Work-related and Non-work-related Lead Poisoning among Adults in Florida

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ABSTRACT

The aim of this study was to identify whether adults with lead poisoning (blood lead level ≥10µg/dL) due to exposure to lead at their workplace have higher blood lead concentration levels compared to persons with lead poisoning who are not occupationally exposed. Data for this study were collected from the Florida Blood Lead Epidemiology Surveillance (ABLES) Program from 2008 to 2010 (n = 2246 adults). The demographic characteristics used for this study included age, gender, race, and ethnicity. The population shows that adults 47years of age have the highest number of cases of blood lead level ≥10µg/dL. In addition, male, white, and non-Hispanic individuals had the most individuals with blood lead level ≥10µg/dL. The modal number of cases was among persons working and residing in Hillsborough County – 34.4% county of exposure and 35.8% county of residence. The results show that those with lead poisoning due to occupational exposure have an average blood lead concentration level that is 2.5 µg/dL more than those who are not occupationally exposed.

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BACKGROUND

Lead exposure and its resulting toxic effects constitute one of the major public health problems In the United States (U.S.). It is an environmental problem that can affect the nervous system, hematopoietic, endocrine, renal, and reproductive systems, causing permanent and possibly fatal consequences, especially in young children (Elliot et al. 1999; Pirkle et al., 1998). Classically, "lead poisoning" or "lead intoxication" has been defined as exposure to high levels of lead typically associated with severe health effects (Kosnett et al., 2007). Poisoning is a pattern of symptoms that occur with toxic effects from modest to high levels of exposure; toxicity is a wider spectrum of effects, including subclinical ones (those that do not cause symptoms) (Kosnett et al., 2007). However, professionals often use "lead poisoning" and "lead toxicity" interchangeably, and official sources do not always restrict the use of "lead poisoning" to refer only to symptomatic effects of lead (Elliot et al. 1999; Pirkle et al 1998).

Chronic poisoning usually presents with symptoms affecting multiple systems, but is associated with three main types of symptoms: gastrointestinal, neuromuscular, and neurological (Elliot et al., 1999; Pirkle et al., 1998). Central nervous system and neuromuscular symptoms usually result from intense exposure, whereas gastrointestinal symptoms usually result from exposure over longer periods (Elliot et al., 1999; Pirkle et al., 1998).

Diagnosis includes determining the clinical signs and the medical history, with inquiry into possible routes of exposure (Pirkle et al., 1998). Clinical toxicologists, who are medical specialists in the area of poisoning, may be involved in diagnosis and treatment. The main tool in diagnosing and assessing the severity of lead poisoning is laboratory analysis of the blood lead level (BLL) (Pirkle et al., 1998). Blood film examination may reveal basophilic stippling of red blood cells (dots in red blood cells visible through a microscope), as well as the changes normally associated with iron-deficiency anemia (microcytosis and hypochromasia) (Pirkle et al., 1998). However, basophilic stippling is also seen in unrelated conditions, such as megaloblastic anemia caused by vitamin B_{12} (colbalamin) and folate deficiencies (Elliot et al., 1999). In most cases, lead poisoning is preventable; the way to prevent it is to prevent exposure to lead (Schwartz et al 2007) Prevention strategies can be divided into individual (measures taken by a family), preventive medicine (identifying and intervening with high-risk individuals), and public health approaches (reducing risk on a population level) (Schwartz et al., 2007).

The aim of this study was to identify adults with lead poisoning (blood lead level ≥10μg/dL) due to their exposure to lead at their work place have higher concentration of blood lead level compared to those with lead poisoning who are not occupationally exposed to lead.

METHODS

The data for this study were collected from the Florida Adult Blood Lead Epidemiology Surveillance (ABLES) program from 2008 to 2010. These data consist of the age, gender, race, ethnicity, county, industry, and occupation/job duties of the cases. In 2009, the Florida ABLES program adopted the federally updated case definition for an elevated blood lead level for surveillance purposes as a blood lead concentration ≥ 10μg/dL. The Florida ABLES program works with the county health department and healthcare providers to: identify the source of lead exposures to assure proper medical guidance, including follow-up blood lead tests; encourage adequate mitigation of lead sources to reduce or eliminate the risk of further exposure; and ensure the household members, particularly children, are tested for lead poisoning. Data collected on individual exposures is used to improve understanding of trends in sources and pathways of exposure. This information is used subsequently to improve lead poisoning prevention efforts.

Aggregate, de-identified blood lead test data are reported bi-annually to the National Institute of Occupational Safety and Health (NIOSH). In addition to reporting demographic information, ABLES reports the source of exposure, when known, for individuals with blood lead level ≥ 10μg/dL. The industry and occupational duties of the exposed person also are reported if exposure occurred at a worksite. NIOSH shares de-identified aggregated adult lead poisoning data with the Occupational Health and Safety Administration (OSHA) at the Federal level. The information provided by NIOSH enables OSHA to improve its understanding of trends in adult lead exposure based on industry and job type. OSHA may use the information provided by NIOSH to target enforcement action within select industries in Florida and other states that do not have an OSHA-approved state plan.

The data collected were de-identified by removing the name, date of birth, and the social security number. After de-identification, the client ID was used as an identifier. The NAICS and SIS codes was used in coding the industry and occupation/job duties of the patient and were decoded using the US Census Bureau North American Industry Classification System (NAICS) and the Standard Industrial Classification (SIC) which is the standard used by Federal statistical agencies in classifying business establishments for collecting, analyzing, and publishing statistical data related to the U.S. business economy.

Data Analysis

All analyses were carried out using the IBM SPSS Statistics 24windows version. These analyses include descriptive and generalized linear modeling (GLM) to analyze the association between the dependent and independent variables.

Generalized Linear Modeling (GLM)

GLM was popularized by McCullagh and Nelder in 1982. In these models, the response variable γ_i is assumed to follow an exponential family distribution with mean μ_i, which is assumed to be some function (often nonlinear) of $x_i^T\beta$. Some would call these "nonlinear" because μ_i is often a nonlinear function of the covariates, but McCullagh and Nelder consider them to be linear, because the covariates affect the distribution of γ_i only through the linear combination $x_i^T\beta$. Some assumptions for GLM are:

- The cases that is Y_1, Y_2, ..., Y_n are independently distributed
- The dependent variable Y_i does *not* need to be normally distributed, but it typically assumes a distribution from an exponential family (e.g. binomial, Poisson, multinomial, normal etc.)
- GLM does not assume a linear relationship between the dependent variable and the independent variables, but it does assume linear relationship between the transformed response in terms of the link function and the explanatory variables; e.g., for binary logistic regression $logit(\pi) = \beta_0 + \beta X$.
- Independent variables can be even the power terms or some other nonlinear transformations of the original independent variables.
- The homogeneity of variance does *not* need to be satisfied and over dispersion maybe present.
- Errors need to be independent but *not* normally distributed.
- It uses maximum likelihood estimation (MLE) rather than ordinary least squares (OLS) to estimate the parameters, and thus relies on large-sample approximations.
- Goodness-of-fit measures rely on sufficiently large samples, where a heuristic rule is that not more than 20% of the expected cells counts are less than 5.

RESULTS

A total of 2246 adult cases of blood lead level ≥10 μg/dL were recorded from 2008 to 2010. The age distribution of the blood lead level ≥ 10µg/dL collected is from age 15 to 92 (minimum 15 and maximum 92). The mean, median and mode of the distribution are 42.92, 43, and 47 respectively. The sex distribution is categorized into three categories: male, female, and unknown. From

Table 1. Demography Characteristics (n = 2246)

Gender	Frequency	Percent	Cumulative Percent
Male	2101	93.5	93.5
Female	136	6.1	99.6
Unknown	9	.4	100.0
Race			
American Indian / Alaska Native	12	.5	.5
Asian	15	.7	1.2
Black	342	15.2	16.4
White	939	41.8	58.2
Mixed race	1	.0	58.3
Unknown	937	41.7	100.0
Ethnicity			
Non- Hispanic / non-Latino	586	26.1	26.1
Hispanic or Latino	247	11.0	37.1
Unknown	1413	62.9	100.0

Table 2. Work Related (n = 2246)

Work Related	Frequency	Percent	Cumulative Percent
Work-related	1233	54.9	54.9
Non-work-related	59	2.6	57.5
Both job- and non-job-related	4	.2	57.7
Unknown	950	42.3	100.0
Total	2246	100.0	

Table 3. Parameter Estimates for Univariate Analysis

Independent Variable: AGE – Dependent Variable: Blood lead level ≥10 µg/dL						
Parameter	B	Std. Error	t	Statistical significance (p-value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	21.935	.788	27.832	.000	20.389	23.480
AGE	-.012	.017	-.703	.482	-.047	.022

Independent Variable: RACE – Dependent Variable: Blood lead level ≥10 µg/dL						
Parameter	B	Std. Error	t	Statistical significance (p-value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	22.963	.373	61.601	.000	22.231	23.694
[RACE=BLACK]	-1.179	.721	-1.634	.102	-2.594	.236
[RACE=WHITE]	0[a]	.	.	.	.	.

Independent Variable: ETHNICITY – Dependent Variable: Blood lead level ≥10 µg/dL						
Parameter	B	Std. Error	t	Statistical significance (p-value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	22.328	.778	28.682	.000	20.800	23.856
[ETHNICITY= Not Hispanic or Latino]	4.008	.928	4.319	.000	2.186	5.830
[ETHNICITY= Hispanic or Latino]	0[a]	.	.	.	.	.

Independent Variable: SEX – Dependent Variable: Blood lead level ≥10 µg/dL						
Parameter	B	Std. Error	t	Statistical significance (p-value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	17.669	.981	18.016	.000	15.746	19.592
[SEX=Male]	3.960	1.012	3.913	.000	1.975	5.944
[SEX=Female]	0[a]	.	.	.	.	.

Independent Variable: WORK-RELATED – Dependent Variable: Blood lead level ≥10 µg/dL						
Parameter	B	Std. Error	t	Statistical significance (p-value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	19.965	.360	55.532	.000	19.260	20.670
Work-related	2.585	.485	5.331	.000	1.634	3.535
Non-work-related	0[a]	.	.	.	.	.

Table 4. Parameter Estimates for Multivariate Analysis

Parameter Estimates						
Dependent Variable: Blood lead level ≥10 µg/dL						
Parameter	B	Std. Error	t	Statistical significance (p-value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	11.703	3.329	3.515	.000	5.166	18.239
Work-related	1.344	1.093	1.230	.219	-.801	3.489
Non-work-related	0[a]	.	.	.	.	.
ETHNICITY=Not Hispanic	3.338	1.304	2.561	.011	.779	5.898
ETHNICITY=Hispanics	0[a]	.	.	.	.	.
RACE=Black	-1.907	1.137	-1.677	.094	-4.140	.326
RACE=White	0[a]	.	.	.	.	.
SEX=Male	9.632	2.830	3.404	.001	4.076	15.189
SEX=Female	0[a]	.	.	.	.	.
AGE	.034	.035	.963	.336	-.035	.103

the 2246 cases collected, males recorded the highest number of cases with (n = 2101) (93.5%); there were 136 cases among females (6.1%) and 9 cases were of unknown gender (0.4%) (Table 1). The races are categorized as American Indian / Alaska Native, Asian, black, white, mixed, and unknown. Whites had the highest number of cases with 939 (41.8%) with mixed race having the lowest number of cases with 1 (0%). American Indians / Alaska Natives had 12 cases (0.5%), Asians, 15 cases (0.7%), blacks, 342 cases (15.2%), and 937 cases were unknown which is equivalent to 41.7% of the total race (Table 1). Ethnicity was classified into non-Hispanic, Hispanic or Latino, and unknown. Most cases (n = 1413 (62.9) did not identify themselves of any ethnic groups and is labeled unknown. Non-Hispanic recorded the highest number of known cases with 586 (26.1%) and Hispanic or Latino had the lowest with 247 (11%) (Table 1).

Lead poisoning is also described based on county of exposure. The county of exposure represents the county of the patient workplace. Hillsborough accounted for the most cases with 772 (34.4%); Pinellas County with second highest with 123 cases (5.5%); Broward county had 96 (4.3%) (Figure 1). Figure 2 shows the county of residence for lead poisoning in Florida. The county of residence may be different from the county of exposure. Hillsborough County accounted for the highest number of cases with 805 cases (35.8%), Pinellas with the second highest number of cases (n = 305; 13.6%) and Miami-Dade with the third highest (n = 126; 5.65%). Overall, 323 cases (14.4%) were unknown. For lead poisoning due to the person's work, Hillsborough had the highest with 707 cases, Pinellas with the second highest number of cases with 130 cases, and Pasco with the third highest with 64 cases (Figure 3). For lead poisoning not due to the person's worksite, Miami-Dade had the highest with 18 cases, Broward with the second highest number (n = 6), and Pinellas with the third highest with 5 cases (Figure 4). For unknown causes of lead poisoning, Pinellas had the highest with 169 cases, Hillsborough with the second highest (n = 97), and Miami-Dade with the third highest (n = 84) (Figure 5).

Figure 1. Lead Poisoning (blood lead level ≥ 10µg/dL) among Persons 15 years and above in Florida - County of Exposure (Total Cases)

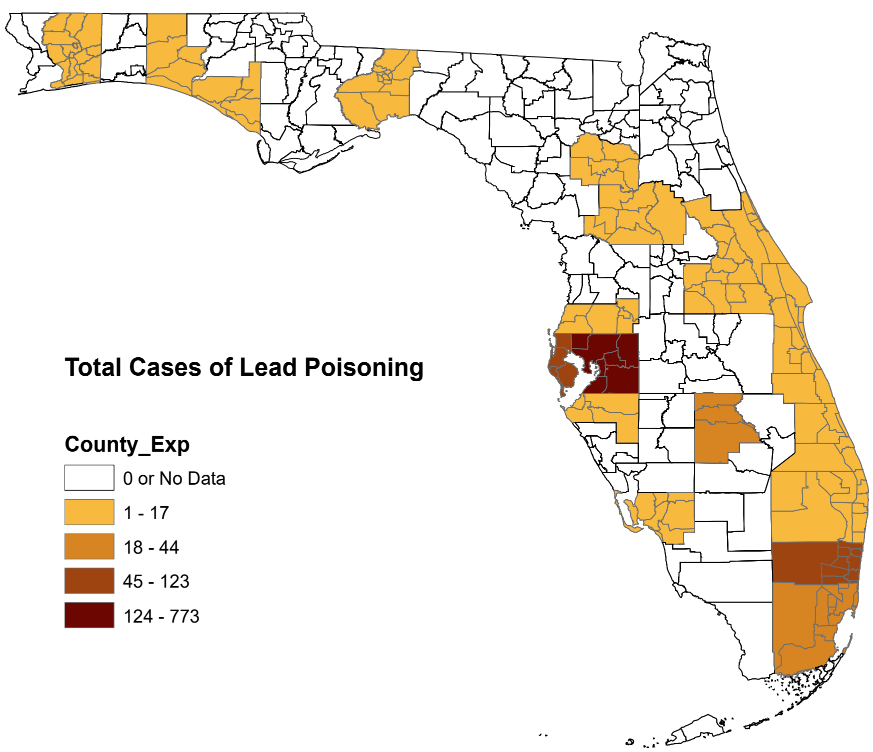


Figure 2. Lead Poisoning (blood lead level ≥ 10µg/dL) among Persons 15 years and above in Florida - County of Residence (Total Cases)

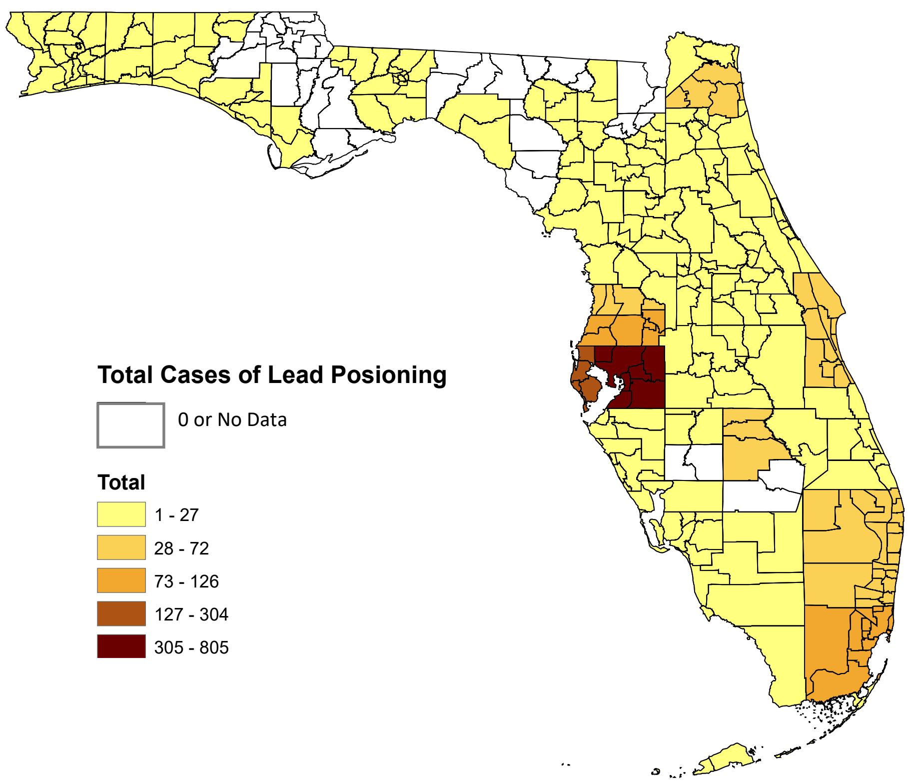


Figure 3. Lead Poisoning (blood lead level ≥ 10µg/dL) among Persons 15 Years and above in Florida - (Work-related cases)

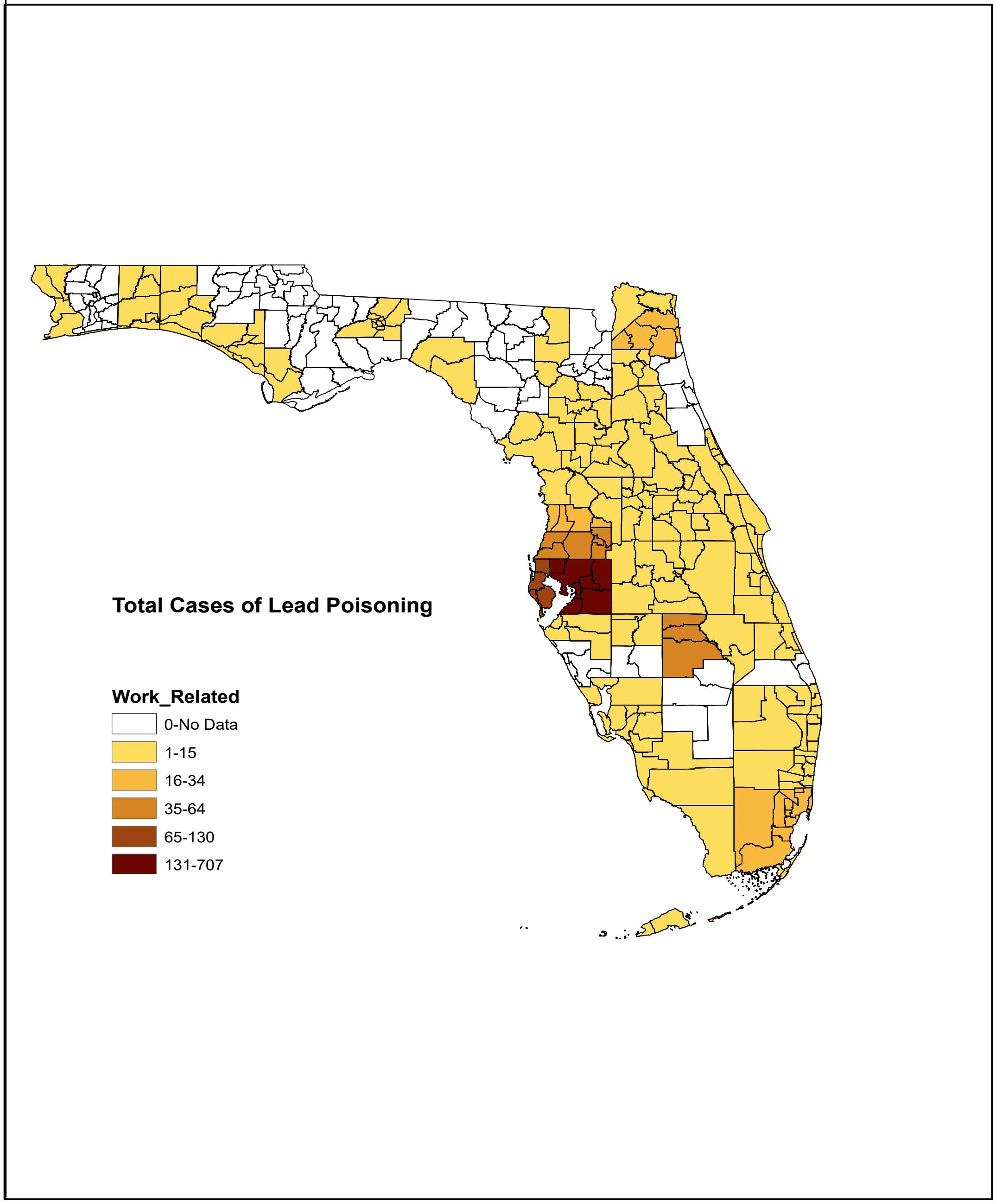


Figure 4. Lead Poisoning (blood lead level ≥ 10µg/dL) among Persons 15 Years and above in Florida - (Non-work-related cases)

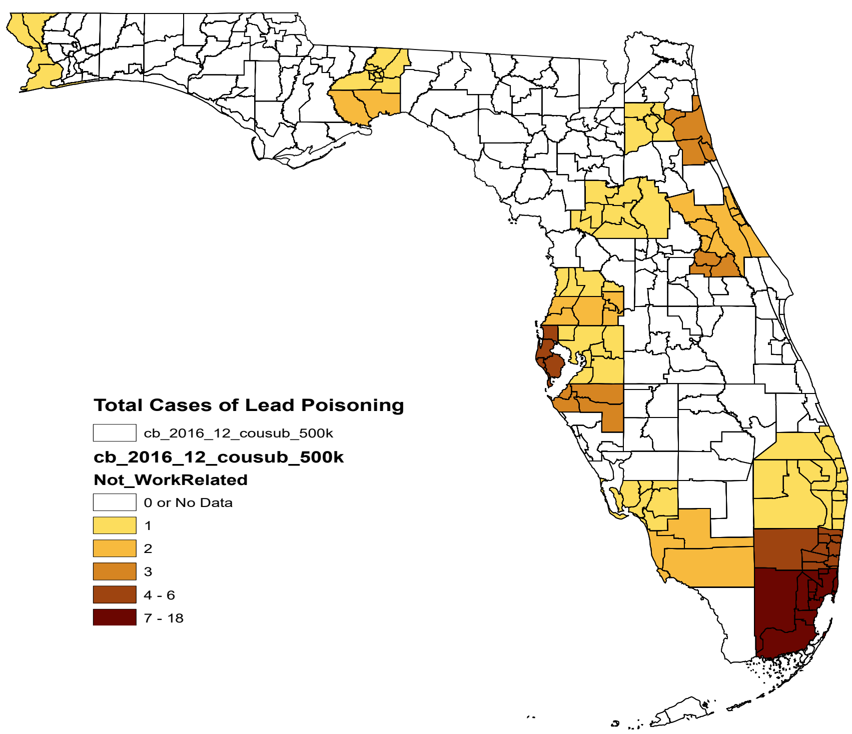
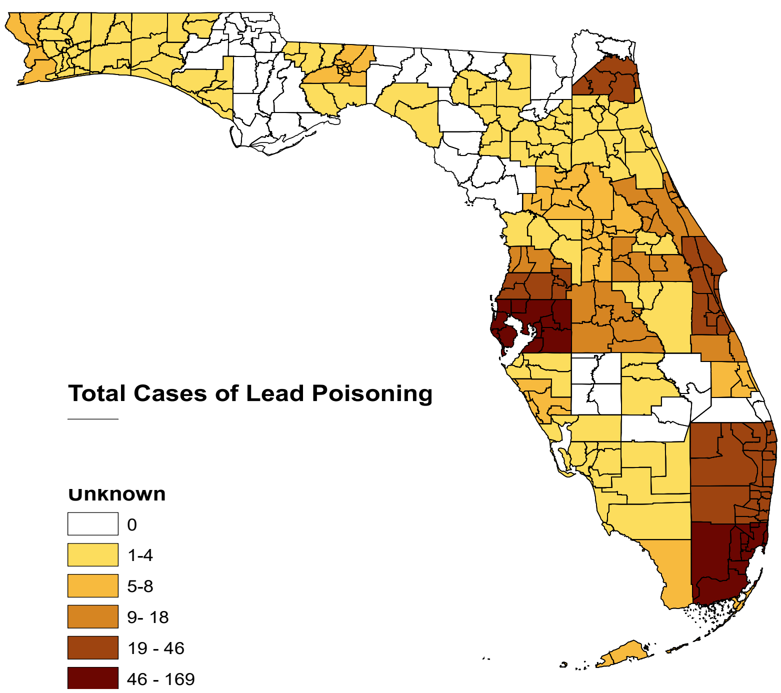


Figure 5. Lead Poisoning (blood lead level ≥ 10µg/dL) among Persons 15 Years and above in Florida - (Unknown Causes)



Lead poisoning is also described based on the county of exposure. The county of exposure represents the county of the patient work place. Hillsborough County accounted for the most cases with 772 (34.4%), Pinellas County with second highest with 123 cases (5.5%), and Broward County with 96 (4.3%) (Figure 1). Figure 2 shows the county of residence for lead poisoning in Florida; it may be. different from the county of exposure. Hillsborough County accounted for the highest number of cases with 805 (35.8%), Pinellas with the second highest number of cases with 305 (13.6%) and Miami-Dade with the third highest with 126 cases (5.65%). Overall, 323 (14.4%) cases were unknown. For lead poisoning due to the person's worksite, Hillsborough County had the highest number with 707 cases; Pinellas County had the second highest number of cases with 130, Pasco County had the third highest with 64 cases (Figure 3). For lead poisoning not due to the person's worksite, Miami-Dade County was highest with 18 cases, Broward County had the second highest number of cases (n = 6), and Pinellas County had the third highest with 5 cases (Figure 4). For unknown causes of lead poisoning, Pinellas had the highest with 169 cases, Hillsborough the second highest number of cases (n = 97), and Miami-Dade with the third highest with 84 cases (Figure 5).

Occupational duties were defined as the job description of the cases. Bridge painter recorded the highest number of cases with 248 (11%) cases. Laborer accounted for the second highest with 197(8.8%) cases and unloader/operator group leader accounted for the third highest with 66 (2.9%) cases. The industry is defined as the manufacturing company where the individual is exposed to lead poisoning. A battery manufacturing company recorded the highest number of cases with 414 (18.4%), followed by a lead recycling company (n = 319; 14.2%) cases and a paint and wall-covering contractor was third with 246 (11%). Overall, 952 cases (42.4%) were unknown.

Five different general linear models were developed to analyze the associations among age, race, ethnicity, gender, and work relation to lead exposure. For accurate statistical analysis, variables containing other, unknown, missing or no values and with sample size less than 20 were excluded. For work-related cases, ones not related to their jobs and cases with unknown causes of lead poisoning was added together. Overall, a total of 681 cases were used for this analysis.

Table 3 presents the parameter estimates for the univariate analysis for the association between age, race, ethnicity, sex, and work-related and blood lead level ≥10 μg/dL. The result shows that there is no association between age and blood lead level ≥10 μg/dL and no association between race (black and white) and blood lead level ≥10 μg/dL. Non-Hispanics with lead poisoning (blood lead concentration ≥10 μg/dL) had an average concentration 4 μg/dL more than Hispanics / Latinos who had lead poisoning (Table 3). Regarding gender, males with lead poisoning had an average blood lead level concentration almost 4 μg/dL more than females with lead poisoning. Persons with occupationally-derived lead poisoning had an average blood lead level concentration 2.5 μg/dL more than persons not occupationally exposed (Table 3).

The final model, which includes gender, work-related exposure, ethnicity, race, and age as the independent variables and lead poisoning (blood lead level ≥10 μg/dL) as the dependent variable shows that ethnicity and gender are the only significant variables after controlling for other variables. The multivariate analysis shows that males with lead poisoning had an average blood lead concentration level almost 9.6 μg/dL more than females with lead poisoning. Non-Hispanics with lead poisoning had an average blood lead concentration level 3.3μg/dL more than Hispanics / Latinos with lead poisoning (Table 10).

Conclusion

Lead poisoning (blood lead level ≥10μg/dL) is associated with the type of work ones does. Non-Hispanics are more likely to have lead poisoning compared to Hispanics / Latinos. Male are more likely to have lead poisoning compare to females, and persons occupationally exposed to lead are more likely to have lead poisoning compared to persons not occupationally exposed. Age and race showed no statistically significant relationship to lead poisoning.

REFERENCES

Elliot, P., Arnold, R., Barltrop, D., Thornton, I., House, I.V., & Henry, J.A. (1999). Clinical lead poisoning in England: An analysis of routine sources of data. *Occupational and Environmental Medicine*, *56*(12), 820-824.

Hu, H., Shih, R., Rothenberg, S., & Schwartz, B. (2007). The epidemiology of lead toxicity in adults: Measuring dose and consideration of other methodologic issues. *Environmental Health Perspectives*, *115*(3), 455-462.

Kosnett, M.J., Wedeen, R.P., Rothenberg, S.J., Hipkins, K.L., Materna, B.L., Schwartz, B.S., Howard, H., & Woolf, A. ((2007). Recommendations for medical management of adult lead exposure. *Environmental Health Perspectives*, *115*(3), 463-471.

Penn State Eberly College of Science. (2018). Analysis of Discrete Data: Introduction to Generalized Linear Models. Retrieved from https://onlinecourses.science.psu.edu/stat504/node/216.

Pirkle, J.L., Kaufmann, R.B., Brody, D.J., Hickman, T., Gunter, E.W., & Pascal, D.C. (1998). Exposure of the U.S. population to lead, 1991-1994. *Environmental Health Perspectives*, *106*(11), 745-750.

Schwartz, S.B., & Hu, H. (2007). Adult lead exposure time for change. *Environmental Health Perspectives*, *115*(3), 451-454.

Shannon, M. (1998). Lead poisoning from an unexpected source in a 4-month-old infant. *Environmental Health Perspectives*, *106*(6), 313-316.

Shih, R., Glass, T., Bandeen,-Roche, K., Carlson, M., Bolla, K., Todd, A., & Schwartz (2006). Environmental lead exposure and cognitive function in community-dwelling older adults. *Journal of the American Academy of Neurology*, *67*(9), 1556-1562.

SPSS Inc. (2016). *PASW Statistics for Windows*, Version 24.0. Chicago, IL: Author.

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