Eliminating Childhood Lead Exposure in Rhode Island's Core Cities

Lead Hazard Mitigation Act Enforcement and Effects

The Providence Plan

Contents

Executive Summary

This property-level analysis evaluates the ability of the 2005 Rhode Island Lead Hazard Mitigation Law to reduce children's exposure to lead in the home. The three main objectives of the paper are to determine: 1) the extent to which properties have complied with the law, 2) whether there is a relationship between compliance and children's exposure to lead at the property level, and 3) whether there is a relationship between exemption from the law and exposure to lead. We analyzed these questions by creating a database of properties in the four core cities of Rhode Island: Central Falls, Pawtucket, Providence, and Woonsocket, from other existing datasets.

Between 2005 and 2009, most properties that were subject to the Lead Hazard Mitigation Law did not comply with its regulations. Only 21 percent of non-exempt properties were compliant with the law at any time in those years.

Half of the core cities' non-exempt two- to five-family properties with a child tested for lead had one or more children with an elevated blood lead level of at least 5 µg/dL (51.2 percent, n=3,028). Of the same non-exempt two- to five-family properties, 12.9 percent had one or more children who were considered lead poisoned, with blood lead levels of 10 µg/dL or higher (n=765). We found evidence that properties that complied by the time a child was tested for lead had fewer cases of lead exposure of at least 5 µg/dL (r_s = -0.165, P < 0.01).

Of all types of residential property in the core cities that housed at least one child with a blood lead test, 56 percent were exempt from the Lead Hazard Mitigation Act (n=9,787). Non-exempt properties had a higher rate of children exposed to lead than exempt properties, but the two categories had similar numbers of properties with children exposed to lead.

Our results suggest that in order to further reduce lead exposure, more owners of non-exempt properties in Rhode Island will need to comply with the Lead Hazard Mitigation Act. In addition, potential ways to reduce lead exposure in children living at exempt properties should be explored.

Introduction

The Problem: Lead Exposure in Childhood

Screening and Health Effects

To date, scientists have not determined any measurable level of exposure to lead, a natural heavy metal, that is safe for children's health (Advisory Committee on Childhood Lead Poisoning Prevention [ACCLPP], 2012; Agency for Toxic Substances and Disease Registry [ATSDR], 2007). For this reason, the Centers for Disease Control and Prevention (CDC) recently modified the benchmark for elevated blood lead levels (EBLLs) from 10 µg/dL (previously known as the "blood lead level of concern") to a reference value of 5 µg/dL. This reference value indicates whether a blood lead test exceeds the 97.5[th] percentile for blood lead levels (BLLs) in children across the United States (ACCLPP, 2012). The benchmark can serve as a public health guide for distributing resources, but does not indicate a threshold at which biological effects take place in individual children (Carlisle, Dowling, Siegel, & Alexeeff, 2009).

Lead exposure can permanently affect a child's health, particularly the nervous system. Lead does not affect all children proportionally—those who lack key nutrients such as calcium and iron are more vulnerable to the effects of lead because they can absorb more of it (Richardson, 2005). Even small amounts of lead in the blood can compromise cognition, behavior, growth, and development. Lead can also contribute to anemia, elevated blood pressure, kidney damage, colic, muscle weakness, and brain damage (Agency for Toxic Substances and Disease Registry, 2007; Environmental Protection Agency, 2006). In sum, evidence shows that lead exposure in youth can cause harm throughout the lifespan.

Lead in the Home

Young children typically spend a substantial amount of their time at home. In or around their homes, children can be exposed to lead from food, water, paint chips, dirt, dust, or sand. They may directly ingest lead-containing substances or inhale lead particles in the air (Environmental Protection Agency, 2006). Alarmingly, approximately 3.6 million properties in the United States where children under the age of six reside still have at least one lead hazard on the premises (US Department of Housing and Urban Development, 2011). Examples of such hazards include plumbing installed before 1930, which may contribute to high levels of lead in the drinking water, as well as paint in homes built

before 1978, which can contain up to 50 percent lead (ATSDR, 2007). Thus, a variety of sources in residential areas can expose children to lead.

Incidence of Childhood Lead Poisoning

Although average blood lead levels have greatly decreased in recent decades, childhood lead poisoning still occurs today. Until recently, Rhode Island defined lead poisoning as BLLs of 10 µg/dL or higher, a definition we will use throughout this paper for consistency. (Published data are not yet available for the incidence of lead poisoning under the new definition of 5 µg/dL or higher. By lowering the threshold for lead poisoning in Rhode Island, even more children will be considered lead poisoned). For the United States overall, 0.61 percent of children tested for lead were confirmed as lead poisoned in 2010 (CDC, 2012). In Rhode Island, between 1997 and 2010, the incidence of childhood lead poisoning decreased from 8.4 percent to 1.0 percent. Among the core cities in Rhode Island, which have the highest concentrations of childhood poverty, lead poisoning decreased from 13.4 percent to 1.4 percent in the same time period (Childhood Lead Poisoning Prevention Program, 2012). Although the current lead poisoning rates seem acceptably low, a statewide incidence rate of one percent still indicates that over 250 children in Rhode Island who had never previously been lead poisoned were newly exposed in 2010.

Rhode Island's Lead Hazard Mitigation Act

Recognizing the effects that lead poisoning can have on the youth of Rhode Island and the limitations of the existing Lead Poisoning Prevention Act to address these impacts, the state created Lead Mitigation Regulations in 2005. The law has the potential to increase the healthiness and quality of the housing stock in the state. Under the law, rental property owners must attend a lead hazard awareness class, inspect rental properties, fix lead hazards, provide tenants information about lead hazards and a copy of the inspection report, respond to tenants' concerns about any lead hazards, and use lead-safe work practices when performing any maintenance. Generally, the law's regulations apply to owners of property built before 1978. However, many properties are exempt from the law, including those that are owner-occupied with three or fewer units, units that have received Lead Safe or Lead Free (LSLF) certificates, temporary or seasonal units, and elderly housing (Housing Resources Commission, 2005). The effect of all of these exemptions on the incidence of lead exposure was previously unknown. To ensure that this policy can protect the health of the state's children, we needed to evaluate the effects that it has had so far.

Purpose

The United States Department of Health and Human Services set a goal to eliminate any new cases of elevated blood lead levels in children by 2020 (Healthy People 2020, 2012). For Rhode Island to achieve this national goal, it is essential that policymakers and residents know the effectiveness of current regulations. Thus, we first aimed to determine the extent of compliance with the Lead Hazard Mitigation Act at the property level. We then analyzed whether the regulations have helped lower the incidence of lead poisoning among children who live at non-exempt properties. We also examined the differences between exempt and non-exempt properties to see if properties that are not subject to the law's parameters still expose children to lead.

We focused our analysis on residential properties in the four core cities in Rhode Island: Central Falls, Pawtucket, Providence, and Woonsocket. The core city designation indicates that 25 percent of children in the city or more live in poverty (RI KIDS COUNT, 2012). These cities comprise much of the state's oldest housing stock, which is a risk factor for lead-based paint exposure, and have historically had higher rates of lead exposure (RI Childhood Lead Poisoning Prevention Program, 2012). We excluded properties built during or after 1978 because lead was banned from housing painting products in 1977 (ATSDR, 2007). We included four main property types: one-family residences, two- to five-family residences, apartments, and commercial and residential mixed-use buildings.

There are three main sections to this analysis. Part One presents the rates of compliance among non-exempt residential properties, which were subject to the regulations in the Lead Hazard Mitigation Act. Part Two describes the relationship between lead exposure and compliance among non-exempt multi-family properties. Finally, since childhood lead exposure is not limited to non-exempt properties, Part Three discusses the relationship between exemption and lead exposure among all residential property types. After investigating these questions, we present findings and conclusions for stakeholders to make informed decisions about the future of childhood lead poisoning prevention for properties in Rhode Island's core cities.

Part One: Compliance with the Lead Hazard Mitigation Act among Non-Exempt Properties

This section focuses on compliance among the 15,678 non-exempt (non-owner occupied) properties in our dataset. Properties may or may not have had children who were screened for lead. Owners of non-exempt properties should have taken action to comply with the Lead Hazard Mitigation Act of 2005. We excluded exempt properties from this section because their owners were not required by law to comply.

Any Compliance

"Any compliance" designates properties that complied at any point between 2005 and 2009. To comply, property owners had to obtain either a Certificate of Conformance (COC) or a Lead Safe Lead Free Certificate (LSLF). COC indicates that the property owner complied with the regulations in the Lead Hazard Mitigation Act according to the Rhode Island Housing Resources Commission. LSLF indicates that the property had passed the legal requirements for lead inspections through the Rhode Island Department of Health and would not be required to also acquire a COC.

Of all non-exempt properties, only about one fifth had any compliance between 2005 and 2009. Table 1.1 shows compliance rates among the four core cities and Table 1.2 shows compliance among the four property types we analyzed.

Table 1.1 Compliance By City		Central Falls	Pawtucket	Providence	Woonsocket	Total
Non-Compliant	n (number)	771	1,951	7,986	1,641	12,349
	% of city	74.6%	80.6%	78.8%	78.6%	78.8%
Any Compliance	**n**	**262**	**471**	**2,148**	**448**	**3,329**
	% of city	**25.4%**	**19.4%**	**21.2%**	**21.4%**	**21.2%**
Total	n	1,033	2,422	10,134	2,089	15,678
	% of city	100.0%	100.0%	100.0%	100.0%	100.0%

Of the cities, Central Falls had the highest compliance at any time, while Pawtucket had the lowest. When comparing the different property types, non-exempt one-family properties had the lowest rate of any compliance, while residential apartments had the highest.[1]

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[1] Owners of apartments with ten or more units could receive certificates of presumptive compliance by meeting certain criteria: built after 1960, no major outstanding housing violations, no history of repeated lead poisonings, and lead inspections completed for at least five percent of units (Housing Resources Commission, 2008).

Table 1.2 Compliance By Property Type		One-Family Residences	Two- to Five- Family Residences	Residential Apartments	Commercial/ Residential	Total
Non- Compliant	n	3,110	7,898	745	596	12,349
	% of property type	90.1%	75.8%	68.0%	83.9%	78.8%
Any Compliance	**n**	**343**	**2,521**	**351**	**114**	**3,329**
	% of property type	**9.9%**	**24.2%**	**32.0%**	**16.1%**	**21.2%**
Total	n	3,453	10,419	1,096	710	15,678
	% of property type	100.0%	100.0%	100.0%	100.0%	100.0%

Thus, in the four years following the Lead Hazard Mitigation Act, a large proportion of non-exempt property owners did not comply with the law.

Independent Compliance

"Any compliance" identifies properties that complied at any point before or after a child at the property had a blood lead test. For this reason, properties with any compliance may have only complied after a child living there experienced an elevated blood lead level (EBLL). This inclusion in the compliant population may bias the results because none of these properties had complied with the law by the time the children tested with EBLLs. Thus, as another measure of compliance, we removed any properties that became compliant one day or more after the date of a positive EBLL test (5 µg/dL or higher) from the "any compliance" population. We refer to the resulting subgroup as "independent compliance." Figure 1 illustrates the distinction between the groups.

**Figure 1.1 Relationship between Compliance Categories**
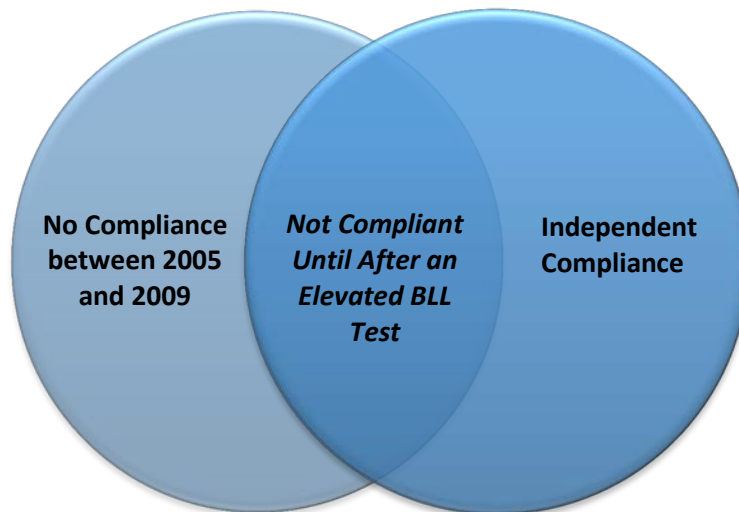
"Any compliance" includes both the center overlap and the independent compliance category on the right. The "independent compliance" category excludes properties that were noncompliant at any point between 2005 and 2009 as well as those that were noncompliant at the time of an EBLL on the property.

Overall, only about 16 percent of non-exempt properties were independently compliant (out of the same 15,678 properties used as the denominator for any compliance). Table 1.3 displays the distribution of properties with independent compliance, compliance after an elevated test, and no compliance at any time between 2005 and 2009.

Table 1.3 Compliance Categories	n	%
Non-Compliant	12,349	78.8
Compliant after EBLL	857	5.5
Independent Compliance	**2,472**	**15.8**
Total	15,678	100.0

The rates and numbers by city and property type are found in the appendix for any compliance in Table A.1 and the compliance categories in Table A.2.

As Figure 1.2 illustrates, the independent compliance rates did not vary greatly across cities, ranging from about 15 percent in Providence to 17 percent in Central Falls.

Figure 1.2 Non-Exempt Compliance, By City

	Central Falls	Woonsocket	Providence	Pawtucket	Total
No Compliance	74.6	78.6	78.8	80.6	78.8
Compliant after EBLL	8.3	4.6	5.9	3	5.5
Independent Compliance	17	16.8	15.3	16.5	15.8
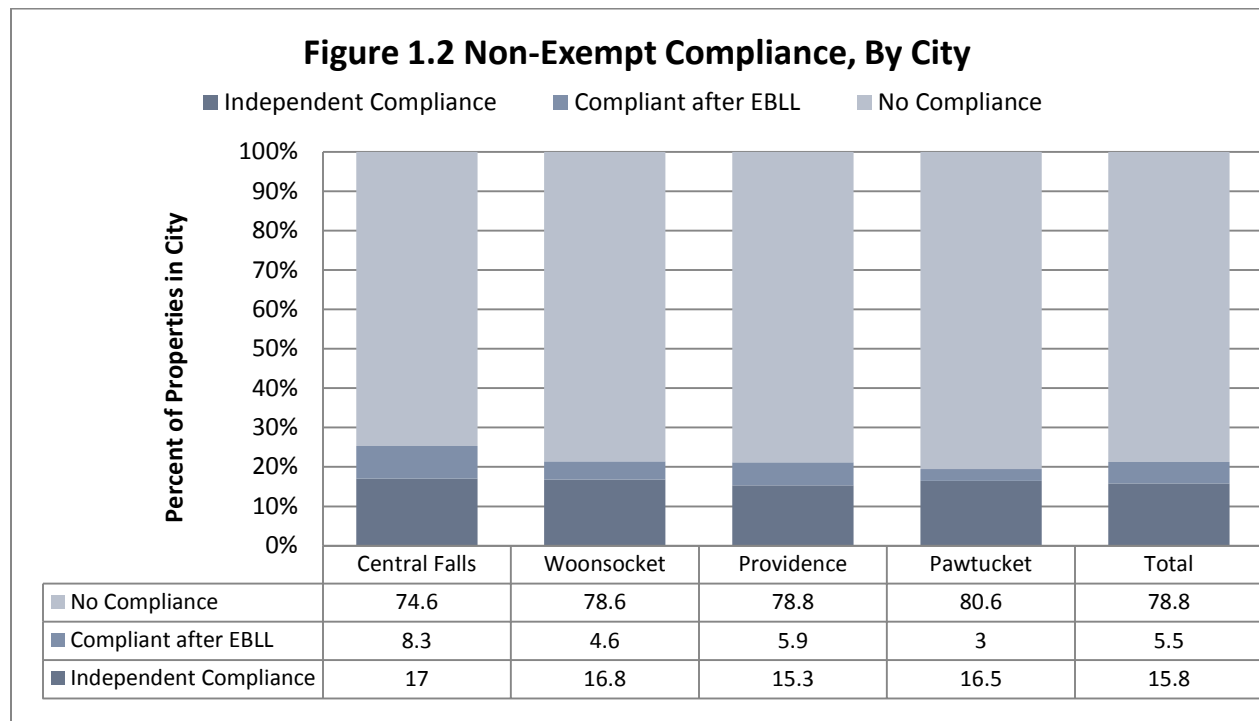
Compliance varied more greatly between property types than between cities. As Figure 1.3 shows, independent compliance was highest among residential apartments[1] and lowest among one-family properties.

Figure 1.3 Compliance, By Property Type

	Apartments	2-5 Family Residences	Commercial/ Residential	One Family Residences
No Compliance	68	75.8	83.9	90.1
Compliant After EBLL	9.7	6.6	2.4	1.3
Independent Compliance	22.4	17.6	13.7	8.6
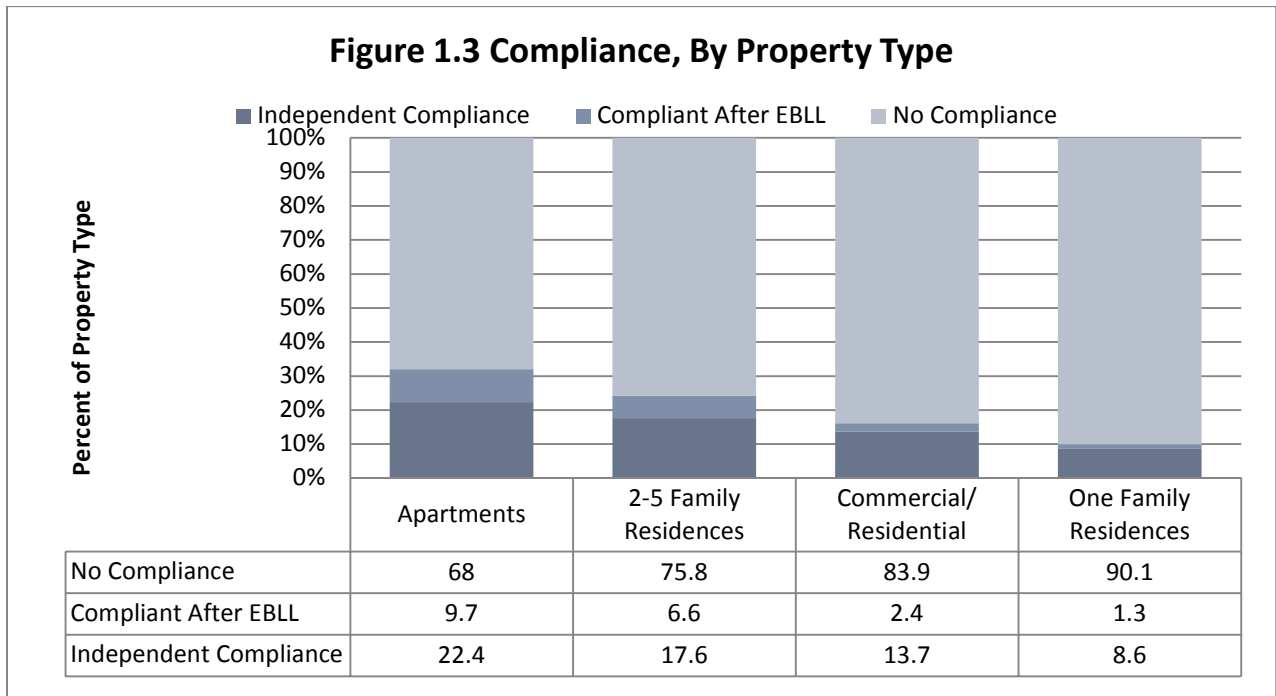
About five percent of all non-exempt properties complied with the Lead Hazard Mitigation Law after a child tested with EBLLs, but were not compliant at the time of the first elevated test (the compliant after EBLL category in Figure 1.2). Of the four cities, Central Falls had the highest proportion of properties that complied after EBLLs, while Pawtucket had the lowest proportion. Of all non-exempt property types, residential apartments had the highest proportion of properties that complied after an EBLL test, while one-family properties had the lowest. Overall, 26 percent of the properties that complied at any time from 2005-2009 did not comply until a child had a BLL of 5 µg/dL or higher.

Key Findings

1. Most non-exempt properties did not comply with the Lead Hazard Mitigation Law between 2005 and 2009, whether those that complied only after an elevated blood lead level test are included or excluded.

2. All four core cities had similar rates of compliance. Central Falls had the highest compliance rates, while Pawtucket and Providence had the lowest.

3. Non-owner occupied one-family properties had the lowest compliance rates.

4. Residential apartments had the highest compliance rates, likely due to the presumptive compliance stipulation.

5. Two- to five-family properties made up the largest group of properties across the categories, but had low independent compliance rates.

Part Two: The Relationship between Lead Exposure and Compliance among Non-Exempt 2-5 Family Properties with Children Tested for Lead

This section presents the relationship between compliance and the number of children with elevated blood lead levels (EBLLs), which are defined as BLLs of 5 μg/dL or higher based on the recently updated CDC reference level. We identified the variation in lead exposure, from 2005 to 2009, between non-exempt multi-family properties that possessed a Certificate of Conformance (COC) or Lead Safe Lead Free Certificate (LSLF) and those that were required to comply but did not during the study timeframe.

We limited this analysis to the 5,911 non-exempt two- to five-family properties in the core cities with children who were screened for lead. Children were included if they were between the ages of 0 to 72 months and had a confirmed lead test between 2005 and 2009. We limited this analysis to non-exempt, residential, two- to five-family properties because they comprise two-thirds of non-exempt properties. Thus, non-exempt, residential two- to five-family properties in Central Falls, Pawtucket, Providence, and Woonsocket where children with blood lead tests resided comprise our study population for Part Two. We refer to this study population simply as "all properties" in this section. Appendix 1 describes the study methods. Appendix 3 provides the results of the same analysis for non-exempt one-family properties with BLL matches in the core cities.

Compliance among Two- to Five-Family Properties

Any Compliance

Of all properties in our study population, most did not comply with the Lead Hazard Mitigation Act at any time between 2005 and 2009 (68.2 percent, n=4,033). Rates of any compliance ranged from 27 percent in Pawtucket to 34 percent in Providence, with an overall rate of about 32 percent. Woonsocket and Central Falls both had about 28 percent compliance. (These rates vary from those presented in Part One because they only describe the two- to five-family properties with at least one BLL match.) Thus, less than one third of two- to five-family properties complied at any time between 2005 and 2009.

Independent Compliance

Of the same population of properties, about 20 percent had independent compliance (n=1,188), meaning that we excluded the properties that complied with the law only after a child living on the property tested positive for EBLLs. Table 2.1 shows rates of compliance, categorized by independent compliance and compliance after an EBLL, by city.

Table 2.1 Compliance Among Non-Exempt 2-5 Families with BLL Matches		Central Falls	Pawtucket	Providence	Woonsocket	Total
Non-Compliant	n	446	681	2359	547	4033
	% of city	71.7%	73.1%	65.7%	71.4%	68.2%
Compliant after EBLL	n	64	63	499	64	690
	% of city	10.3%	6.8%	13.9%	8.4%	11.7%
Independent Compliance	n	112	187	734	155	1188
	% of city	18.0%	20.1%	20.4%	20.2%	20.1%
Total	n	622	931	3592	766	5911
	% of city	100.0%	100.0%	100.0%	100.0%	100.0%

The rates of independent compliance ranged from 18 percent in Central Falls to 20 percent in the other three cities. Almost 12 percent of all properties overall (n=690) fell into the category of complying after an EBLL.

Elevated Blood Lead Level Rates

Overall

Over half of all properties had at least one child with BLLs of 5 µg/dL or higher, or elevated BLLs (EBLLs) (51.2 percent, n=3,028)**.** Across the four cities, almost one fifth of properties housed at least two children with EBLLs (19.9 percent, n=1,178). Having more than one child with EBLLs may indicate a higher likelihood that the positive tests are attributable to the property, rather than another source of exposure.

By Compliance Status Categories

Figure 2.1 shows the comparison, among all properties in the four cities, of the number of exposures of BLL 5 µg/dL or higher at a property by the three categories of compliance status: any compliance, independent compliance, and no compliance. In addition, Table A.3 in Appendix 2 provides the numbers of properties that are in each category.

Figure 2.1 Number of Children Exposed to BLL 5+, by Compliance Status

■ One or more children   ■ Two or more children

Percent of Properties in Compliance Category (y-axis)

55.5

24.7

49.2

17.7

29.6

9

Any Compliance   No Compliance   Independent Compliance

Compliance Status
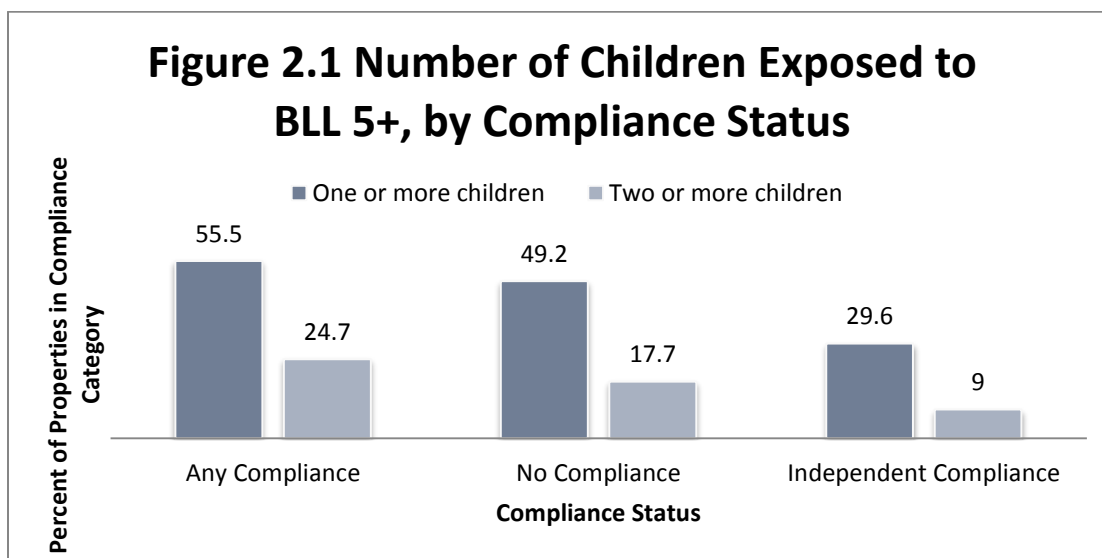
As visualized in Figure 2.1, the "any compliance" group has the highest rates of EBLLs. The properties in the independent compliance group (those that became compliant at any time except after a positive test) have the lowest rates of exposures.

Statistical Comparison of Compliance Status Categories

These results were confirmed through statistical analyses that showed statistically significant differences between the compliance categories. First, we compared the number of children with EBLLs residing at properties with any compliance and properties with no compliance. There was a statistically significant difference between the compliant and non-compliant properties (Mann-Whitney U, P<0.01). Compliance at any time was positively correlated with the number of children at the property with BLLs of 5 µg/dL and higher (r_s = 0.079, P<0.01). Thus, properties with any compliance had a slightly higher likelihood to house children with EBLLs compared to properties with no compliance history.

Second, we compared the number of children with EBLLs who lived at each property that had independent compliance to the number of children at each property with no compliance. There was a statistically significant difference between the independently compliant and non-compliant properties (Mann-Whitney U, P<0.01). Independent compliance had a negative correlation with the number of children at the property with BLLs of 5 µg/dL and above (r_s = -0.165, P<.01). This indicates that independently compliant properties were likely to have fewer children with EBLLs than properties with no compliance. Therefore, after excluding properties that had not complied by the time of an EBLL test on the property from the compliant population, compliant properties have fewer children with EBLLs than non-compliant properties.

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Rates of compliance and exposure varied by city, as shown in Figure 2.2.

Figure 2.2 At Least One Child Exposed to BLL 5+, by Compliance Status and City
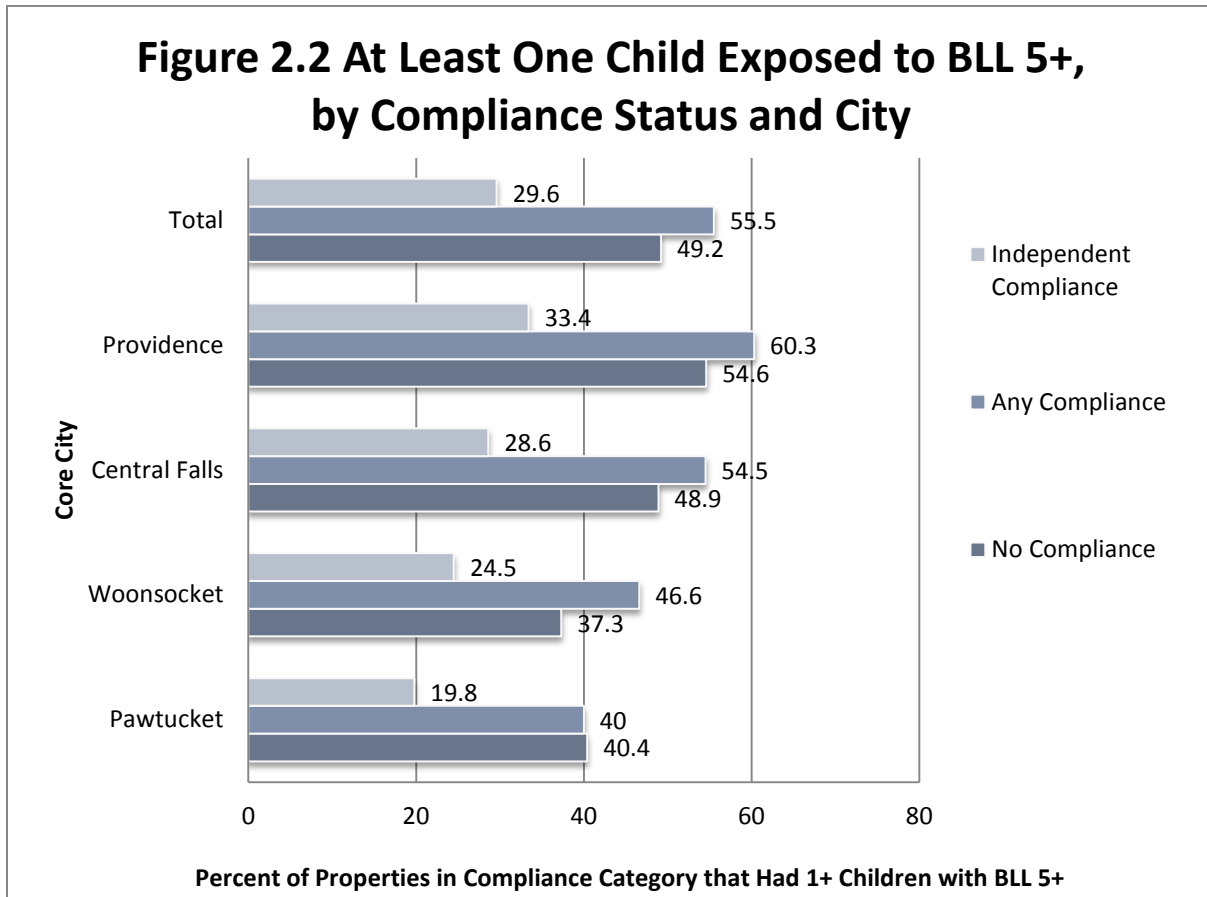
Providence had the highest rates of at least one exposure to BLL 5 μg/dL or higher across all compliance categories. Among those that were compliant at any time and those that were independently compliant, Pawtucket had the lowest percentage of EBLLs.   Among properties that were not compliant, Woonsocket had the lowest percentage of EBLLs.

Overall, about 20 percent of properties had more than one child with EBLLs. Table A.3 in Appendix 2 shows the rates by city and compliance status for no exposures, one exposure, and two or more exposures of BLL 5 μg/dL or higher. Within the any compliance category, rates of two or more EBLLs ranged from 13 percent of properties in Pawtucket to 28 percent in Providence. Providence also had the highest proportion of two or more EBLL exposures over all the compliance categories, at 23 percent of properties. Woonsocket had the lowest rates of two or more EBLLs overall (11 percent).

Lead Poisoning Rates

Overall

In total, about 13 percent of all non-exempt two- to five-family properties with a BLL test on the property had at least one child with BLLs of 10 µg/dL or higher, which we refer to as lead poisoning (12.9 percent, n=765). In almost three percent of all properties, at least two children tested were lead poisoned (2.6 percent, n=152).

By Compliance Status Categories

Figure 2.3 shows the number of lead poisoned children across compliance categories.

Figure 2.3 Number of Children Exposed to BLL 10+, by Compliance Status

■ One or more children   ■ Two or more children
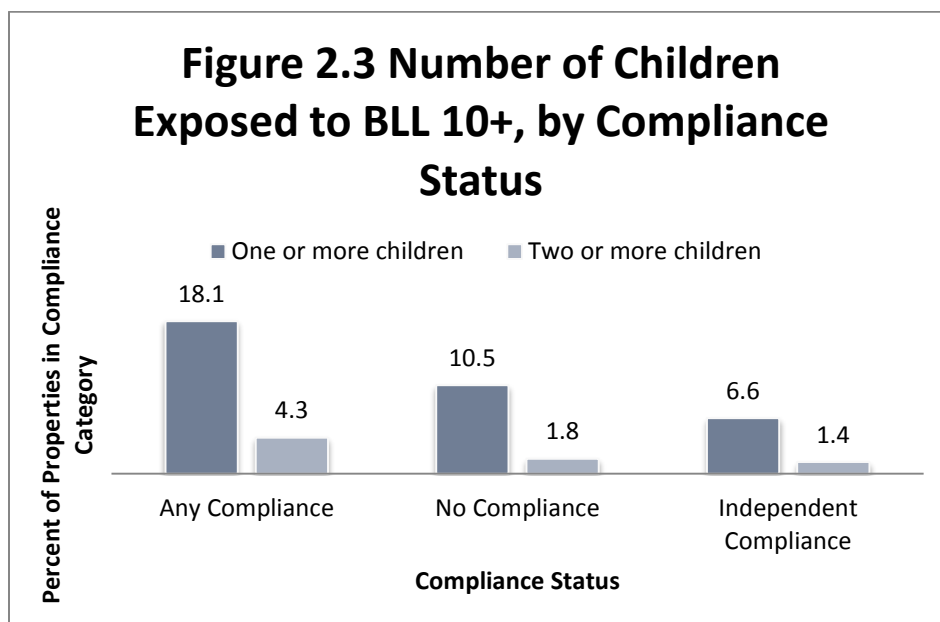
Properties with any compliance had the highest proportion of children exposed to BLLs of 10 µg/dL or above, followed by no compliance and independent compliance, respectively.

### *Statistical Comparison of Compliance Status Categories*

The number of lead poisonings at a property within compliance status categories followed a pattern similar to that of EBLLs: the independent compliance category had the lowest rates of exposures, any compliance had the highest rates, and no compliance fell in the middle. There were statistically significant differences between the compliant and non-compliant property populations (*Mann-Whitney U*, P<0.01).

The positive correlation between compliance at any time and lead poisoning was statistically significant at the 0.01 level (r_s = .107). This indicates that properties with any compliance are likely to have had more lead poisoned children on the property than those with no compliance.

When we changed the classification of compliance from any compliance to independent compliance, the direction of the relationship reversed. The negative correlation between independent compliance and lead poisoning was statistically significant ($r_s = -0.056$, P<.01). Thus, non-compliant properties are likely to have slightly more lead poisoned children than those with independent compliance.

Rates by City

Providence had the highest rates of one or more lead poisonings within all three compliance categories: no compliance, any compliance, and independent compliance (see Figure 2.4).

Figure 2.4 At Least One Child Exposed to BLL 10+, By Compliance Status and City

Core City	Independent Compliance	Any Compliance	No Compliance
Total	6.6	18.1	10.5
Providence	7.8	20.5	13.5
Central Falls	6.3	17	7.8
Woonsocket	3.9	12.3	5.7
Pawtucket	4.3	12	6

Percent of Properties in Compliance Category that Had 1+ Children with BLL 10+
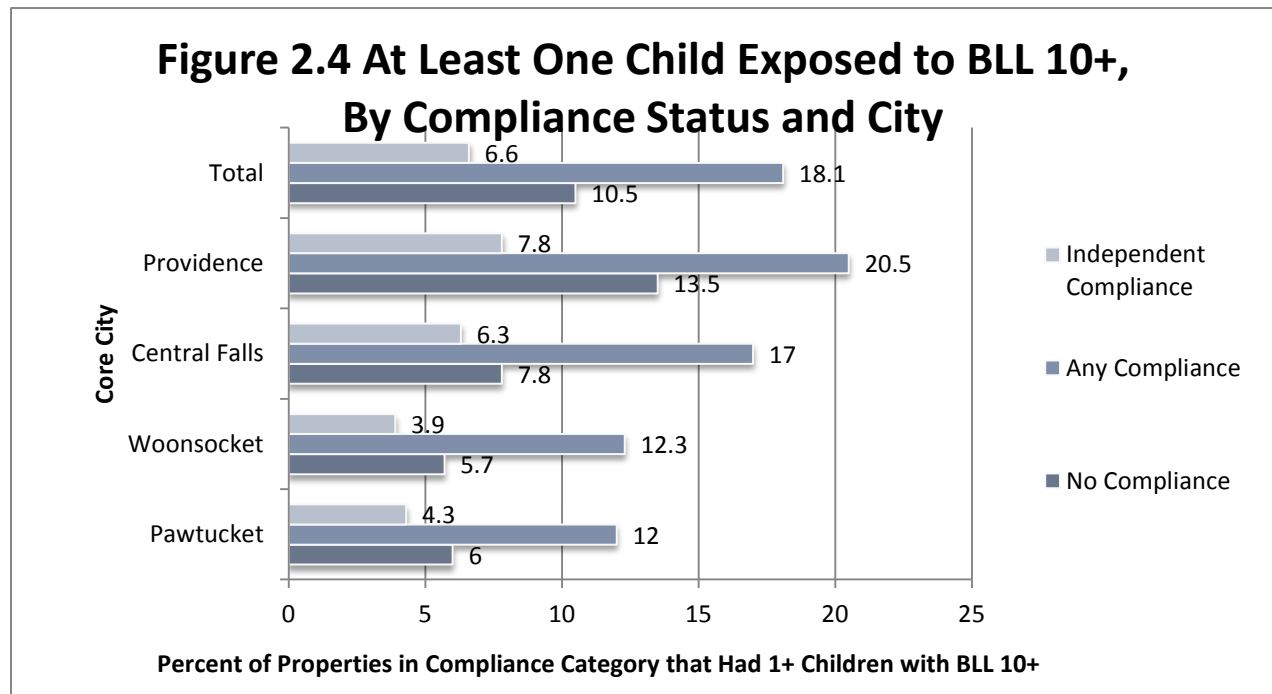
Among those that were compliant at any time, Pawtucket had the lowest proportion of lead poisoning. Within the independent compliance and no compliance categories, Woonsocket had the lowest proportion of lead poisoning (3.9 percent and 5.7 percent, respectively).

Table A.4 in Appendix 2 shows the distribution of the rates of the number of lead poisoned children between cities and compliance status categories. Providence had the highest rate of two or more lead poisonings at a property, at over three percent (n=123). Pawtucket and Woonsocket had about one percent of properties with two or more lead poisonings at a property, while Central Falls had about two percent. Within Providence, the properties with any compliance had the highest proportion of two or more lead poisonings (5.7 percent).

1. Compliance with the Lead Hazard Mitigation law is low among non-exempt residential two- to five-family properties.

2. Of the four core cities, Providence had the highest rates of EBLLs and lead poisonings overall and within each compliance category.

3. Properties that complied at any time during the study period (before or after a blood lead test took place) were likely to have more children exposed to EBLLs or lead poisoning than those with no compliance history.

4. The direction of the relationship between compliance and lead exposure reversed when the population was limited to independent compliance (properties that were noncompliant at the time of an EBLL screening but became compliant afterward were excluded). Independently compliant properties were likely to have fewer children exposed to EBLLs or lead poisoning than those with no compliance history. This suggests that living in a property that is compliant at the time of lead screening may be a protective factor for children's lead exposure.

Priorities

1. **Emphasize that Compliance is Vital**

   Without a Certificate of Conformance or Lead Safe Lead Free Certificate, the safety of the interior and exterior paint, dust, or soil on a property is unknown. Because properties that have complied by the time of screening may have fewer cases of EBLLs, more non-exempt property owners should comply with the Lead Hazard regulations.

2. **Identify New Ways to Enforce the Lead Hazard Mitigation Law**

   The current approach to enforcing the law appears insufficient for children's health, since less than half of owners of two- to five-family non-exempt properties complied with the law from 2005 to 2009. More resources could be devoted to ensuring that owners of all non-exempt properties follow the necessary steps to obtain Certificates of Conformance or Lead Safe Lead Free certificates.

3. **Prioritize Compliance among Properties with a History of Lead Exposure**

   Although not an effective prevention strategy as a general rule, identifying properties with the most children who have already been exposed to lead can help identify properties that might

have lead hazards. This can help limit any further lead exposure to children who currently
reside there and prevent additional children from being exposed in the future.

4. **Empower Tenants**

Continuing to promote knowledge of the law's parameters among tenants and the general
public may prove valuable. Tenants have the potential to hold property owners accountable for
the lead hazards in their units or elsewhere on the premises. It is important that tenants feel
entitled to address lead hazard concerns with property owners, since tenants have the right to
seek court orders that compel compliance.

5. **Investigate the Maintenance of Compliance**

Property owners are expected to renew lead certification every two years. The extent to which
this is maintained and enforced should be investigated. The maintenance of compliance can be
analyzed to see if it affects lead exposure.

Part Three: The Relationship between Lead Exposure and Exemption among Properties with Children Tested for Lead

Part Three examines elevated blood lead levels in the four core cities between four different property types as well as exempt and non-exempt properties. The 17,530 properties that had a blood lead test match between 2005 and 2009 comprised the study population. (This includes confirmed lead screening results for children ages 0 to 72 months). By broadening the scope of analysis, we hoped to better understand the effect that exemption has had on lead exposure in children. Appendix 1 describes the study methods.

Exemption Rates

Properties that were exempt from the regulations in the Lead Hazard Mitigation Act include those that were owner-occupied with less than four units. Figure 3.1 indicates the proportion of properties in each city that was exempt during the study timeframe. Overall, 56 percent of properties in the core cities that had at least one child with a confirmed blood lead test were exempt from the law. Exemption rates ranged from 44 percent in Central Falls to 70 percent in Pawtucket.

Figure 3.1 Exemption Rates Among Properties with BLL Matches, By City

Percent of Properties in City

	Central Falls	Woonsocket	Providence	Pawtucket	Total
■ Exempt %	43.5	49.2	52.3	72.2	55.8
■ Non-Exempt %	56.5	50.8	47.7	27.8	44.2
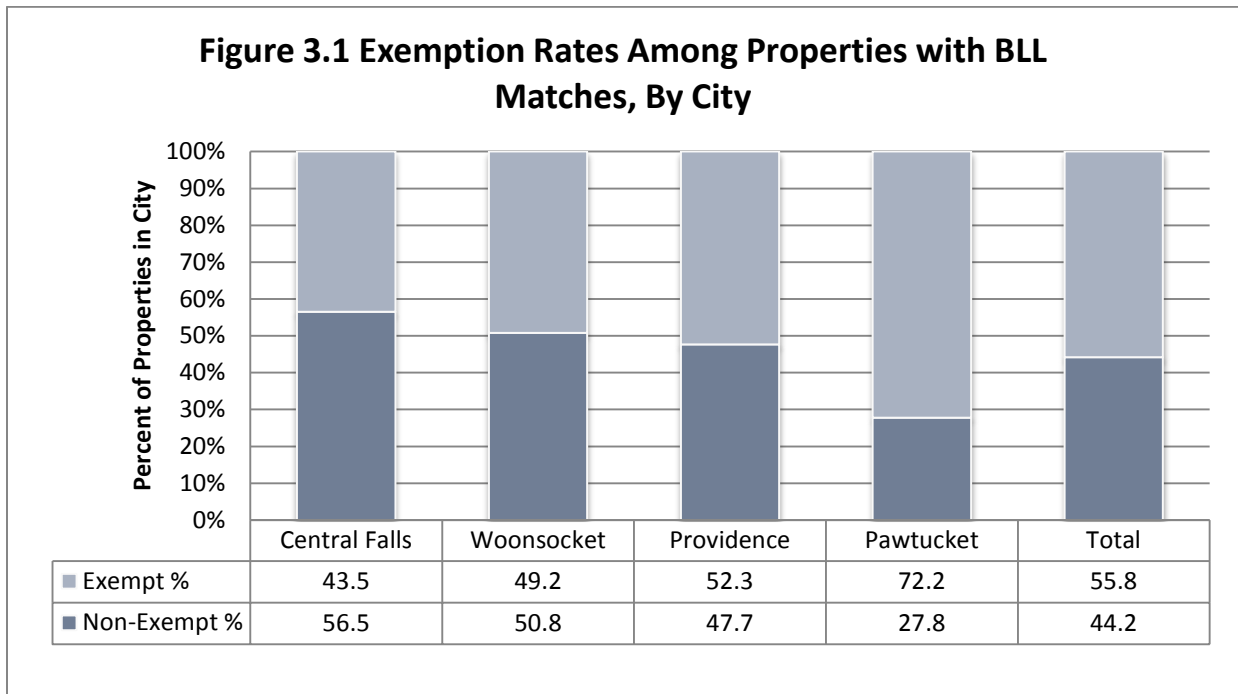
Therefore, across the core cities, more properties that house children who had been tested for lead between 2005 and 2009 were exempt than non-exempt.

Figure 3.2 presents the rates of exemption and number of properties by type of property.

Figure 3.2 Exemption Rates Among Properties with BLL Matches, By Property Type

	Residential Apartments	Commercial/ Residential	Two to Five Family Residences	One Family Residences
■ Exempt %	0	18.2	49.5	81.1
■ Non-Exempt %	100	81.8	50.5	18.9
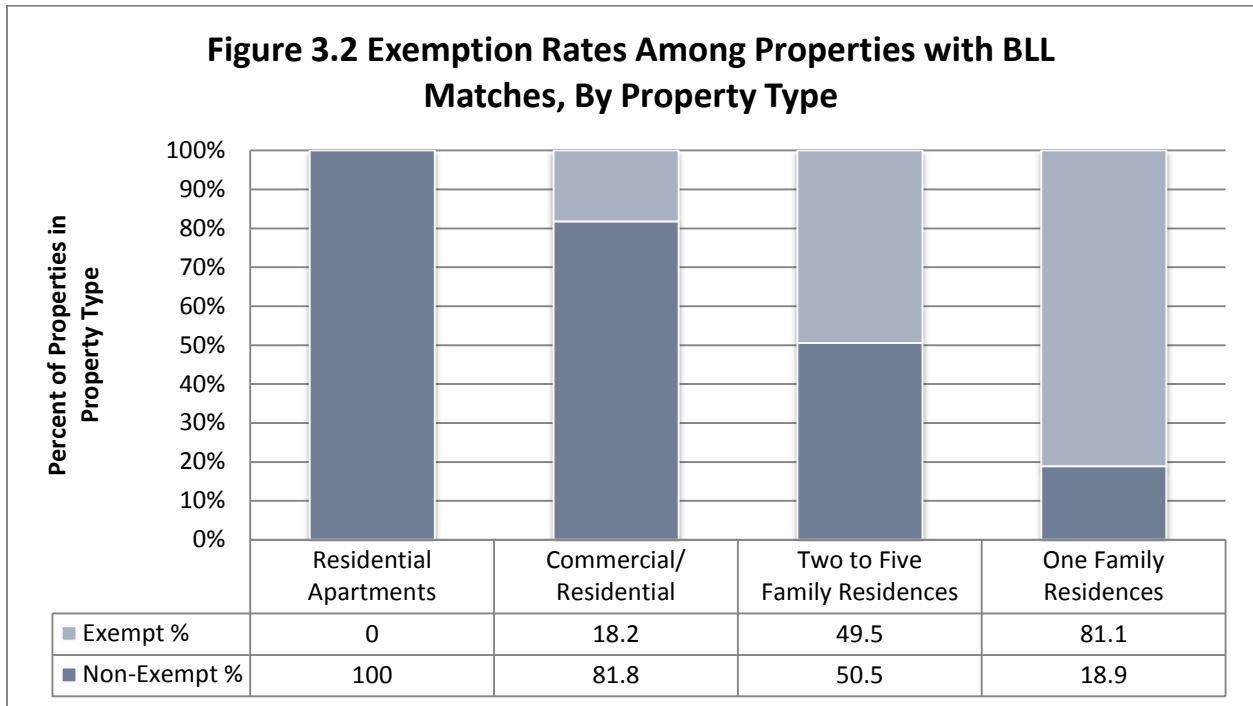
One-family properties had the highest exemption rate. Commercial and residential mixed use properties had the lowest exemption rate. No apartments were considered exempt in our analysis because all of these properties had over four units. Table A.5 in Appendix 2 presents the exemption rates and numbers of properties stratified by city and property type.

Elevated BLLs

Overall

Over 40 percent of all properties in the core cities with BLL matches had at least one elevated blood lead level (EBLL) on the property (42.6 percent, n=7,474). About 14 percent of properties had two or more EBLL on the property (14.0 percent, n=2,458).

By Exemption Status

Again, exempt properties are those that are not subject to the Lead Hazard Mitigation regulations. Non-exempt properties had higher rates of one or more and two or more exposures at the property than exempt properties. Figure 3.3 visualizes this relationship. Fifty percent of non-exempt properties with BLL matches had at least one child with EBLLs compared to 37 percent of exempt properties.

Figure 3.3 Number of Elevated Blood Lead Levels at Property By Exemption Status (Percent)

	Non-Exempt	Exempt	Total
No EBLL	50.0%	63.2%	57.4%
One EBLL	30.8%	26.9%	28.6%
Two or more EBLL	19.3%	9.8%	14.0%
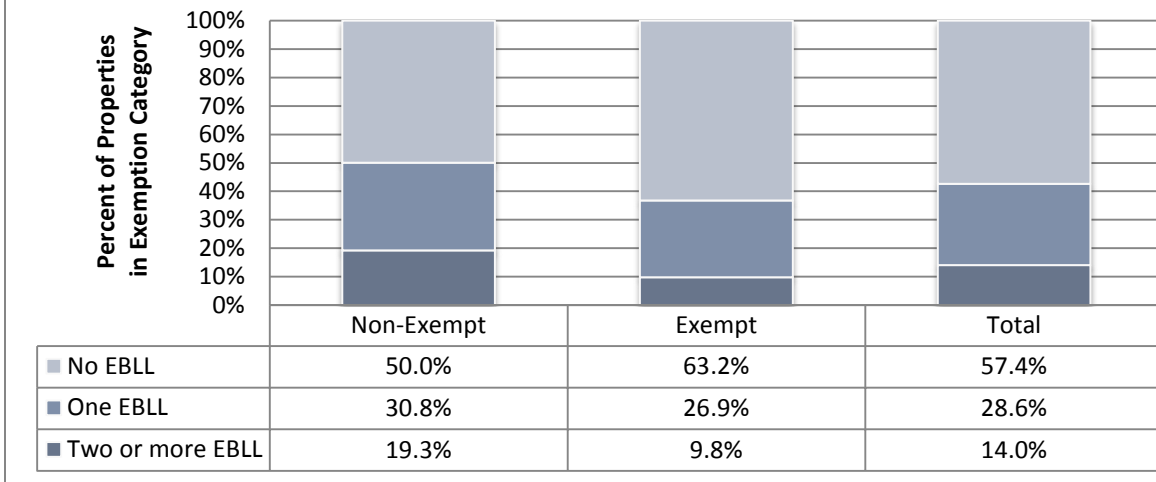
Table 3.1 shows the distribution of one or more EBLLs by property type and exemption status.

Table 3.1 At Least One EBLL at Property			One-Family Residences	2-5 Family Residences	Apartments	Commercial/ Residential	*Total*
Non-Exempt	No Exposure	n	565	2883	305	115	3868
		% of property type	61.2%	48.8%	44.3%	52.3%	50.0%
	1+ Exposures	**n**	**358**	**3028**	**384**	**105**	**3875**
		% of property type	**38.8%**	**51.2%**	**55.7%**	**47.7%**	**50.0%**
	Total	n	923	5911	689	220	7743
		% of property type	100.0%	100.0%	100.0%	100.0%	100.0%
Exempt	No Exposure	n	2921	3236	0	31	6188
		% of property type	73.9%	55.9%	0%	63.3%	63.2%
	1+ Exposures	**n**	**1033**	**2548**	**0**	**18**	**3599**
		% of property type	**26.1%**	**44.1%**	**0%**	**36.7%**	**36.8%**
	Total	n	3954	5784	0	49	9787
		% of property type	100.0%	100.0%	0%	100.0%	100.0%
Total	No Exposure	n	3486	6119	305	146	10056
		% of property type	71.5%	52.3%	44.3%	54.3%	57.4%
	1+ Exposures	**n**	**1391**	**5576**	**384**	**123**	**7474**
		% of property type	**28.5%**	**47.7%**	**55.7%**	**45.7%**	**42.6%**
	Total	n	4877	11695	689	269	17530
		% of property type	100.0%	100.0%	100.0%	100.0%	100.0%

For non-exempt properties, rates of EBLL exposure ranged from 50 percent among one-family residences to 56 percent among apartments.

Within the exempt category, each property type had over a quarter of properties with at least one EBLL exposure (except apartment houses or complexes, which are never exempt). Rates of at least one EBLL exposure among only the exempt properties were lowest among one-family residences (26 percent). Two- to five-family properties had the highest rate of one or more EBLLs for the exempt category (to 44 percent).

Table A.6 in Appendix 2 show the data in Tables 3.1 stratified by city. Central Falls had the highest rate of one or more exposures among exempt properties (46.3 percent). Providence had the highest rate of one or more exposures among non-exempt properties (54.2 percent). Pawtucket and Woonsocket had the lowest rates of one or more exposures among both non-exempt and exempt properties (Pawtucket non-exempt, 39.2 percent; Woonsocket non-exempt, 41.0 percent; Pawtucket exempt, 28.7 percent; Woonsocket exempt, 27.2 percent).

The number and rate of two or more EBLLs are found in Table 3.2 among the same total properties as in Table 3.1. The lowest rates of two or more EBLLs were found in exempt one-family residences. Non-exempt apartments had the highest rates of two or more EBLLs.

Table 3.2 Two or More EBLLs at Property			One-Family Residences	2-5 Family Residences	Apartments	Commercial/ Residential	Total
Non-Exempt	Two or more EBLL	n	88	1178	187	41	1494
		% of property type	9.5%	19.9%	27.1%	18.6%	19.3%
	Total	n	923	5911	689	220	7743
		% of property type	100.0%	100.0%	100.0%	100.0%	100.0%
Exempt	Two or more EBLL	n	151	809	n/a	4	964
		% of property type	3.8%	14.0%	n/a	8.2%	9.8%
	Total	n	3954	5784	n/a	49	9787
		% of property type	100.0%	100.0%	n/a	100.0%	100.0%
Total	Two or more EBLL	n	239	1987	187	45	2458
		% of property type	4.9%	17.0%	27.1%	16.7%	14.0%
	Total	n	4877	11695	689	269	17530
		% of property type	100.0%	100.0%	100.0%	100.0%	100.0%

Table A.7 in Appendix 2 shows two or more EBLLs by exemption status and city. For two or more EBLLs at the property, Central Falls had the highest rates among non-exempt and exempt properties (23.1 percent and 13.6 percent, respectively). Woonsocket had the lowest rates of two or more EBLLs (non-exempt, 12.2 percent; exempt, 4.8 percent).

Statistical Comparison of Exemption Status Categories

We found a statistically significant difference between the number of lead exposures and lead poisonings at exempt properties compared to non-exempt properties (*Mann-Whitney U*, P < 0.01). Non-exemption was positively correlated with the number of EBLLs at a property (r_s = 0.15, P < 0.01) and lead poisonings (r_s = 0.10, P < 0.01).

Number of Properties with Children Exposed to Lead

Certainly, non-exempt properties had higher rates of EBLL exposure than exempt. However, as visualized in Figure 3.1, a similar *number* of exempt properties as non-exempt had at least one child with EBLLs (3,599 in exempt compared to 3,875 in non-exempt). Furthermore, almost 1,000 exempt properties had more than one child with EBLLs.

Figure 3.4 Number of Elevated Blood Lead Levels at Property By Exemption Status (Counts)

	Non-Exempt	Exempt	Total
No EBLL	3,868	6,188	10,056
One EBLL	2,381	2,635	5,016
Two or more EBLL	1,494	964	2,458
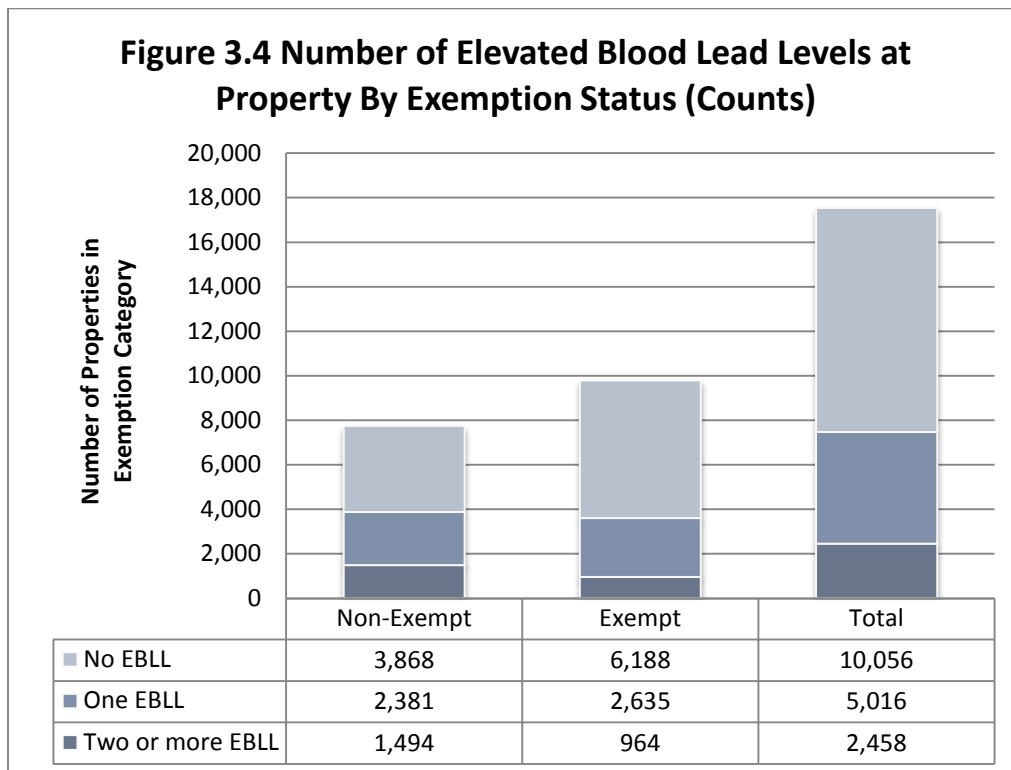
When looking at the numbers of properties with one or more EBLL by city, the majority were found in Providence (2,627 non-exempt, 2,226 exempt). These data are listed in Table A.6 in Appendix 2. Notably, in Pawtucket, more exempt properties had at least one child with EBLLs than non-exempt properties (438 non-exempt, 835 exempt). In the other three cities, the number of properties that had children with EBLL exposure was higher among non-exempt properties than exempt.

Exemption and Compliance

Although not required by law, 13 percent of exempt property owners became compliant at any time during our study period and 9.1 percent were independently compliant (n=1,268 and 892, respectively). For both exempt and non-exempt properties that were independently compliant, rates of one or more EBLL were lower compared to properties with no compliance (non-exempt and non-compliant, 47.8 percent; non-exempt and independently compliant, 29.6 percent; exempt and non-compliant, 35.3 percent; exempt and independently compliant, 24.0 percent). One reason some exempt property owners may have complied is if they had been subject to the law at some point during the study period, but were not when we assessed their exemption status.

Key Findings

1. A majority of properties with children living on the property who had blood lead tests were exempt from the Lead Hazard Mitigation Act. Pawtucket had the highest rate of exemption. Of the property types, one-family properties had the highest exemption rate.

2. Overall, about two fifths of properties—over 7,000 properties—in the core cities had one or more children with elevated blood lead levels (EBLLs). In addition, over 2,000 had at least two children with EBLLs.

3. Non-exempt properties had higher percentages of one or more and two or more EBLLs on the property than exempt properties. However, the two exemption categories had similar numbers of properties with EBLLs overall.

4. Rates of at least one EBLL were over one third among exempt properties, which is cause for concern.

5. Exempt properties that complied with the Lead Hazard Mitigation Act (excluding those that had not complied until after an EBLL on the property) had lower rates of one or more EBLL.

1. **Acknowledge that Exempt Properties Can Expose Children to Elevated BLLs**

   Policymakers and the public should be aware that non-exempt properties are not the only properties that can house children with EBLLs in the core cities. Exempt properties should also be monitored for rates of EBLL exposures.

2. **Inspect the Highest Risk Properties for Lead Hazards**

   The core cities should focus on alerting owners of properties built before 1978 that have had the most children with EBLLs to lead hazards, regardless of exemption status.

3. **Encourage Owners of Exempt Properties to Comply**

   If property owners have complied with the Lead Mitigation Regulations, children who reside there may be less likely to be tested with EBLLs.

4. **Consider Removing the Owner-Occupied Exemption**

   Owner-occupied one-family and multi-family properties still have children on the property with EBLLs. Thus, to best protect the health of children in the core cities, an expansion of the law to owner-occupied properties may be worthwhile.

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Appendix 1: Study Methods

Data

We combined property-level data from five datasets. Tax assessor information for each city allowed us to determine the age and type of properties, the number of units associated with each, and whether the owner resided in the building. To ensure that our address data corresponded with the physical property location and tax record information, we checked them against a "Master Lookup Table", which identifies every address for every property in the core cities. Two datasets, which listed the Certificates of Conformance and the Lead Safe Lead Free designations, determined whether the property complied with Rhode Island's lead regulations. Blood lead screening data associated with the properties helped us determine exposures that could be associated with properties.

Tax Assessor Data

We gathered property information about type and age of structure, occupancy unit count, and owner-occupancy status from each city's tax assessor's office. We tried to obtain information closest to the study timeframe. Recent property information was used for each of the study cities. The data for Providence and Woonsocket are current as of 2009, Pawtucket as of 2010, and Central Falls as of 2011. We focused our analysis on properties that were marked in the tax assessor data as single-family units, multi-family units, apartment buildings, and commercial/residential mixed properties.

Although condominiums are another form of residential living units, we did not include them in our study. We were unable to confidently match lead screening results to compliance information because the condo unit number was frequently omitted from the lead screening and compliance data. Further, the ages of many condominium units were missing in the tax assessor's databases. We speculate that this was due to the conversion into singular units from a larger, older structure. Anecdotal evidence suggests that structures that have been converted to individual condominium units have had renovations that decrease the risk of lead poisoning, such as repainted surfaces, new windows, or removal and replacement of interior walls and ceilings. We would have been unable to determine the condition of each condo unit and the extent to which they had been renovated.

Master Lookup Table

A "Master Lookup Table" (MLT) was created for each study city. For every known address, the MLT designated the parcel identification, plat and lot. We used the MLT to ensure that any living units that share the same address were matched to the correct property-level information. In this way, the MLT allowed us to add more accurate and specific property-level information to addresses in the other datasets used. Each city's MLT was maintained separately, but can be joined together to create one multi-city file.

The Providence MLT was created first through a variety of analytic methods. It consisted of known addresses for the city of Providence compiled from physical plat maps, addresses for historical blood lead screening data, and child addresses from educational data resources. A highly detailed knowledge of Providence properties and experience with matching addresses to property information helped create a file that was distinct from the other three study cities in methodology.

We created the MLTs for Central Falls, Pawtucket, and Woonsocket from the RI Enhanced-911 sites shapefile, available through Rhode Island Geographic Information Systems (RIGIS). This file provided the addresses for all buildings and structures in the state for use by emergency management departments; specifically, the Uniform Emergency Telephone System. The address file was current as of December 2011. We matched the Enhanced-911 point addresses to properties for each respective city with the use of a computer program that could analyze spatial relationships (ESRI ArcMap software).

Compliance Data

Two datasets listed the properties that had obtained Certificates of Conformance or Lead Free and Lead Safe certificates. We aggregated Certificates of Conformance and Lead Free and Lead Safe designations to the property level for all of the study cities. We considered a unit compliant if it had either classification at least once during 2005-2009. If a property had two or more living units, a certificate for at least one unit at the property identified it as compliant. Properties with multiple certificates are counted only once.

Lead Screening Data

RIDOH maintains a unique address identification code for addresses given at the time of the screening. Screening records for children who lived at the same address contained the same address identifier. To ensure accuracy, addresses for children's screening records were compared to an address locator (an enhanced Rhode Island street file) using ESRI software. Unmatched addresses were manually checked for misspellings and incorrect town names. Incomplete addresses and addresses at

post office boxes were dropped from the analysis. Before making any changes to addresses, we checked property tax records and aerial photographs. Matched addresses were also checked for correctness.

We included any confirmed screenings for children ages 0 to 72 months (up to six years) between the years of 2005 through 2009 that could be matched to an address in our population of properties. Rhode Island Department of Health (RIDOH) requires that all children are screened for lead at least twice by the time they are 36 months old. The first screening should occur by the time the child is 12 months old and the second screening should occur by 36 months. Children with elevated lead levels may be screened several times. RIDOH also recommends screening children for lead until age six.

Match Rates

After matching each property-level dataset with the MLT, we joined them together with the tax assessor data. Figure A.1 shows the size of our population as we matched the different datasets.

Figure A.1 Number of Properties in Study Population

Tax Assessor Data
Total Pre-1978 Parcels= 50,961

Non-Exempt=15,678

Exempt= 35,283

COCs
92.8% matched*
(4,388 properties of 4,726 with certificates)

LSLF
83.3% matched*
(1,170 properties of 1,404 with certificates)

Child Lead Screenings
86.6% matched*
(17,530 properties of 20,234)

Non-Exempt with BLL matches= 7,743

Exempt with BLL matches= 9,787
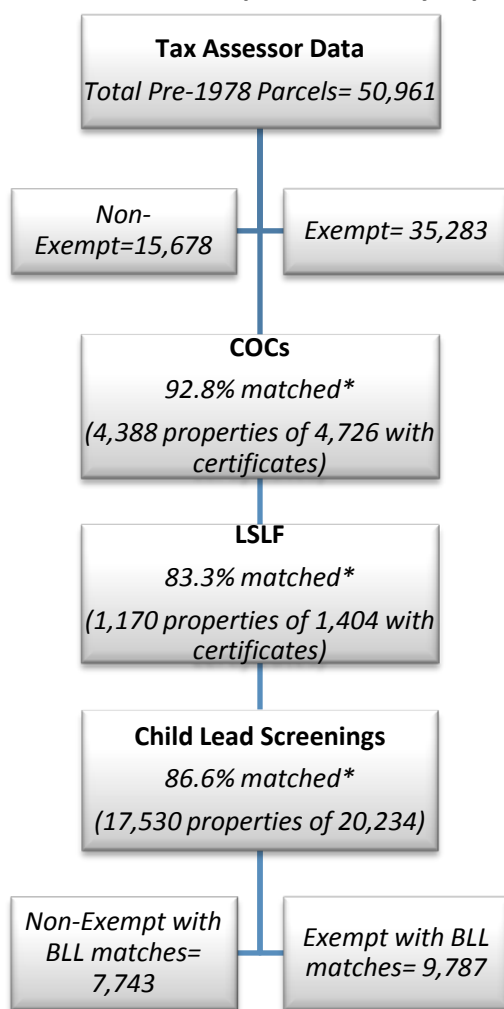
*The match rates report the percent of properties in the dataset from which they originate that matched the properties in our tax assessor dataset. We limited the tax assessor dataset to pre-1978 properties for which we had data from 2005-2009.

Analysis Procedure

From these different sources, we created a property-level data file for analysis. The database identifies, for residential properties in the four core cities in Rhode Island, the Lead Hazard law exemption status, compliance rates, and lead exposure rates. A property-based database can serve as a tool to identify properties to target for lead mitigation efforts.

We followed several steps to create the property database. First, we converted tax assessor data from the four municipalities into a standardized format that could align with the MLT code system. These variables included structure type, unit counts, age of structure, and owner-occupied status. Next, we transformed the address-level datasets into property-level files, summarizing the number of children exposed to lead at each property and the number of times a property was compliant. Finally, we linked the property-level compliance and blood lead screening data with the property-level information dataset.

Study Variables

Exemption

The number of units in each residential structure was retained for multi-family units and commercial/residential mixed properties to determine the Lead Hazard Mitigation Law exemption status. In the Providence and Woonsocket datasets, owner-occupancy status was determined by checking for the presence of a homestead tax exemption. If a property is owner-occupied, the homestead exemption states that owner can apply for a tax abatement for as long as they live at the property. To establish owner occupancy for properties in Central Falls and Pawtucket, the physical address was checked against the tax bill mailing address. If the addresses were the same, the property was considered owner-occupied. Owner-occupied units with one, two, or three living units were exempt from compliance with the law; structures with four or more living units were required to comply with the law, regardless of owner-occupancy status.

Property owners were exempt from the Lead Hazard Mitigation Law if they demonstrated owner occupancy for structures with less than four units. Apartment buildings and structures with four or more living units were not exempt from the law's requirements, regardless of owner occupancy.

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Units built during or after 1978 were exempt because lead-based paint was banned after 1977. For this analysis, all units built after 1978 were removed.

Exemption at each property was analyzed with a dichotomous variable that described whether the property was exempt. This was calculated from variables that identified the age of the property, the number of units at a property, and whether the property was owner-occupied.

Compliance

As described in the introduction, the Lead Hazard Mitigation Law compels owners of rental property to maintain a lead-safe environment. Owners who demonstrated that they complied with the law would receive a Certificate of Conformance (COC). Property owners could have been exempt from the law by obtaining Lead Safe and Lead Free Certificates (LSLF), which demonstrated that a structure either sufficiently reduced lead hazards or had no lead on the premises. Taken together, a COC or LSLF on a property should indicate that a property owner took action to control lead exposure and comply with the regulations of the Lead Hazard Mitigation Law.

The COCs and LSLF datasets only include records for properties that received certificates. Thus, properties that did not match either dataset were assumed to be non-compliant.

Two categorical variables described a property's compliance status: "any compliance" and "independent compliance." If at least one unit on a property had at least one COC or LSLF at any time during the study time frame, that property was identified as having "any compliance."

We also created an "independent compliance" category by comparing the date a property complied with the law to the date the first child living at the property had an exposure of at least 5 µg/dL. If the date of compliance was at least one day later than the date of an elevated blood lead level test, the property was excluded from the "any compliance" population. The subpopulation that remained was identified as independent compliance.

Blood Lead Levels

We created dichotomous variables of 5 µg/dL or above (elevated blood lead levels) and 10 µg/dL and above (lead poisoning) from individual child-level data of confirmed blood screening results. We then summarized these variables to the child's address. Children with screenings at multiple addresses were counted uniquely at each address. If a child had more than one positive test at a given address, we retained only the highest exposure category for the address. We then summed the address-level screening information to the property level. Addresses that could not be matched to a

property in the four cities were removed from the analysis. Thus, we knew how many children were screened at each property and the number of children within each exposure category.

At the property level, we created continuous variables that identified how many elevated blood lead levels or lead poisoning cases occurred. From these, we created dichotomous variables that identified whether one or more children were exposed to lead, as well as a categorical variable that identified if no children, one child, or more than one child was exposed to lead.

Statistical Analyses

We conducted a retrospective cohort study. We used ArcMap 10 for spatial analysis and performed all other statistical analyses using IBM SPSS Statistics software Version 20. Using the Kolmogorov-Smirnov Test for normality, we determined that the variables used in the analysis deviated significantly from a normal distribution (exemption, compliance, and blood lead level counts). Therefore, nonparametric tests were used in all analyses.

We used Spearman's rank order correlations to estimate the direction and magnitude of the associations between variables. Mann-Whitney U tests further assessed whether the differences found between groups were statistically significant.

To compare the differences between cities and property types, we used Kruskal-Wallis H tests, a non-parametric test for categorical variables.

Table A.1 Any Compliance 2005-2009 By City and Property Type			Central Falls	Pawtucket	Providence	Woonsocket	Total
One-Family Residences	No Compliance	n	50	432	2,325	303	3,110
		% in city	90.9%	92.3%	89.1%	94.7%	90.1%
	Any Compliance	**n**	**5**	**36**	**285**	**17**	**343**
		% in city	**9.1%**	**7.7%**	**10.9%**	**5.3%**	**9.9%**
	Total	n	55	468	2,610	320	3,453
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
2-5 Family Residences	No Compliance	n	634	1,379	4,756	1,129	7,898
		% in city	75.4%	78.5%	74.6%	78.0%	75.8%
	Any Compliance	**n**	**207**	**377**	**1,619**	**318**	**2,521**
		% in city	**24.6%**	**21.5%**	**25.4%**	**22.0%**	**24.2%**
	Total	n	841	1,756	6,375	1,447	10,419
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
Apartments	No Compliance	n	74	122	345	204	745
		% in city	61.2%	68.9%	71.6%	64.6%	68.0%
	Any Compliance	**n**	**47**	**55**	**137**	**112**	**351**
		% in city	**38.8%**	**31.1%**	**28.4%**	**35.4%**	**32.0%**
	Total	n	121	177	482	316	1,096
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
Commercial/ Residential	No Compliance	n	13	18	560	5	596
		% in city	81.3%	85.7%	84.0%	83.3%	83.9%
	Any Compliance	**n**	**3**	**3**	**107**	**1**	**114**
		% in city	**18.8%**	**14.3%**	**16.0%**	**16.7%**	**16.1%**
	Total	n	16	21	667	6	710
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
Total	No Compliance	n	771	1,951	7,986	1,641	12,349
		% in city	74.6%	80.6%	78.8%	78.6%	78.8%
	Any Compliance	**n**	**262**	**471**	**2,148**	**448**	**3,329**
		% in city	**25.4%**	**19.4%**	**21.2%**	**21.4%**	**21.2%**
	Total	n	1,033	2,422	10,134	2,089	15,678
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%

Table A.2 Compliance Categories By City and Property Type			Central Falls	Pawtucket	Providence	Woonsocket	Total
One-Family Residences	Non-Compliant	n	50	432	2,325	303	3,110
		% in city	90.9%	92.3%	89.1%	94.7%	90.1%
	Compliant after EBLL	n	0	0	41	3	44
		% in city	0.0%	0.0%	1.6%	.9%	1.3%
	Independent Compliance	**n**	**5**	**36**	**244**	**14**	**299**
		% in city	**9.1%**	**7.7%**	**9.3%**	**4.4%**	**8.7%**
	Total	n	55	468	2,610	320	3,453
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
2-5 Family Residences	Non-Compliant	n	634	1,379	4,756	1,129	7,898
		% in city	75.4%	78.5%	74.6%	78.0%	75.8%
	Compliant after EBLL	n	64	63	499	64	690
		% in city	7.6%	3.6%	7.8%	4.4%	6.6%
	Independent Compliance	**n**	**143**	**314**	**1,120**	**254**	**1,831**
		% in city	**17.0%**	**17.9%**	**17.6%**	**17.6%**	**17.6%**
	Total	n	841	1,756	6,375	1,447	10,419
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
Apartments	Non-Compliant	n	74	122	345	204	745
		% in city	61.2%	68.9%	71.6%	64.6%	68.0%
	Compliant after EBLL	n	21	9	47	29	106
		% in city	17.4%	5.1%	9.8%	9.2%	9.7%
	Independent Compliance	**n**	**26**	**46**	**90**	**83**	**245**
		% in city	**21.5%**	**26.0%**	**18.7%**	**26.3%**	**22.4%**
	Total	n	121	177	482	316	1,096
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
Commercial/ Residential	Non-Compliant	n	13	18	560	5	596
		% in city	81.3%	85.7%	84.0%	83.3%	83.9%
	Compliant after EBLL	n	1	0	15	1	17
		% in city	6.3%	0.0%	2.2%	16.7%	2.4%
	Independent Compliance	**n**	**2**	**3**	**92**	**0**	**97**
		% in city	**12.5%**	**14.3%**	**13.8%**	**0.0%**	**13.7%**
	Total	n	16	21	667	6	710
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%
Total	Non-Compliant	n	771	1,951	7,986	1,641	12,349
		% in city	74.6%	80.6%	78.8%	78.6%	78.8%
	Compliant after EBLL	n	86	72	602	97	857
		% in city	8.3%	3.0%	5.9%	4.6%	5.5%
	Independent Compliance	**n**	**176**	**399**	**1,546**	**351**	**2,472**
		% in city	**17.0%**	**16.5%**	**15.3%**	**16.8%**	**15.8%**
	Total	n	1,033	2,422	10,134	2,089	15,678
		% in city	100.0%	100.0%	100.0%	100.0%	100.0%

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Table A.3 One or 2+ EBLLs By Compliance Category and City			No Compliance	Any Compliance	Independent Compliance (Excludes Compliant after EBLL)	Total
Central Falls	No EBLL	n	228	80	80	308
		% of Compliance Category	51.1%	45.5%	71.4%	49.5%
	One EBLL	n	132	48	20	180
		% of Compliance Category	29.6%	27.3%	17.9%	28.9%
	2+ EBLLs	**n**	**86**	**48**	**12**	**134**
		% of Compliance Category	**19.3%**	**27.3%**	**10.7%**	**21.5%**
	Total	n	446	176	112	622
		% of Compliance Category	100.0%	100.0%	100.0%	100.0%
Pawtucket	No EBLL	n	406	150	150	556
		% of Compliance Category	59.6%	60.0%	80.2%	59.7%
	One EBLL	n	189	67	30	256
		% of Compliance Category	27.8%	26.8%	16.0%	27.5%
	2+ EBLLs	**n**	**86**	**33**	**7**	**119**
		% of Compliance Category	**12.6%**	**13.2%**	**3.7%**	**12.8%**
	Total	n	681	250	187	931
		% of Compliance Category	100.0%	100.0%	100.0%	100.0%
Providence	No EBLL	n	1070	489	489	1559
		% of Compliance Category	45.4%	39.7%	66.6%	43.4%
	One EBLL	n	797	395	166	1192
		% of Compliance Category	33.8%	32.0%	22.6%	33.2%
	2+ EBLLs	**n**	**492**	**349**	**79**	**841**
		% of Compliance Category	**20.9%**	**28.3%**	**10.8%**	**23.4%**
	Total	n	2359	1233	734	3592
		% of Compliance Category	100.0%	100.0%	100.0%	100.0%
Woonsocket	No EBLL	n	343	117	117	460
		% of Compliance Category	62.7%	53.4%	75.5%	60.1%
	One EBLL	n	154	68	29	222
		% of Compliance Category	28.2%	31.1%	18.7%	29.0%
	2+ EBLLs	**n**	**50**	**34**	**9**	**84**
		% of Compliance Category	**9.1%**	**15.5%**	**5.8%**	**11.0%**
	Total	n	547	219	155	766
		% of Compliance Category	100.0%	100.0%	100.0%	100.0%
Total	No EBLL	n	2047	836	836	2883
		% of Compliance Category	50.8%	44.5%	70.4%	48.8%
	One EBLL	n	1272	578	245	1850
		% of Compliance Category	31.5%	30.8%	20.6%	31.3%
	2+ EBLLs	**n**	**714**	**464**	**107**	**1178**
		% of Compliance Category	**17.7%**	**24.7%**	**9.0%**	**19.9%**
	Total	n	4033	1878	1188	5911
		% of Compliance Category	100.0%	100.0%	100.0%	100.0%

Table A.4 One or 2+ Lead Poisoned Children By Compliance Category and City			No Compliance	Any Compliance	Independent Compliance	Total
Central Falls	No Lead Poisonings	n	411	146	105	557
		% within Compliance Category	92.2%	83.0%	93.8%	89.5%
	One Lead Poisoning	n	26	25	6	51
		% within Compliance Category	5.8%	14.2%	5.4%	8.2%
	2+ lead poisonings	**n**	**9**	**5**	**1**	**14**
		% within Compliance Category	**2.0%**	**2.8%**	**.9%**	**2.3%**
	Total	n	446	176	112	622
		% within Compliance Category	100.0%	100.0%	100.0%	100.0%
Pawtucket	No Lead Poisonings	n	640	220	179	860
		% within Compliance Category	94.0%	88.0%	95.7%	92.4%
	One Lead Poisoning	n	36	29	8	65
		% within Compliance Category	5.3%	11.6%	4.3%	7.0%
	2+ lead poisonings	**n**	**5**	**1**	**0**	**6**
		% within Compliance Category	**.7%**	**.4%**	**0.0%**	**.6%**
	Total	n	681	250	187	931
		% within Compliance Category	100.0%	100.0%	100.0%	100.0%
Providence	No Lead Poisonings	n	2041	980	677	3021
		% within Compliance Category	86.5%	79.5%	92.2%	84.1%
	One Lead Poisoning	n	265	183	41	448
		% within Compliance Category	11.2%	14.8%	5.6%	12.5%
	2+ lead poisonings	**n**	**53**	**70**	**16**	**123**
		% within Compliance Category	**2.2%**	**5.7%**	**2.2%**	**3.4%**
	Total	n	2359	1233	734	3592
		% within Compliance Category	100.0%	100.0%	100.0%	100.0%
Woonsocket	No Lead Poisonings	n	516	192	149	708
		% within Compliance Category	94.3%	87.7%	96.1%	92.4%
	One Lead Poisoning	n	27	22	6	49
		% within Compliance Category	4.9%	10.0%	3.9%	6.4%
	2+ lead poisonings	**n**	**4**	**5**	**0**	**9**
		% within Compliance Category	**.7%**	**2.3%**	**0.0%**	**1.2%**
	Total	n	547	219	155	766
		% within Compliance Category	100.0%	100.0%	100.0%	100.0%
Total	No Lead Poisonings	n	3608	1538	1110	5146
		% within Compliance Category	89.5%	81.9%	93.4%	87.1%
	One Lead Poisoning	n	354	259	61	613
		% within Compliance Category	8.8%	13.8%	5.1%	10.4%
	2+ lead poisonings	**n**	**71**	**81**	**17**	**152**
		% within Compliance Category	**1.8%**	**4.3%**	**1.4%**	**2.6%**
	Total	n	4033	1878	1188	5911
		% within Compliance Category	100.0%	100.0%	100.0%	100.0%

Table A.5 Exemption Among Properties with BLL Matches by Property Type and City			Central Falls	Pawtucket	Providence	Woonsocket	Total
One-Family Residences	Non-Exempt	n	13	78	780	52	923
		% of city	16.5%	5.3%	27.8%	9.8%	18.9%
	Exempt	**n**	**66**	**1384**	**2025**	**479**	**3954**
		% of city	**83.5%**	**94.7%**	**72.2%**	**90.2%**	**81.1%**
	Total	n	79	1462	2805	531	4877
		% of city	100.0%	100.0%	100.0%	100.0%	100.0%
Two- to five-Family Residences	Non-Exempt	n	622	931	3592	766	5911
		% of city	55.4%	38.0%	52.6%	59.0%	50.5%
	Exempt	**n**	**500**	**1518**	**3233**	**533**	**5784**
		% of city	**44.6%**	**62.0%**	**47.4%**	**41.0%**	**49.5%**
	Total	n	1122	2449	6825	1299	11695
		% of city	100.0%	100.0%	100.0%	100.0%	100.0%
Apartments*	Non-Exempt	n	93	105	266	225	689
		% of city	100.0%	100.0%	100.0%	100.0%	100.0%
	Total	n	93	105	266	225	689
		% of city	100.0%	100.0%	100.0%	100.0%	100.0%
Commercial/ Residential	Non-Exempt	n	8	4	206	2	220
		% of city	88.9%	44.4%	82.7%	100.0%	81.8%
	Exempt	**n**	**1**	**5**	**43**	**0**	**49**
		% of city	**11.1%**	**55.6%**	**17.3%**	**0.0%**	**18.2%**
	Total	n	9	9	249	2	269
		% of city	100.0%	100.0%	100.0%	100.0%	100.0%
Total	Non-Exempt	n	736	1118	4844	1045	7743
		% of city	56.5%	27.8%	47.7%	50.8%	44.2%
	Exempt	**n**	**567**	**2907**	**5301**	**1012**	**9787**
		% of city	**43.5%**	**72.2%**	**52.3%**	**49.2%**	**55.8%**
	Total	n	1303	4025	10145	2057	17530
		% of city	100.0%	100.0%	100.0%	100.0%	100.0%

*Apartments in our dataset were all non-exempt by definition because they had more than four units.

Table A.6 One or More EBLL By Property Type, Exemption Status, and City				One-Family Residences	2-5 Family Residences	Apartments	Commercial/ Residential	Total
Central Falls	Non-Exempt	No EBLL	n	9	308	34	3	354
			%	69.2%	49.5%	36.6%	37.5%	48.1%
		1+ EBLLs	n	4	314	59	5	382
			%	30.8%	50.5%	63.4%	62.5%	51.9%
		Total	n	13	622	93	8	736
			%	100.0%	100.0%	100.0%	100.0%	100.0%
	Exempt	No EBLL	n	35	268		1	304
			%	53.0%	53.6%		100.0%	53.6%
		1+ EBLLs	n	31	232		0	263
			%	47.0%	46.4%		0.0%	46.4%
		Total	n	66	500		1	567
			%	100.0%	100.0%		100.0%	100.0%
	Total	No EBLL	n	44	576	34	4	658
			%	55.7%	51.3%	36.6%	44.4%	50.5%
		1+ EBLLs	n	35	546	59	5	645
			%	44.3%	48.7%	63.4%	55.6%	49.5%
		Total	n	79	1122	93	9	1303
			%	100.0%	100.0%	100.0%	100.0%	100.0%
Pawtucket	Non-Exempt	No EBLL	n	60	556	60	4	680
			%	76.9%	59.7%	57.1%	100.0%	60.8%
		1+ EBLLs	n	18	375	45	0	438
			%	23.1%	40.3%	42.9%	0.0%	39.2%
		Total	n	78	931	105	4	1118
			%	100.0%	100.0%	100.0%	100.0%	100.0%
	Exempt	No EBLL	n	1075	993		4	2072
			%	77.7%	65.4%		80.0%	71.3%
		1+ EBLLs	n	309	525		1	835
			%	22.3%	34.6%		20.0%	28.7%
		Total	n	1384	1518		5	2907
			%	100.0%	100.0%		100.0%	100.0%
	Total	No EBLL	n	1135	1549	60	8	2752
			%	77.6%	63.3%	57.1%	88.9%	68.4%
		1+ EBLLs	n	327	900	45	1	1273
			%	22.4%	36.7%	42.9%	11.1%	31.6%
		Total	n	1462	2449	105	9	4025
			%	100.0%	100.0%	100.0%	100.0%	100.0%
Providence	Non-Exempt	No EBLL	n	457	1559	93	108	2217
			%	58.6%	43.4%	35.0%	52.4%	45.8%
		1+ EBLLs	n	323	2033	173	98	2627
			%	41.4%	56.6%	65.0%	47.6%	54.2%
		Total	n	780	3592	266	206	4844
			%	100.0%	100.0%	100.0%	100.0%	100.0%
	Exempt	No EBLL	n	1436	1613		26	3075
			%	70.9%	49.9%		60.5%	58.0%
		1+ EBLLs	n	589	1620		17	2226
			%	29.1%	50.1%		39.5%	42.0%
		Total	n	2025	3233		43	5301
			%	100.0%	100.0%		100.0%	100.0%
	Total	No EBLL	n	1893	3172	93	134	5292
			%	67.5%	46.5%	35.0%	53.8%	52.2%
		1+ EBLLs	n	912	3653	173	115	4853
			%	32.5%	53.5%	65.0%	46.2%	47.8%
		Total	n	2805	6825	266	249	10145
			%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table A.6 Continued, One or More EBLL By Property Type, Exemption Status, and City				One-Family Residences	2-5 Family Residences	Apartments	Commercial/ Residential	Total
Woonsocket	Non-Exempt	No EBLL	n	39	460	118	0	617
			%	75.0%	60.1%	52.4%	0.0%	59.0%
		1+ EBLLs	**n**	**13**	**306**	**107**	**2**	**428**
			%	**25.0%**	**39.9%**	**47.6%**	**100.0%**	**41.0%**
		Total	n	52	766	225	2	1045
			%	100.0%	100.0%	100.0%	100.0%	100.0%
	Exempt	No EBLL	n	375	362			737
			%	78.3%	67.9%			72.8%
		1+ EBLLs	**n**	**104**	**171**			**275**
			%	**21.7%**	**32.1%**			**27.2%**
		Total	n	479	533			1012
			%	100.0%	100.0%			100.0%
	Total	No EBLL	n	414	822	118	0	1354
			%	78.0%	63.3%	52.4%	0.0%	65.8%
		1+ EBLLs	**n**	**117**	**477**	**107**	**2**	**703**
			%	**22.0%**	**36.7%**	**47.6%**	**100.0%**	**34.2%**
		Total	n	531	1299	225	2	2057
			%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	Non-Exempt	No EBLL	n	565	2883	305	115	3868
			%	61.2%	48.8%	44.3%	52.3%	50.0%
		1+ EBLLs	**n**	**358**	**3028**	**384**	**105**	**3875**
			%	**38.8%**	**51.2%**	**55.7%**	**47.7%**	**50.0%**
		Total	n	923	5911	689	220	7743
			%	100.0%	100.0%	100.0%	100.0%	100.0%
	Exempt	No EBLL	n	2921	3236		31	6188
			%	73.9%	55.9%		63.3%	63.2%
		1+ EBLLs	**n**	**1033**	**2548**		**18**	**3599**
			%	**26.1%**	**44.1%**		**36.7%**	**36.8%**
		Total	n	3954	5784		49	9787
			%	100.0%	100.0%		100.0%	100.0%
	Total	No EBLL	n	3486	6119	305	146	10056
			%	71.5%	52.3%	44.3%	54.3%	57.4%
		1+ EBLLs	**n**	**1391**	**5576**	**384**	**123**	**7474**
			%	**28.5%**	**47.7%**	**55.7%**	**45.7%**	**42.6%**
		Total	n	4877	11695	689	269	17530
			%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table A.7 Two or More EBLLs By Exemption Status and City			Non-Exempt	Exempt	Total
Central Falls	No EBLL	n	354	304	658
		% of exempt category	48.1%	53.6%	50.5%
	One EBLL	n	212	186	398
		% of exempt category	28.8%	32.8%	30.5%
	2+ EBLL	n	170	77	247
		% of exempt category	23.1%	13.6%	19.0%
	Total	n	736	567	1303
		% of exempt category	100.0%	100.0%	100.0%
Pawtucket	No EBLL	n	680	2072	2752
		% of exempt category	60.8%	71.3%	68.4%
	One EBLL	n	301	661	962
		% of exempt category	26.9%	22.7%	23.9%
	2+ EBLL	n	137	174	311
		% of exempt category	12.3%	6.0%	7.7%
	Total	n	1118	2907	4025
		% of exempt category	100.0%	100.0%	100.0%
Providence	No EBLL	n	2217	3075	5292
		% of exempt category	45.8%	58.0%	52.2%
	One EBLL	n	1568	1562	3130
		% of exempt category	32.4%	29.5%	30.9%
	2+ EBLL	n	1059	664	1723
		% of exempt category	21.9%	12.5%	17.0%
	Total	n	4844	5301	10145
		% of exempt category	100.0%	100.0%	100.0%
Woonsocket	No EBLL	n	617	737	1354
		% of exempt category	59.0%	72.8%	65.8%
	One EBLL	n	300	226	526
		% of exempt category	28.7%	22.3%	25.6%
	2+ EBLL	n	128	49	177
		% of exempt category	12.2%	4.8%	8.6%
	Total	n	1045	1012	2057
		% of exempt category	100.0%	100.0%	100.0%
Total	No EBLL	n	3868	6188	10056
		% of exempt category	50.0%	63.2%	57.4%
	One EBLL	n	2381	2635	5016
		% of exempt category	30.8%	26.9%	28.6%
	2+ EBLL	n	1494	964	2458
		% of exempt category	19.3%	9.8%	14.0%
	Total	n	7743	9787	17530
		% of exempt category	100.0%	100.0%	100.0%

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Appendix Three: The Relationship between Lead Exposure and Compliance among Non-Exempt One-Family Properties with Children Tested for Lead

Table A.8 Any Compliance	n	%
Non-Compliant	767	83.1
ANY Compliance	156	16.9
Total	923	100.0

Table A.9 Independent Compliance	n	%
Non-Compliant	767	83.1
Compliant after EBLL	44	4.8
Independent Compliance	112	12.1
Total	923	100.0

Table A.10 Number of Lead Exposures at Property	BLL 5+		BLL 10+	
	n	%	n	%
No Exposures	565	61.2	847	91.8
One Exposure	270	29.3	66	7.2
Two or more Exposures	88	9.5	10	1.1
Total	923	100.0	923	100.0

Table A.11 Number of EBLLs at Property By Compliance Category		Non-Compliant	Compliant after EBLL	Independent Compliance	Total
No EBLL	n	479	0	86	565
	%	62.5%	0.0%	76.8%	61.2%
One EBLL	n	221	29	20	270
	%	28.8%	65.9%	17.9%	29.3%
Two or more EBLL	n	67	15	6	88
	%	8.7%	34.1%	5.4%	9.5%
Total	n	767	44	112	923
	%	100.0%	100.0%	100.0%	100.0%

Discussion

Properties with independent compliance were likely to house fewer children with EBLLs than properties with no compliance (Mann-Whitney U, $p < 0.01$; $r_s = -0.097$, $P < 0.01$). This was the only statistically significant relationship between compliance categories and BLL categories.

Percent of Children with Exposures of BLL 5 and Above, 2005-2009

WOONSOCKET

North EndSocial District
Downtown Woonsocket
East Woonsocket
Fairmount
Constitution Hill
Hamlet Heights
Globe District
Bernon District

NORTH ATTLEBOROUGH

LINCOLN

ATTLEBORO

CENTRAL FALLS
Pine Crest
Pleasant View

SMITHFIELD

Downtown Pawtucket

PAWTUCKET

Quality Hill
Darlington

Fairlawn
Woodlawn

NORTH PROVIDENCE

Oak Hill

Charles
Hope

Wanskuck

Elmhurst
Mount Hope
Blackstone

Mount Pleasant

Smith Hill

Manton

Valley
College Hill
Wayland

SEEKONK

PROVIDENCE
Downtown

Hartford
Olneyville
Federal Hill
Fox Point

JOHNSTON

Silver Lake
West End
Upper South Providence

EAST PROVIDENCE

Lower South Providence

Elmwood

Reservoir
Washington Park

South Elmwood

CRANSTON

N
0   0.5   1   2 Miles

WARWICK

LEGEND

% in Neighborhood with BLL 5+

6 - 17

18 - 25

26 - 31

32 - 36

37 - 43