Adult Blood Lead Reporting in New York State, 1994–2006

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SYNOPSIS

Objectives. Laboratories that test New York State (NYS) employees and adult residents for lead exposure are required to report blood lead test results to the NYS Department of Health's Heavy Metals Registry. This registry is used to monitor exposures and to identify new high-risk occupational and nonoccupational activities.

Methods. We used interviews conducted with people having blood lead levels of ≥25 micrograms/deciliter (μg/dL) reported to the Heavy Metals Registry to determine the primary source of lead exposure. We reviewed this information, together with demographic information, for the years 1994 through 2006.

Results. While overall there has been an increase in the number of tests being conducted on NYS residents since 1994, the vast majority of the increase is among those with the lowest blood lead levels (<10 μg/dL). Conversely, there has been a decline in the number of adults tested with blood lead levels of ≥25 μg/dL in NYS due primarily to occupational exposures. However, nonoccupational exposures do represent a relatively large percentage of the individuals with severely elevated blood lead levels (≥60 μg/dL).

Conclusions. Although a surveillance system based on blood lead levels cannot identify the true magnitude of adult lead poisoning, the NYS Heavy Metals Registry has proven to be an important tool for identifying situations in which adult lead poisoning is occurring, and assists in guiding lead poisoning prevention among adults.

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Exposure to lead can adversely affect the nervous, hematopoietic, endocrine, renal, and reproductive systems.[1] Although the adverse health effects from lead have been recognized for centuries, adults and children in the United States continue to be exposed to lead through occupational and environmental sources. If detected early, many health problems associated with lead exposure are reversible. Regular surveillance of blood lead levels allows for the early identification of individuals at risk for poisoning, and presents an opportunity to provide interventions that can help prevent lead poisoning.

Since 1982, the New York State (NYS) Department of Health (DOH) has maintained a Heavy Metals Registry (HMR) to conduct surveillance of adult exposures to lead, arsenic, mercury, and cadmium. At the inception of the registry, laboratory reports of blood lead levels ≥40 micrograms/deciliter (μg/dL) in adults (aged ≥16 years) were required by regulation to be reported to the NYS DOH. In 1987, this reporting level was reduced to 25 μg/dL. In 1994, as part of a major childhood lead poisoning prevention initiative, legislation was enacted to require the reporting of all blood lead results for all age groups, regardless of level. Since 1994, the HMR has followed all people aged 16 years and older with blood lead levels of ≥10 μg/dL.

Monitoring of blood lead levels is required by the Occupational Safety and Health Administration's (OSHA's) lead standard when an employer's air sampling for lead results are elevated;[2] however, previous studies and common experience suggest that biological monitoring practices vary by size of the facility, and it is likely that many facilities have never conducted any monitoring.[3] This limits the ability of surveillance systems based on blood lead levels to identify the true magnitude of the problem. While the HMR provides only an estimate of the total burden of adult lead poisoning in NYS, it has proven to be an important tool for identifying situations in which adult lead poisoning can occur and for conducting lead poisoning prevention among adults.

This article describes the HMR data during a 13-year period. Examination of cumulative data and exposure trends allows for the development of prevention strategies aimed at populations not previously considered to be at high risk. In addition, examining reporting trends can also provide an indication of companies that have either discontinued using lead in their processes or stopped conducting biomonitoring. Because 1994 marked the enactment of the Lead in Construction Standard[4] as well as a significant change in the reporting levels to the HMR, this analysis focuses on adults reported to the HMR from 1994 through 2006.

METHODS

NYS regulations require that both in-state and out-of-state laboratories report blood lead test results for specimens collected on NYS employees and residents. More than 94% of all blood lead test results received are reported electronically by the laboratories; the remaining tests are reported on paper forms.

A registry of blood lead levels can be used to identify potential sentinel occupational health events.[5] The Sentinel Health Event (occupational) model states that the occurrence of occupational disease, or a medical event such as an elevated blood lead level, serves as a warning that industrial hygiene controls may be required. The NYS DOH follows this model to address the potential for lead poisoning in the state. Adults with blood lead levels ≥25 μg/dL are interviewed by registry staff. Proxy interviews are conducted for those younger than 18 years of age, and those institutionalized or in prison. Demographic information is collected along with information on the subject's work and home environment. This interview is used to determine possible sources of exposure and to advise the person on appropriate control measures to limit future exposures. If an exposure is work-related, information is gathered on the employer, work location, lead protection measures in place, and whether coworkers are also potentially exposed. Information on reducing exposures is provided during interviews with the exposed individual, and brochures and relevant fact sheets are sent following an interview.

Individuals with blood lead levels between 10 μg/dL and 25 μg/dL are case matched and included in the registry, but because this group is not interviewed, much of the exposure information is often missing. Adults with blood lead levels <10 μg/dL are reported to the NYS DOH, but because of the magnitude of these reports, they are not case matched. Therefore, only information reported by the laboratory (name, address, date of birth, ethnicity, and blood lead level) is available on adults with blood lead levels <10 μg/dL.

NYS DOH uses the reported blood lead levels and interview data to target specific workplaces for public health prevention and to identify potential problem industries or hobbies.[6] Sixty-five percent of those contacted for an interview have been successfully reached; for those not reached, an effort is made to obtain exposure information from the physician or laboratory. The NYS DOH industrial hygiene staff provides consulting services to worksites with employees who have high or persistently elevated blood lead levels, and to individuals engaged in hobbies with lead exposure. Recommendations to reduce lead exposure are made when problems are identified.

To test for differences in characteristics by blood lead levels, we conducted Chi-square tests. We conducted simple regression analysis to test for trends over time except when there were fewer than 10 observations over time.

RESULTS

Overall, there have been 1,178,380 blood lead test results for individuals aged 16 years or older reported to the HMR since 1994. Of these, 84% (988,708) were blood lead levels <10 μg/dL. Because of the high volume of reports received for individuals with blood lead levels <10 μg/dL, the lab reports on these people are not case matched. In general, it is assumed for this group that there is only one test per person. Supporting this, a recent analysis of a subset of the data from 2003 to 2005 indicated that females with blood lead levels <10 μg/dL had a mean of 1.1 tests (Unpublished data, NYS DOH). More than 99% of the females reported had blood lead levels <10 μg/dL, while approximately 92% of the males reported had blood lead levels <10 μg/dL. A mean of 3.7 tests were conducted per individual with blood lead levels ≥10 μg/dL, although those with the highest blood lead levels (≥60 μg/dL) had fewer tests conducted (for a mean of 2.0 tests per individual).

Table 1 shows the number of adults tested each year, by blood lead level. Individuals may be tested in more than one year. There has been a substantial increase in the total number of blood lead tests reported with levels <10 μg/dL (F-value = 187.86, $p<0.0001$). Overall, the number of adults reported to the NYS HMR with blood lead levels ≥10 μg/dL has decreased (F-value = 24.91, $p=0.0004$), mimicking national trends.[7] This decrease was significant at all blood lead levels since 1996. The number of individuals reported with blood lead levels ≥25 μg/dL in NYS has declined 44%.

Table 2 describes demographic characteristics including gender, age, place of residence, and source of exposure of those individuals reported since 1994, by their highest blood lead level for those with levels ≥10 μg/dL. Among those with blood lead levels ≥10 μg/dL, 80% were male. A significantly higher percentage of females had lower blood lead levels (10–24 μg/dL vs. all others, $\chi^2=562.5$, $p<0.0001$). Figure 1 shows the number of males and females reported to the NYS DOH by all blood lead levels and year. The number of tests with results <10 μg/dL among males increased from 10,004 in 1994 to 28,143 in 2006 (F-value = 61.75, $p<0.0001$), whereas the number of tests among females with blood lead levels <10 μg/dL increased 10-fold, from 11,808 tests in 1994 to 119,997 tests in 2006 (F-value = 201.84, $p<0.0001$). The majority of this increase was observed among females in New York City (NYC) (data not shown). Since 1996, more than 60% of the women tested with blood lead levels <10 μg/dL were younger than 30 years of age, suggesting that more women may be receiving prenatal screening for lead. There was a significant decrease in the number of tests among males with blood lead levels ≥10 μg/dL (F-value = 27.13, $p=0.0003$), but not among females (F-value = 2.26, $p=0.16$).

As seen in Table 2, slightly more than half of the adults tested with blood lead levels ≥10 μg/dL were between 30 and 49 years of age. A significantly higher percentage of individuals aged 16 to 29 years reported lower blood lead levels (10–24 μg/dL vs. all others, $\chi^2=163.8$, $p<0.0001$). There was a significant increase in the number of adults tested each year, in each age group (data not shown).

Table 1. Number of adults tested for lead in New York State, by year and blood lead level, 1994–2006

Year	*<10 μg/dL*	*10–24 μg/dL*	*25–39 μg/dL*	*40–59 μg/dL*	*≥60 μg/dL*	*Total ≥10 μg/dL*
1994	11,808	2,707	903	214	17	3,841
1995	25,085	2,954	823	189	26	3,992
1996	32,817	3,702	879	198	30	3,809
1997	38,620	3,581	846	182	26	4,635
1998	38,492	3,242	718	180	19	4,159
1999	40,666	3,094	744	180	23	4,041
2000	56,681	3,217	769	160	14	4,160
2001	58,397	3,038	688	126	15	3,867
2002	73,837	2,797	661	122	18	3,598
2003	76,473	2,605	535	98	8	3,246
2004	89,729	2,433	555	109	17	3,114
2005	87,749	2,523	454	91	11	3,079
2006	119,997	2,218	435	61	12	2,726

μg/dL = micrograms/deciliter

Table 2. Number of adults reported to the New York State Department of Health Heavy Metals Registry, by demographic characteristics and blood lead level, 1994–2006[a]

Demographic characteristic	10–24 μg/dL		25–39 μg/dL		40–59 μg/dL		≥60 μg/dL		Total	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
Total adults	19,784	100.0	4,505	100.0	1,308	100.0	212	100.0	25,809	100.0
Gender										
Male	15,212	76.9	4,110	91.2	1,203	92.0	196	92.5	20,721	80.3
Female	4,315	21.8	386	8.6	104	8.0	16	7.5	4,821	18.7
Unknown	257	1.3	9	0.2	1	0.0	0	0.0	267	1.0
Age (in years)										
16–29	5,463	27.6	1,059	23.5	279	21.3	46	21.7	6,847	26.5
30–49	10,134	51.2	2,582	57.3	770	58.9	116	54.7	13,602	52.7
≥50	3,988	20.2	850	18.9	256	19.6	50	23.6	5,144	19.9
Unknown	199	1.0	14	0.3	3	0.2	0	0.0	216	0.8
Place of residence										
NYC	6,595	33.3	1,236	27.4	430	32.9	74	34.9	8,335	32.3
NYS, excluding NYC	11,097	56.1	2,712	60.2	708	54.1	114	53.8	14,631	56.7
Out of state	1,120	5.7	488	10.8	140	10.7	20	9.4	1,768	6.9
Unknown	972	4.9	69	1.5	30	2.3	4	1.9	1,075	4.2
Exposure source										
Occupational	3,416	17.3	3,405	75.6	1,032	78.9	144	67.9	7,997	31.0
Nonoccupational	140	0.7	517	11.5	181	13.8	49	23.1	887	3.4
Both	17	0.1	87	1.9	24	1.8	7	3.3	135	0.5
Unknown	16,211	81.9	496	11.0	71	5.4	12	5.7	16,790	65.1
Total tests	73,500		19,626		3,615		431		97,172	

[a]Excluded 988,708 tests reported at blood lead levels <10 μg/dL

μg/dL = micrograms/deciliter

NYC = New York City

NYS = New York State

A higher percentage of adults reported to the HMR were residents of upstate New York (all of NYS excluding NYC) compared with NYC (57% vs. 32%). This is consistent with the NYS population, where approximately 57% of adults aged 18 years and older live in NYS outside of NYC.[8] The number of residents in NYC reported with blood lead levels ≥10 μg/dL has remained relatively stable over time, while there has been a statistically significant decrease in the number of residents in the rest of NYS reported with blood lead levels ≥10 μg/dL (F-value = 54.17, $p<0.0001$). This is consistent and statistically significant for blood lead levels of 10–24 μg/dL, 25–39 μg/dL, and ≥40 μg/dL (Figure 2).

The exposure source is identified primarily through interviews conducted with adults with blood lead levels ≥25 μg/dL. For 82% of the adults with blood lead levels between 10 and 24 μg/dL, source of exposure was unknown (Table 2). Among those with blood lead levels between 25 and 39 μg/dL, 76% had exposures only from their occupation, while 12% had only non-occupational exposures. For adults with the highest blood lead levels (≥60 μg/dL), significantly more had nonoccupational exposures compared with the lower blood lead levels ($\chi^2=21.5$, $p<0.0001$). There has been a significant decline (F-value = 179.24, $p<0.0001$) over time in those with occupational exposures to lead accompanied by decreases in the number of workplaces (46%), new workers (51%), and new workplaces (62%) reported each year (Table 3).

The primary sources of lead for occupationally exposed individuals with elevated blood lead levels (≥25 μg/dL) are displayed in Table 4. The number of individuals in the "other" category has declined over the years due to quality control efforts to better classify the source of exposure. Individuals included in this category are machine operators, assemblers, and non-construction laborers working in the manufacture of primary metals, as well as electronics and electrical equipment workers. We conducted tests for trends by source of exposure and blood lead level group; however, the number of individuals per year tested was relatively small, leading to instability in the data. Increases in the number of people reported with blood lead levels ≥25 μg/dL were observed among lead abaters. We observed statistically significant decreases among those with blood lead levels ≥40 μg/dL working with lead glass, and among those with blood lead levels between 25 and 39 μg/dL working in casting crafts or bullets, and target shooters.

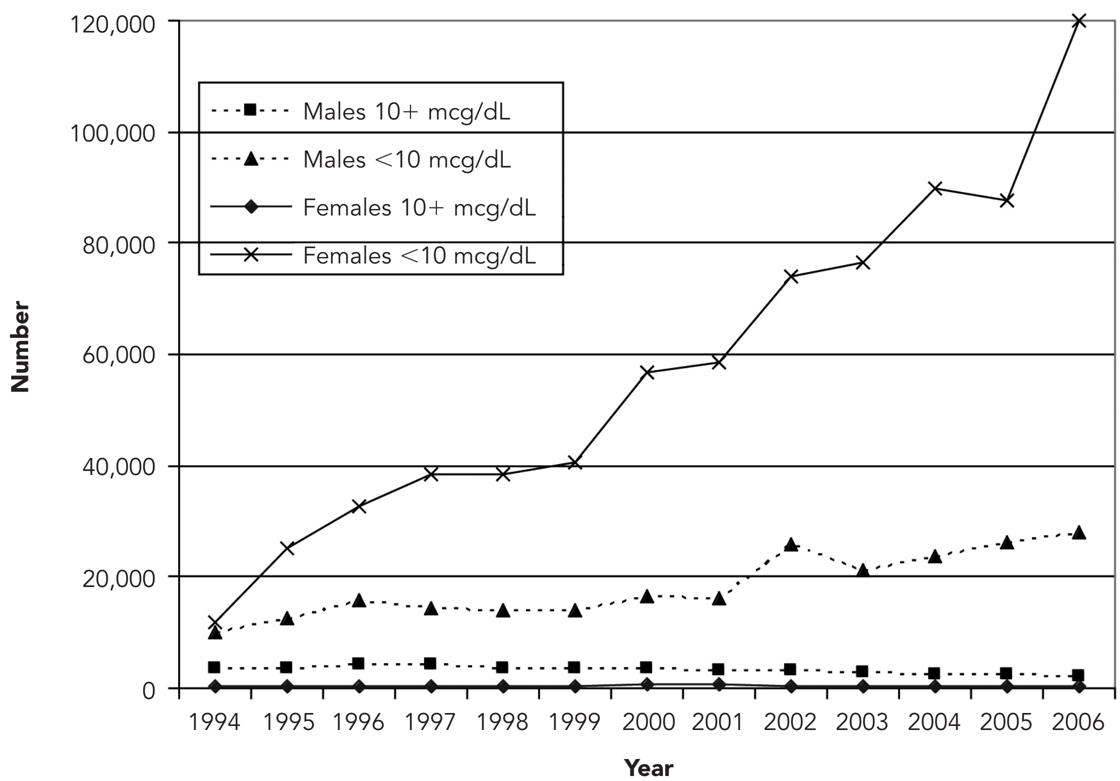
The number of people reported with nonoccupational exposures to lead each year has remained relatively steady, with a mean of 79 people (range: 63–106). Nonoccupational exposures represent 6% to 24% of those with blood lead levels between 25 and 59 μg/dL, and 11% to 75% of those with blood lead levels ≥60 μg/dL (data not shown). The primary sources of nonoccupational exposure among individuals with blood lead levels ≥25 μg/dL are shown in Table 5. Individuals who have ingested lead are exposed through accidental ingestion, cookware, pica, or folk medicines. Many institutionalized people, primarily developmentally disabled, may also ingest lead. Environmental exposures often occurred outside the U.S. and were due to lead contamination of drinking water or soil, often from lead processing plants near the person's residence. Almost two-thirds of those with the highest blood lead levels (≥40 μg/dL) were either involved in residential remodeling or were target shooters (data not shown).

DISCUSSION

Overall, there has been an increase in the number of tests being conducted on NYS residents since 1994, with more than 95% of the test results in recent years being <10 μg/dL. While increases in the number of tests have been observed among males and females, the vast majority of these tests are being conducted on females. Most of this increase has been among women of childbearing age (ages 16 to 45), suggesting that more women may be receiving prenatal screening for lead, especially within NYC. NYS has established guidelines for health-care practitioners to assist them in determining a woman's risk of lead poisoning on her initial prenatal visit.[9] If the potential for lead poisoning exists, the health-care provider is required to test the woman's blood lead level.[10]

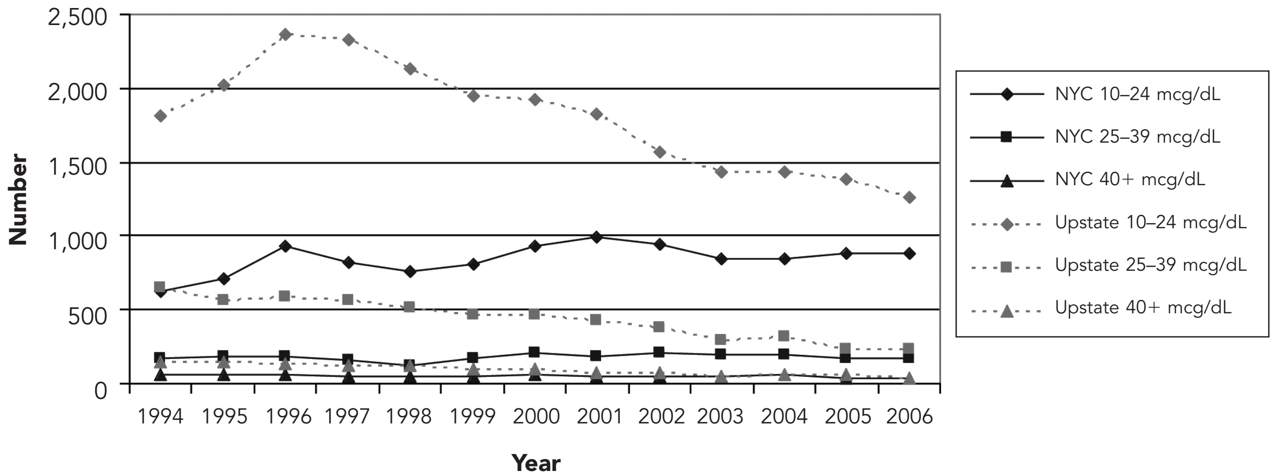
While the number of tests has increased dramatically among those with the lowest blood lead levels, there

Figure 1. Number of adults with blood lead test results reported to the New York State Department of Health Heavy Metals Registry, by blood lead level, 1994–2006



mcg/dL = micrograms/deciliter

Figure 2. Number of adults with blood lead test results reported to the New York State Department of Health Heavy Metals Registry, by blood lead level and area of residence, 1994–2006



NYC = New York City
mcg/dL = micrograms/deciliter

has been a decline in the prevalence of elevated blood lead levels (≥25 μg/dL) among adults reported to the NYS HMR, following a national trend.[7] This decrease has been observed only among those in NYS, excluding NYC, and among those with occupational exposures where there has been a 62% decrease in the number of workers with blood lead levels ≥25 μg/dL since 1994. While the majority of the reduction in elevated blood lead levels appears to be due to better mechanisms to control lead exposure in the workplace, other factors may also be involved. The number of NYS companies using lead has decreased as a result of either work process changes to eliminate lead or companies closing, following national trends.[11]

An earlier NYS DOH survey of companies using lead in 1995 found that in 1997, approximately 7% of the companies interviewed no longer used lead, and another 7% of companies went out of business

Table 3. Number of new workers and workplaces reported to the New York State Department of Health Heavy Metals Registry each year among occupationally exposed workers with blood lead levels ≥25 μg/dL, 1994–2006

Year	Reports	Workers	New workers	Workplaces	New workplaces
1994	2,169	1,021	391	219	64
1995	2,008	935	402	213	52
1996	1,967	904	338	180	42
1997	1,899	932	428	196	57
1998	1,677	796	329	166	40
1999	1,651	818	351	165	40
2000	1,914	806	329	169	43
2001	1,653	668	261	145	32
2002	1,446	605	243	133	33
2003	1,087	488	204	114	37
2004	1,421	598	307	141	48
2005	978	461	211	110	29
2006	811	389	201	101	40
Total	20,681	4,739[a]		833[b]	

[a]Total of all workers, 1994–2006, combined
[b]Total of all workplaces, 1994–2006, combined
μg/dL = micrograms/deciliter

Table 4. Primary source of occupational exposure for workers with blood lead levels ≥25 μg/dL, New York State Department of Health Heavy Metals Registry, 1994–2006

	25–39 μg/dL			*≥40 μg/dL*		
	N	*Percent*	P-*value*[a]	N	*Percent*	P-*value*[a]
Bridge renovation	816	23.4	0.38[b]	360	29.9	0.36
Foundry/smelting	64	1.8	0.32[b]	15	1.2	0.10
Iron/steel structures	171	4.9	0.40[b]	66	5.5	0.94[b]
Casting	32	0.9	0.002	8	0.7	NA[c]
Lead abatement	66	1.9	0.001[b]	33	2.7	0.26[b]
Lead glass	136	3.9	0.16	47	3.9	0.0003
Metal recycling	24	0.7	0.65[b]	14	1.2	0.50[b]
Radiator repair	29	0.8	0.65	6	0.5	NA[c]
Residential remodeling	148	4.2	0.75	93	7.7	0.90[b]
Stained glass	30	0.9	0.21[b]	6	0.5	0.60
Target shooting	78	2.2	0.03	20	1.7	0.78[b]
Other	1,869	53.5	<0.0001	533	44.2	0.0001
Unknown	41	1.2	0.05	8	0.7	NA[c]
Total occupational exposure	3,492			1,206		

[a]*P*-values determined using F-value

[b]Trends increased over time; all others decreased.

[c]Trend analyses not conducted on fewer than 10 observations

μg/dL = micrograms/deciliter

NA = not applicable

(Unpublished data, NYS DOH). The same survey found a decrease in the number of companies conducting employee biomonitoring. In addition, between 1998 and 2005, there was an overall decline in the number of manufacturing businesses and employees in NYS, which has primarily occurred outside of NYC, helping to explain that trend.[12,13] Another factor in the decrease of elevated blood lead levels may be the reduction or elimination of biomonitoring by some companies, although there are no data to support this.

Despite the overall decline in prevalence of elevated blood lead levels reported to the HMR, occupationally

Table 5. Primary source of nonoccupational exposure for workers with blood lead levels ≥25 μg/dL, New York State Department of Health Heavy Metals Registry, 1994–2006

	25–39 μg/dL			*≥40 μg/dL*		
	N	*Percent*	P-*value*[a]	N	*Percent*	P-*value*[a]
Environmental[b]	17	3.3	0.87	10	4.4	0.60
Ingestion	100	19.3	0.009[c]	74	32.6	0.64[c]
Casting	20	3.9	0.57[c]	6	2.6	NA[d]
Residential remodeling	150	29.0	0.76[c]	54	23.8	0.15
Retained bullet	13	2.5	0.30	10	4.4	0.19[c]
Stained glass	3	0.6	NA[d]	0	0.0	NA[d]
Target shooting	149	28.8	0.54	46	20.3	0.33
Other	3	0.6	NA[d]	0	0.0	NA[d]
Unknown	63	12.2	0.13[c]	27	11.9	0.85[c]
Total nonoccupational exposure	518			227		

[a]*P*-values determined using F-value

[b]Environmental exposures occurred primarily outside of the U.S. and included contaminated drinking water or residence near a lead operation.

[c]Trends increased over time; all others decreased.

[d]Trend analyses not conducted on fewer than 10 observations

μg/dL = micrograms/deciliter

NA = not applicable

exposed lead abaters have shown an increase in prevalence. Nonoccupational exposures represented a relatively large percentage of the individuals with severely elevated blood lead levels (compared with lower blood lead levels). The reason for this difference is unknown; however, it is possible that these individuals are symptomatic and are therefore being tested.

Although a substantial number of New York adults are having their blood lead levels tested, the HMR is unlikely to reflect the true magnitude of exposure to lead in the state. A study in California found that less than 3% of workers with direct exposure to lead were in routine blood monitoring programs.[3,14] In NYS, there are approximately 371,000 people employed in industries with the potential for lead exposure; however, in 2006, only 389 workers were reported with blood lead results of ≥25 μg/dL.[12,15] There are also numerous individuals engaged in home renovations, target shooting, and other hobbies with the potential for lead exposure who often do not get their blood lead levels tested.

CONCLUSIONS

It is accepted that a surveillance system based on blood lead levels cannot identify the true magnitude of the burden of adult lead poisoning. Despite this, the NYS HMR has proven to be an important tool for identifying situations in which adult lead poisoning is occurring and assists in guiding lead poisoning prevention among adults.

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