008	3.68	2.57	60	Both	6mo-6yrs	Alhemiary et al
Belize	Central America	2002	4.94	2.46	164	Both	2-8yrs	Charalambous et al
Mexico	Central America	2000	5	2.9	455	Both	2yrs	Claus Henn et al
Mexico	Central America	2002	6.2	1.5	34	Both	6-10yrs	Schnaas et al
Mexico	Central America	2000	4.9	1.6	100	Both	1-10yrs	Schnaas et al
Argentina	South America	2006	3.78		74	Both	6mo-5yrs	Disalvo et al
Argentina	South America	2000	5.2	0.5	203	Both	13mo-5yrs	Garcia et al
Brazil	South America	2006	6.2	4	97	Both	0-5yrs	Ferron et al
Brazil	South America	2008	1.48	1.2	48	Both	1-<11yrs	Menezes-Filho et al
Brazil	South America	2009	2.4		444	Both	6-8yrs	Costa de Almeida et al
Brazil	South America	2008	5.5	2.34	62	Both	0-16yrs	Oliveira da Costa Mattos et al
Brazil	South America	2000	3.05	1.96	200	Both	8-12yrs	Alvarez-Leite et al
Colombia	South America	2004	4.74		189	Both	5-9yrs	Olivero-Verbel et al
Colombia	South America	2010	3	1.2	194	Both	6-14yrs	Filigrana et al
Ecuador	South America	2010	3.17		69	Both	7-11yrs	Hrubá et al
Peru	South America	2002	3.3	1.65	26	Both	3-12yrs	Naeher et al
Peru	South America	2010	8.4	3.7	120	Both	0-17yrs	Anticona et al
Uruguay	South America	2004	5.7	2.3	180	Both	0-15yrs	Cousillas et al
Uruguay	South America	2007	9	6	222	Both	5-45mo	Queirolo et al
Uruguay	South America	2010	5.7	2.8	88	Both	13-55mo	Kordas et al
Uruguay	South America	2003	9.4	2.9	112	Both	2-14yrs	Cousillas et al

Country	Subegion	Year of study	Mean BLL [$\mu\text{g/dl}$]	Standard Deviation [$\mu\text{g/dl}$]	Sample Size	Sex	Age or age group	Author source
Venezuela	South America	2000	11.62		243	Both	1-12yrs	Rojas et al
Jamaica	Caribbean	2005	4.35		1081	Both	2-6yrs	Lalor et al

Table S2. Total PPP GDP, lost LEP and corresponding percentage of GDP lost to lead-attributable IQ loss in Africa, Asia, and Latin America & the Caribbean.

Country	Region	Subregion	Total PPP GDP (\$)	Lost LEP per each 1-year cohort of under 5yrs (\$)	% of GDP lost to lead-attributable IQ loss
Burundi	Africa	Western Africa	5,214,000,000	179,785,229	3.45
Comoros	Africa	Western Africa	843,000,000	49,635,805	5.89
Djibouti	Africa	Western Africa	1,997,000,000	108,961,500	5.46
Eritrea	Africa	Western Africa	3,189,000,000	169,339,796	5.31
Ethiopia	Africa	Western Africa	94,604,000,000	4,474,799,004	4.73
Kenya	Africa	Western Africa	71,498,000,000	3,759,544,820	5.26
Madagascar	Africa	Western Africa	20,725,000,000	1,187,707,142	5.73
Malawi	Africa	Western Africa	14,124,000,000	878,020,196	6.22
Mauritius	Africa	Western Africa	18,677,000,000	402,814,536	2.16
Mozambique	Africa	Western Africa	23,499,000,000	1,354,089,047	5.76
Rwanda	Africa	Western Africa	13,691,000,000	789,725,385	5.77
Somalia	Africa	Western Africa	Not Available	370,908,871	
Uganda	Africa	Western Africa	46,730,000,000	3,541,522,830	7.58
Tanzania	Africa	Western Africa	68,218,000,000	4,135,136,684	6.06
Zambia	Africa	Western Africa	21,870,000,000	1,441,579,133	6.59
Zimbabwe	Africa	Western Africa	Not Available	297,764,292	
Botswana	Africa	Southern Africa	29,959,000,000	1,492,620,701	4.98
Lesotho	Africa	Southern Africa	3,762,000,000	167,728,418	4.46
Namibia	Africa	Southern Africa	15,863,000,000	708,437,400	4.47
South Africa	Africa	Southern Africa	558,216,000,000	17,708,263,135	3.17
Swaziland	Africa	Southern Africa	6,512,000,000	268,349,295	4.12
Benin	Africa	Western Africa	14,813,000,000	861,084,536	5.81
Burkina Faso	Africa	Western Africa	22,220,000,000	1,376,581,795	6.20
Cape Verde	Africa	Western Africa	2,064,000,000	75,357,268	3.65
Cote d'Ivoire	Africa	Western Africa	36,338,000,000	1,761,748,023	4.85
Gambia	Africa	Western Africa	3,793,000,000	150,083,277	3.96
Ghana	Africa	Western Africa	47,035,000,000	2,150,990,737	4.57
Guinea	Africa	Western Africa	11,534,000,000	670,831,259	5.82
Guinea-Bissau	Africa	Western Africa	1,936,000,000	105,574,120	5.45
Liberia	Africa	Western Africa	2,382,000,000	105,824,893	4.44
Mali	Africa	Western Africa	17,401,000,000	1,150,230,877	6.61
Mauritania	Africa	Western Africa	9,106,000,000	359,280,161	3.95
Niger	Africa	Western Africa	11,763,000,000	809,070,406	6.88
Nigeria	Africa	Western Africa	411,372,000,000	16,218,372,547	3.94
Senegal	Africa	Western Africa	25,288,000,000	1,491,856,637	5.90
Sierra Leone	Africa	Western Africa	5,260,000,000	297,503,901	5.66
Togo	Africa	Western Africa	6,414,000,000	319,422,821	4.98
Angola	Africa	Middle Africa	116,345,000,000	7,667,370,737	6.59
Cameroon	Africa	Middle Africa	47,738,000,000	2,520,424,705	5.28
Central African Republic	Africa	Middle Africa	3,661,000,000	185,048,267	5.05
Chad	Africa	Middle Africa	17,645,000,000	990,098,783	5.61
Congo	Africa	Middle Africa	18,337,000,000	990,089,075	5.40
DRC	Africa	Middle Africa	25,440,000,000	1,524,789,582	5.99
Gabon	Africa	Middle Africa	24,487,000,000	1,041,752,895	4.25
Sao Tome & Principe	Africa	Middle Africa	347,000,000	16,164,879	4.66
Algeria	Africa	Northern Africa	313,552,000,000	11,832,235,381	3.77
Egypt	Africa	Northern Africa	521,964,000,000	17,786,045,188	3.41

Country	Region	Subregion	Total PPP GDP (\$)	Lost LEP per each 1-year cohort of under 5yrs (\$)	% of GDP lost to lead-attributable IQ loss
Libya	Africa	Northern Africa	105,555,000,000	4,510,938,345	4.27
Morocco	Africa	Northern Africa	163,659,000,000	5,647,046,979	3.45
Sudan	Africa	Northern Africa	95,555,000,000	4,936,802,415	5.17
Tunisia	Africa	Northern Africa	100,496,000,000	3,666,261,844	3.65
China	Asia	Eastern Asia	11,379,182,000,000	227,193,796,810	2.00
Mongolia	Asia	Eastern Asia	13,340,000,000	490,771,006	3.68
Afghanistan	Asia	Southern Asia	41,328,000,000	2,740,680,604	6.63
Bangladesh	Asia	Southern Asia	269,127,000,000	15,877,470,243	5.90
Bhutan	Asia	Southern Asia	4,289,000,000	154,908,540	3.61
India	Asia	Southern Asia	4,533,919,000,000	236,075,873,647	5.21
Iran	Asia	Southern Asia	839,572,000,000	29,127,897,851	3.47
Nepal	Asia	Southern Asia	38,302,000,000	1,533,245,125	4.00
Pakistan	Asia	Southern Asia	488,420,000,000	37,849,991,695	7.75
Sri Lanka	Asia	Southern Asia	117,282,000,000	1,761,117,825	1.50
Kazakhstan	Asia	Southern Asia	218,393,000,000	8,179,244,100	3.75
Kyrgyzstan	Asia	Southern Asia	13,348,000,000	463,057,489	3.47
Tajikistan	Asia	Southern Asia	16,327,000,000	830,269,327	5.09
Turkmenistan	Asia	Southern Asia	46,889,000,000	1,468,564,391	3.13
Uzbekistan	Asia	Southern Asia	97,116,000,000	3,757,477,351	3.87
Cambodia	Asia	South-Eastern Asia	33,925,000,000	1,294,491,599	3.82
Indonesia	Asia	South-Eastern Asia	1,131,166,000,000	37,898,249,791	3.35
Lao PDR	Asia	South-Eastern Asia	17,664,000,000	719,501,628	4.07
Malaysia	Asia	South-Eastern Asia	449,876,000,000	11,820,685,513	2.63
Myanmar	Asia	South-Eastern Asia	Not Available	3,158,364,032	
Philippines	Asia	South-Eastern Asia	392,679,000,000	15,019,373,494	3.82
Thailand	Asia	South-Eastern Asia	605,019,000,000	12,522,675,327	2.07
Timor-Leste	Asia	South-Eastern Asia	1,868,000,000	73,329,137	3.93
Vietnam	Asia	South-Eastern Asia	301,728,000,000	7,718,516,082	2.56
Armenia	Asia	Western Asia	18,071,000,000	413,769,244	2.29
Azerbaijan	Asia	Western Asia	92,927,000,000	2,490,181,420	2.68
Georgia	Asia	Western Asia	24,684,000,000	427,255,280	1.73
Iraq	Asia	Western Asia	128,237,000,000	7,565,979,730	5.90
Jordan	Asia	Western Asia	37,130,000,000	466,412,076	1.26
Lebanon	Asia	Western Asia	62,650,000,000	1,588,855,198	2.54
Syria	Asia	Western Asia	107,584,000,000	5,043,120,306	4.69
Turkey	Asia	Western Asia	1,288,638,000,000	22,116,719,752	1.72
Yemen	Asia	Western Asia	58,257,000,000	2,090,616,995	3.59
Belize	Latin America & the Caribbean	Central America	2,397,000,000	51,554,488	2.15
Costa Rica	Latin America & the Caribbean	Central America	57,836,000,000	1,325,312,244	2.29
El Salvador	Latin America & the Caribbean	Central America	42,829,000,000	1,305,258,131	3.05
Guatemala	Latin America & the Caribbean	Central America	73,216,000,000	3,289,701,595	4.49
Honduras	Latin America & the Caribbean	Central America	31,530,000,000	1,202,295,126	3.81
Mexico	Latin America & the Caribbean	Central America	1,752,883,000,000	32,582,356,784	1.86
Nicaragua	Latin America & the Caribbean	Central America	17,263,000,000	623,283,948	3.61

Country	Region	Subregion	Total PPP GDP (\$)	Lost LEP per each 1-year cohort of under 5yrs (\$)	% of GDP lost to lead-attributable IQ loss
Panama	Latin America & the Caribbean	Central America	56,051,000,000	1,607,463,745	2.87
Argentina	Latin America & the Caribbean	South America	720,488,000,000	9,781,430,507	1.36
Bolivia	Latin America & the Caribbean	South America	51,751,000,000	1,699,222,188	3.28
Brazil	Latin America & the Caribbean	South America	2,304,646,000,000	33,024,539,420	1.43
Chile	Latin America & the Caribbean	South America	298,947,000,000	6,446,169,908	2.16
Colombia	Latin America & the Caribbean	South America	474,113,000,000	8,906,102,580	1.88
Ecuador	Latin America & the Caribbean	South America	124,462,000,000	2,458,673,422	1.98
Guyana	Latin America & the Caribbean	South America	2,599,000,000	72,269,649	2.78
Paraguay	Latin America & the Caribbean	South America	35,590,000,000	1,261,327,670	3.54
Peru	Latin America & the Caribbean	South America	303,342,000,000	10,724,435,709	3.54
Suriname	Latin America & the Caribbean	South America	4,140,000,000	123,286,437	2.98
Uruguay	Latin America & the Caribbean	South America	51,140,000,000	1,339,509,882	2.62
Venezuela	Latin America & the Caribbean	South America	375,815,000,000	20,352,716,902	5.42
Dominican Republic	Latin America & the Caribbean	Caribbean	99,186,000,000	3,154,090,570	3.18
Grenada	Latin America & the Caribbean	Caribbean	1,173,000,000	33,813,602	2.88
Haiti	Latin America & the Caribbean	Caribbean	11,940,000,000	439,851,115	3.68
Jamaica	Latin America & the Caribbean	Caribbean	21,851,000,000	387,445,439	1.77
Saint Lucia	Latin America & the Caribbean	Caribbean	1,652,000,000	53,483,894	3.24
Saint Vincent	Latin America & the Caribbean	Caribbean	1,182,000,000	32,797,994	2.77

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