MARYLAND TARGETING PLAN FOR AREAS AT RISK FOR CHILDHOOD LEAD POISONING

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EXECUTIVE SUMMARY

This 2015 Targeting Plan for Areas at Risk for Childhood Lead Poisoning revises the previous Targeting Plan, adopted by the Maryland Department of Health and Mental Hygiene (DHMH) in 2004. The 2015 Targeting Plan is based on changes in public health recommendations regarding lead exposure and the changing face of lead exposure in Maryland. The revised 2015 Targeting Plan is part of a comprehensive reassessment of Maryland's public health lead strategy, whose goal is the elimination of lead exposure in the State. The key recommendations in this revised Targeting Plan are:

1. ***Testing of all Maryland children ages 12 and 24 months:*** For a period of three years, all Maryland children under the age of 6 years should be tested for lead exposure at 12 and 24 months of age, based on a determination by DHMH that all ZIP codes and census tracts in the State should be considered "at risk" under the requirements of Maryland Code Annotated, Health-General Article, § 18-106, and Code of Maryland Regulations (COMAR) 10.11.04.
2. ***Re-evaluation of recommendations based on surveillance findings:*** At the end of three years, DHMH will re-evaluate these recommendations, based on the analysis of blood lead testing data developed over the three year period.
3. ***Clinical management:*** Like children with higher blood lead levels, children with blood lead levels of 5 – 9 micrograms per deciliter (mcg/dL) should have a confirmatory test, an assessment of possible sources of lead exposure, an assessment of other vulnerable individuals in the home, and a repeat blood test until it is clear that they do not have ongoing lead exposure.

These recommendations are one part of a comprehensive State strategy to eliminate or control known sources of lead in the environment, conduct surveillance of blood lead levels, ensure appropriate clinical follow-up for those exposed, and provide case management for lead exposed children. The State's Lead Poisoning Prevention Program is based at the Maryland Department of the Environment (MDE) and is conducted in concert with DHMH and local health departments.

In addition to this revised 2015 Targeting Plan, DHMH has also amended its regulations on point-of-care testing (COMAR 10.10.03.02(C)) to make it easier for providers to do lead testing in the office and report the results directly to parents and caregivers. Together with new State laws and regulations governing rental properties and home renovation and repairs, this revised Targeting Plan is intended to move the State towards the goal of eliminating childhood lead exposure in Maryland.

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1. BACKGROUND AND INTRODUCTION

The 2015 Targeting Plan for Areas at Risk of Childhood Lead Poisoning (hereafter referred to as the 2015 Targeting Plan) recommends a revised strategy for testing Maryland children for lead exposure. It is the first comprehensive reassessment of lead testing strategies in the State since 2004 and incorporates new recommendations from the U.S. Centers for Disease Control and Prevention (CDC) regarding blood lead levels that will require follow up action from clinicians, government agencies, and other stakeholders. The 2015 Targeting Plan was also prepared in response to significant changes in both statutory and regulatory requirements, as well as the progress that Maryland has made in reducing lead poisoning cases in the State since 1985.

Exposure to lead remains the most significant and widespread environmental hazard for children in Maryland, although substantial reductions in lead exposure and lead poisoning have also been achieved. While the prevalence of elevated blood lead levels in children in Maryland has declined dramatically over the years, there are still children with persistently elevated blood lead levels from previous exposures, and children who are newly exposed to lead every year (Figure 1). Children are most vulnerable to the adverse effects of lead exposure before age six, a period when their neurological systems are developing and when hand-to-mouth behaviors increase the opportunity for ingestion of lead-containing material. Exposure to lead can cause permanent neurological damage that may be associated with learning disabilities, decreased intelligence, and behavioral problems. Exposure to lead in paint chips and lead-contaminated dust from deteriorated painted surfaces is the primary cause of elevated blood lead levels in young children; however, some old or imported toys, lead-painted pottery, certain hobbies, traditional home remedies or cosmetic items, and clothing contaminated with lead from the workplace are all other possible sources of lead.

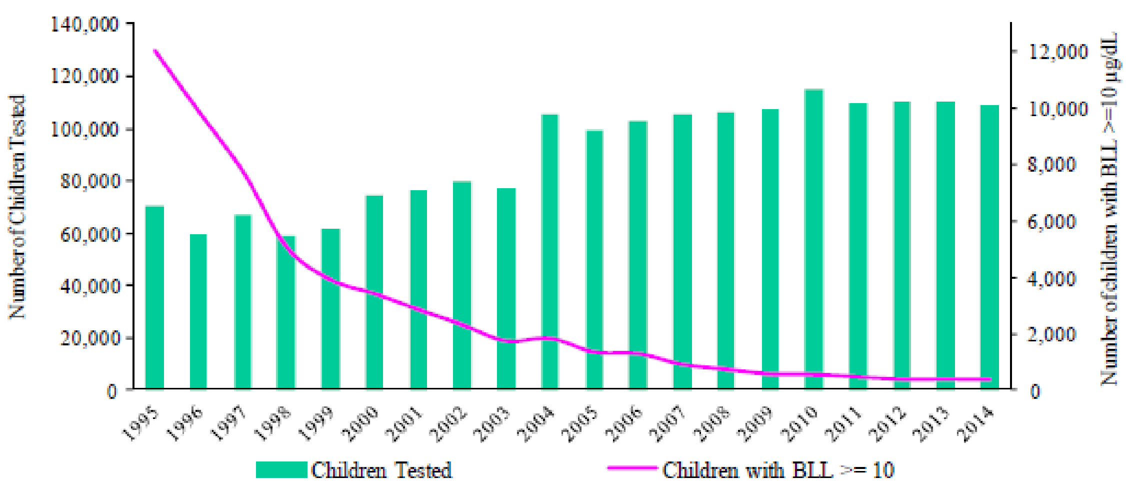

Figure 1. Number of children tested and newly-diagnosed with blood leads ≥10 mcg/dL, 1995-2014 (source = Maryland Department of the Environment, 2015).

The Maryland Department of the Environment (MDE) and and the Department of Health and Mental Hygiene (DHMH) are the principal state agencies charged with lead poisoning prevention. MDE maintains the Maryland Childhood Lead Registry (CLR), conducts enforcement actions, and coordinates with state and local agencies on lead poisoning prevention measures. MDE works in conjunction with the DHMH toward the goal of eliminating childhood lead poisoning through identification and elimination of sources of lead in the environment, surveillance, blood lead testing, coordination of resources, and case management.

2. EVOLUTION OF MARYLAND'S CURRENT TARGETING PLAN

The goal of the State's lead poisoning prevention program is to eliminate lead poisoning in Maryland. The State has made significant progress towards this goal through the identification and elimination of lead sources, such as lead paint in rental housing, and the testing and identification of children with lead exposure. The goal of testing is to identify children exposed to lead as soon as possible so that interventions can effectively address both sources of exposure and the clinical course of action for the child. There is an additional goal of preventing other children from being exposed.

In 1997, the CDC issued a report on childhood lead poisoning (CDC, 1997) revising an earlier recommendation for universal screening (CDC, 1991). The report recommended universal testing of children receiving Medicaid or Supplemental Food Program for Women Infants and Children (WIC) as well as those residing in areas identified as high-risk, and advocated targeted screening for all other children. In response to the public health concern regarding childhood lead poisoning in Maryland and revised CDC guidance, the 1997 Maryland General Assembly enacted House Bill (HB) 1138 as emergency legislation. This bill directed DHMH to establish a Childhood Lead Screening Program to increase awareness of lead poisoning and to ensure testing of children under age six in areas identified as "at risk." HB 1138 suggested specifically targeting childhood blood lead testing to "at risk" areas, specifically those census tracts with large concentrations of pre-1978 housing, as well as those with the highest rates of lead poisoned children, based on CLR surveillance results. In response, DHMH collaborated with various organizations and the University of Maryland to develop the first State Targeting Plan in 2000, identifying geographic areas in Maryland that were at increased risk for childhood lead poisoning (Center for Health Development, 2000).

The most important factors in the 2000 Targeting Plan found to predict the risk of elevated blood levels in a particular ZIP code were: (1) the percentage of pre-1950 housing; (2) median housing value; (3) "poverty index" (based on a formula incorporating the percentage of residents receiving public assistance income, the percentage of female-headed households, and the percentage of families below the poverty threshold); and (4) the percentage of homes built between 1950 and 1979. These variables were then used to identify "at risk" ZIP codes across the entire State.

Legislation enacted by the 2000 General Assembly required testing of children at 12 and 24 months of age residing in these "at risk" areas of the state (Maryland Code Annotated, Health-General Article § 18-106). Additionally, all children living in Baltimore City or children receiving Medicaid services, regardless of their place of residence, were designated as "at risk," thus requiring testing. A lead exposure risk assessment questionnaire evaluating children for exposures to known sources of lead was also required of all children at their 12 and 24-month doctor's visits regardless of their place of residence. In 2003, a law was passed that required the parent of a child that either previously or currently resided in an "at risk" area to provide documentation of lead testing at first enrollment into pre-kindergarten, kindergarten, or first grade (Maryland Code Annotated, Family Law Article § 5-556.1). Under Maryland law, a child under six years of age must have evidence of appropriate lead screening within 30 days of entering a child care center, family child care home, or non-public nursery school.

In early 2004, DHMH again commissioned the University of Maryland, this time to evaluate and update the 2000 model and Targeting Plan. This update focused on: (1) analysis of the 2000 model variables, (2) reapplication of the 2000 model using data from the 2000 U.S. Census and 2001-2002 CLR data, (3) creation of an updated "at risk" ZIP code list, and (4) development of recommendations for future lead testing in Maryland (Maryland Department of Health and Mental Hygiene, 2004). As a result of this 2004 evaluation, an additional 78 "at risk" ZIP codes were identified. Appendix 1 lists the specific counties and ZIP codes identified as "at risk" as a result of the 2004 revision to the State targeting plan. The results of the updated 2004 Targeting Plan supported targeting outreach and education efforts to increase childhood lead testing in areas at greatest risk, as well as testing all children living in Baltimore City and all children receiving services through Medicaid, as required by Maryland law.

3. REVISION OF FEDERAL AND STATE CLINICAL GUIDELINES FOR LEAD EXPOSURE

In May, 2012, the CDC accepted recommendations from its Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) regarding lowering children's acceptable blood lead levels from 10 mcg/dL to 5 mcg/dL (Advisory Committee on Childhood Lead Poisoning Prevention, 2012; CDC, 2012). This recommendation included eliminating the term "level of concern" (previously set at 10 mcg/dL), and substituting a new term, "reference level," equal to the 97.5th percentile of blood lead measured in children in the National Health and Nutrition Examination Survey (NHANES), which is currently 5 mcg/dL.

DHMH endorsed this recommendation and issued a letter to clinicians on June 7, 2012, recommending that clinicians follow the new CDC guideline and re-test children with blood lead levels of 5 – 9 mcg/dL within three months (Appendix 2). At the time, DHMH also stated that it would follow up on these guidelines with additional guidance on: "the referral and case management process for children with new blood lead tests between 5 and 9 mcg/dL, whether and how far to "look back" for children who previously have had blood lead levels between 5 and 9 mcg/dL, and the appropriate clinical and administrative management of children with historic blood lead levels between 5 and 9 mcg/dL." DHMH subsequently embarked on a detailed analysis of surveillance results for childhood lead exposure in the State in cooperation with MDE, leading to the current plan. In addition, DHMH has developed recommendations for case management of children with blood lead levels between 5 and 9 mcg/dL, which are being issued separately from this document. The next section describes the rationale for and evaluation of DHMH's revision of the State testing strategy.

4. TARGETING PLAN REVISION: RATIONALE AND EVALUATION

There are four important factors that make this an appropriate time to revise the State's targeting plan. First, it has been a decade since the plan was last re-evaluated; a decade that has seen a significant decline in the number and rate of new cases of childhood lead poisoning. Second, the risk factors for new cases have changed. A decade ago, most of the cases of elevated blood lead were from children in rental units exposed to peeling and chipping lead paint. While these sources are still important, a larger proportion of cases now come from sources including owner-occupied housing, rental housing not previously covered under Maryland law, non-paint sources such as food or consumer products, or sources that cannot be identified. Third, the change in Federal recommendations adopted in 2012 means that a large number of children, who previously might have been tested and had blood lead levels less than 10 mcg/dL or who might not have been tested at all, should now be tested and identified by their primary care providers. And fourth, even under the current targeting plan, many children who should be tested have not been, prompting DHMH to take a fresh look at the entire strategy and assess why testing rates are not as high as recommended.

Three options were evaluated in developing the revised strategy: (1) targeted testing strategy based on lead levels in children tested for lead exposure, using data from the Maryland CLR for the period 2005-2009; (2) targeted testing based on criteria similar to the previous 2000 and 2004 strategies, which used factors such as housing age and demographics in a model to predict the areas of highest lead exposure risk; and (3) designation of all areas of the State as "at risk," which would result in testing of all children under the age of six (the period when children are at greatest risk of permanent damage from lead exposure). These options are described in Table 1 and in more detail in Appendix 3, Methods.

Table 1. Description of testing strategy options evaluated

Testing Strategy	Description of Strategy
Option 1: Testing based on ZIP code distribution of 2005-2009 test results	Lead test results between 2005-2009 for children under age 6 in the Maryland Childhood Lead Registry were used to predict the ZIP codes that would yield the greatest number of children with lead levels ≥ 5 µg/dL (Appendix 3)
Option 2: Testing based on updated Maryland targeting model	"At-risk" areas defined using risk factors similar to 2000, 2004 targeting plans: housing characteristics, population demographics (Appendix 3)
Option 3: Universal testing	All areas of the State are designated "at risk;" all children under 72 months tested at 12, 24 months of age (Appendix 3)

Each option was evaluated according to how well it addressed health disparities, its efficiency in identifying children with elevated lead levels (sensitivity), simplicity, its completeness of coverage, and its potential cost-effectiveness.

The evaluation criteria also included the following assumptions:

- The State should prioritize testing populations that are disproportionately exposed to or affected by lead poisoning.
- All children enrolled in Medicaid should be tested for lead exposure at ages one and two years, as per the current policy.
- Targeting strategies should be designed to maximize the likelihood of identifying children with higher lead levels first, then children with lower levels.
- Any targeting strategy that does not involve universal testing should be simple to administer and understand, so that parents, health care providers, and health care organizations can easily determine whether a particular child should be tested.
- Any targeting strategy that does not involve universal testing should, at a minimum, ensure that all children who are not tested are screened by questionnaire for potential lead exposure, then tested based on suspicion of potential lead exposure.
- Any targeting strategy that does not involve universal testing should also be designed to avoid disproportionate or systematic exclusion of particular groups from testing.
- The testing strategy should be cost-effective; specifically, it should assure that the anticipated large numbers of blood lead levels of 5 – 9 mcg/dL results do not consume resources to the extent that they prevent an adequate response to more severely exposed children.
- The State should provide guidance to health care practitioners and organizations on how to manage children who are tested and found to have blood lead levels between 5 – 9 mcg/dL.

5. FINDINGS AND RECOMMENDATIONS

In developing its recommendations, DHMH has weighed the strengths and weaknesses of each of the three options. The selection of the best strategy depended on a number of factors, including: (1) the estimated number of lead-exposed children identified through selective (i.e., non-universal) testing, as well as the estimated number of lead-exposed children who might be missed; (2) the costs of testing and associated follow-up; (3) the impacts of expanded testing on both the public and the health care system; (4) the potential benefits of identifying children with low-level exposures before they become significantly exposed; and (5) potential limitations of data and models used to analyze each of the targeting strategy options.

The findings of the evaluation are summarized in Table 2, and in more detail in Appendix 4. Using methods similar to those in the 2000 and 2004 Maryland targeting plan, options one and two characterized areas as "high", "moderate," or "low" risk groups. Adoption of the first strategy would result in testing 420,158 children. Of those tested, 293,258 would be expected to have a blood lead level at or above the reference level of 5 mcg/dL and an additional 5,631 children with blood lead levels at or above the reference are expected to miss out on testing. Using the second model, it is expected that 106,570 children would be indicated to receive testing. Of these children, 31,747 are predicted to have a blood lead level at or above the reference and an additional 614 children predicted to have a blood lead level at or above the reference level of 5 mcg/dL are expected to miss testing.

Finding 1: Targeted Testing has Significant Limitations

Any targeted (non-universal) testing strategy would inevitably lead to the exclusion of some at-risk children from testing. Thus, any testing strategy that does not test children in every part of the State will produce a non-representative picture of lead levels in the entire population. For instance, in areas with newer housing, parents and providers may not consider lead testing because lead is considered to be a problem of older inner cities. In addition, the use of historical test data from particular areas could result in biased projections of test results when making inferences to the entire population, although the direction of the bias is not easily predicted. For example, in areas not currently considered "at risk" under the 2004 Targeting Plan, it is possible that testing is more likely to occur in individuals who are suspected of lead exposure, which would bias those results towards higher concentrations in those tested. Furthermore, the use of a model that emphasizes housing characteristics and demographics would underemphasize the role of non-housing-related sources of lead exposure, and would partly ignore the progress Maryland has made in controlling lead paint exposures.

Additionally, a testing strategy that does not test children in every part of the State will produce a non-representative picture of lead levels in the entire population. The population of children who are currently tested for elevated blood lead is also strongly influenced by the 2004 Targeting Plan, which may bias the risk areas identified using any of these revised targeting strategies. In the ZIP codes targeted under the 2004 Targeting Plan, the average percentage of children in the population tested from 2005-2009 ranges from 10 to 61% with a median of 32%, while in non-targeted areas, the average percentage tested ranges from 0.5 to 46% with a median of 18%.

Since a lower percentage of children from non-at risk ZIP codes are currently tested, the lead levels of children who are tested are unlikely to be representative of the population of children in the area. This could lead either to under-estimation of the "true" population lead level, or over-estimation, depending on whether the few children who are tested are suspected of lead exposure (meaning their levels would likely be higher than other children) or are tested for some other reason, such as access to care (which could lead to misclassification in any direction).

Another limitation of the targeted testing approaches is that they are determined from, and influenced by, population size and 2005-2009 testing rates in the areas. These testing strategies involve a calculation of the predicted number of children with a blood lead level at or above the reference based on this population data. Areas with a large population are more likely to be identified as "at risk," even if they have a lower proportion of tests above the reference level, or a smaller predicted probability. For example, consider ZIP code A with a total population of 100 children and 6/10 (60%) test results above the reference level, and consider ZIP code B with a total population of 1,000 children and 1/10 (10%) test results above the reference level. Targeting approach 1 would result in 60 and 100 children (respectively) estimated to have a blood lead level above reference. Based on this, ZIP code B is more likely to be targeted, although children in ZIP code A may be at greater risk for having a blood lead level above the reference. The implication is that areas with a high proportion of test results ≥5 mcg/dL and a small population are less likely to be targeted than ZIP codes with a large population that have a small proportion of test results ≥5 mcg/dL.

Finding 2: Testing of All Children is More Expensive, but is Easier to Implement, More Equitable, and Provides More Useful Data

Although more costly to implement, a universal testing strategy for a limited time period, based on a determination that all areas of the State should be considered "at risk," is easier and simpler to implement and communicate, and will provide useful data on the true prevalence and distribution of children with elevated blood lead levels in the State. Appendix 5 provides details of the potential costs of the targeting options. This improved understanding of lead risks would ultimately improve future lead testing strategies for the State. The U.S. Census Bureau estimated there were 439,326 children less than 6 years old in 2011. The 2011 MDE Lead Poisoning Prevention Program's annual report indicates that 21.9% of MD children less than 6 years old were tested in 2011 and found 2.5% of those tested had a blood lead level ranging from 5 – 9 mcg/dL, and 0.4% had a blood lead level greater than or equal to 10 mcg/dL. As an upper limit estimate of the "true" number of children with significant lead levels in the State, if the same proportion of tests held in the total population of children, an estimated 12,740 children would be expected to have a blood lead level greater than or equal to 5 mcg/dL.

Testing of all children would be the most expensive of the proposed testing strategies to implement. This strategy also presents an additional issue of how to manage the increased numbers of children with lead levels in the 5-9 mcg/dL range who would likely be identified if all children were tested. Children with blood lead levels in the 5-9 mcg/dl range would require repeat testing, even though many of them might ultimately not go on to develop higher blood lead levels. However, research has indicated that there is no "safe" level of lead exposure in children, and cognitive effects have been noted in children with increasingly low levels. If adopted, an estimated 10,862 children would require follow-up testing, at an estimated cost of between $471,000 and $831,000 per year for the three years of universal testing. It is likely, however, that most of these children will only require repeat testing to confirm that they are *not* being exposed to lead on an ongoing basis. However, a small, but unknown, number will also be found to have lead exposures, which, if prevented through this early detection, would significantly lower the lifetime costs associated with lead poisoning.

Finding 3: All Testing Options, Including Universal Testing, Offer Significant Returns on Investment When Compared with the Costs of Lead Poisoning

A complete cost-effectiveness analysis is beyond the scope of this document, but it is notable that the greatest rate of IQ loss has been found at blood lead levels *below* 10 mcg/dL (Canfield, 2003). In addition, there are many economic costs associated with lead poisoning including lifetime earnings, tax revenue, special education, criminal justice, and long term health effects. Appendix 9 details a cost-benefit analysis of the lead testing strategy. Using multiple methods from the available literature, the lifetime future earnings saved by reducing blood lead levels in 100% of Maryland children ages one and two, with a blood lead level ≥5 mcg/dL, is between $131-$512 million. Adding on savings from tax revenue, special education, juvenile delinquency, and violent crimes the savings in Maryland range from $143-$556 million.

Using the estimated cost range of the Maryland universal testing strategy and the range of savings in the cost-benefit analysis the return for each dollar invested ranges from $24-$142. This may be an underestimate; there is currently not enough research to estimate a cost from associated health conditions and behavioral problems. The Maryland estimate falls within the range calculated by a nationwide study that found a return of $17-$221 (Gould, 2009). Therefore the cost of any of the proposed strategies pales in comparison to the costs of untreated disease, and maximizing detection efforts should remain paramount.

Recommendation: DHMH Should Find All Areas of the State are "At Risk" and Test All Children Age 12 and 24 Months for a Limited Time Period

Given these considerations, DHMH has determined that all areas of the State should be considered "at risk" for a period of three years, and thus require the testing of all children aged 12 and 24 months. This strategy is most likely to produce a true picture of lead exposures across the State, is easy to administer and understand for all parties involved, and is most likely to move the State towards the goal of eliminating lead poisoning and lead exposure among children. At the end of the three-year period, the State intends to re-evaluate the results and decide whether to modify the test strategy. Coincident with the adoption of this strategy, DHMH is providing outreach to health care providers on the management of children with blood lead levels of 5 – 9 mcg/dL, anticipating the need to clarify issues such as how long such cases should be followed.

In making this determination, DHMH recognizes that heath care providers, parents, and other stakeholders will need extensive communication regarding testing, test interpretation, and test follow-up. In particular, there may be questions about the need for testing in areas where people have not previously been subject to testing requirements. Outreach and communication will need to address the ease of testing, the importance and value of early identification of lead exposure, the fact that the strategy will be re-evaluated after a period of time, and DHMH’s determination that all areas of the State are considered “at risk.” Ultimately, this Targeting Plan represents significant progress in the State’s efforts to eliminate childhood lead exposure.

Table 2. Evaluation of Targeting Plan Options

Testing Strategy	Estimated number of 1- and 2-year old children to be tested[§]	Estimated number of children with EBL ≥10 mcg/dL[§]	Estimated number of children with EBL 5 – 9 mcg/dL[§]	Prioritizes populations based on dispropor-tionate exposure or effects	Simple for providers, parents to interpret	Ensures screening by questionnaire for children not tested	Addresses disparities observed in current testing	Estimated cost of implement-ation[§]
Option 1 – Testing based on ZIP code distribution of 2005-2009 test results	91,201 (79,983 Venous, 11,218 Capillary)	1,100 (1,040 Venous, 60 Confirmed Capillary)	7,108 (6,159 Venous, 949 Confirmed Capillary)	May be biased towards areas where testing more likely to be done only in cases of suspected lead poisoning	No	No	No	$2,577,901 - $3,853,697
Option 2 – Testing based on updated Maryland targeting model	108,245 (92,008 Venous, 16,237 Capillary)	1,148 (1,104 Venous, 44 Confirmed Capillary)	8,051 (6,809 Venous, 1,242 Confirmed Capillary)	Assumes exposures primarily related to housing characteristics	No	No	No	$2,904,642 - $4,403,261
Option 3 – Universal testing of all children under 6 at 12 and 24 months	146,037 (124,131 Venous, 21,906 Capillary)	1,548 (1,489 Venous, 59 Confirmed Capillary)	10,862 (9,186 Venous, 1,676 Confirmed Capillary)	Most equitable	Yes	Not applicable	Yes	$3,918,061 – $5,939,876

[§]See Appendix 5, Table A-5.1 for details.

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APPENDIX 1. Current (2015) "At Risk" Areas (Based On 2004 Targeting Plan)

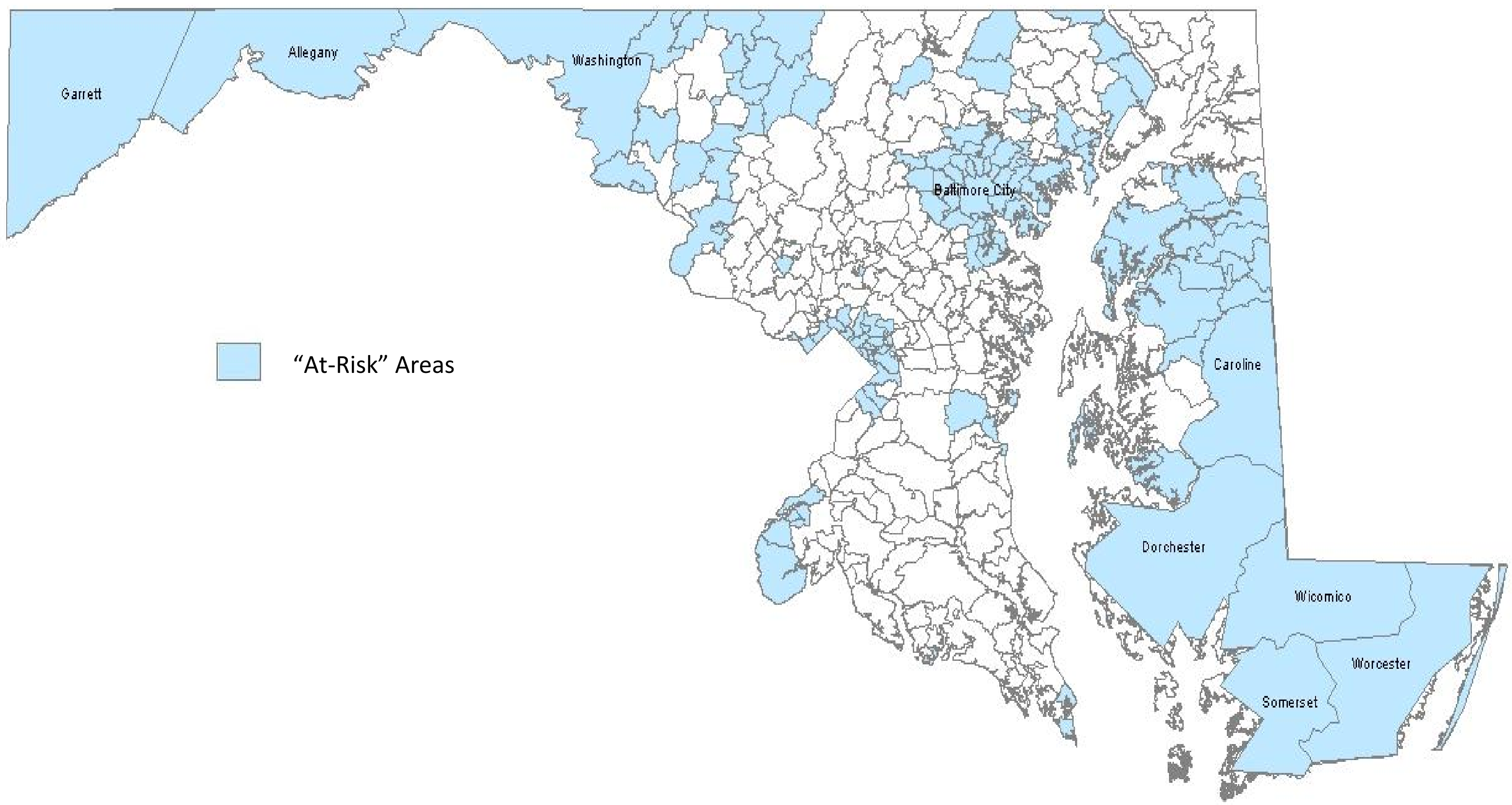

Figure A-1.1. Maryland Lead Targeting Plan, 2004 Revision

Table A-1.1. “At risk” ZIP Codes Identified in the Maryland Lead Targeting Plan, 2004 Revision

Allegany	**Baltimore County**	**Frederick**	**Montgomery**	**Prince George’s** (cont.)
ALL	(cont.)	(cont.)	20783	20913
	21239	21719	20787	
Anne Arundel	21244	27127	20812	**Queen Anne’s**
20711	21250	21757	20815	21607
20714	21251	21758	20816	21617
20764	21282	21762	20818	21620
20779	21286	21769	20838	21623
21060		21776	20842	21628
21061	**Baltimore City**	21778	20868	21640
21225	ALL	21780	20877	21644
21226		21783	20901	21649
21402	**Calvert**	21787	20910	21651
	20615	21791	20912	21657
Baltimore County	20714	21798	20913	21668
21027				21670
21052	**Caroline**		**Prince George’s**	
21071	ALL	**Garrett**	20703	**Somerset**
21082		ALL	20710	ALL
21085	**Carroll**		20712	
21093	21155	**Harford**	20722	**St. Mary’s**
21111	21757	21001	20731	20606
21133	21776	21010	20737	20626
21155	21787	21034	20738	20628
21161	21791	21040	20740	20674
21204		21078	20741	20687
21206	**Cecil**	21082	20742	
21207	21913	21085	20743	**Talbot**
21208		21130	20746	21612
21209	**Charles**	21111	20748	21654
21210	20640	21160	20752	21657
21212	20658	21161	20770	21665
21215	20662		20781	21671
21219		**Howard**	20782	21673
21220	**Dorchester**	20763	20783	21676
21221	ALL		20784	
21222		**Kent**	20785	**Washington**
21224	**Frederick**	21610	20787	ALL
21227	20842	21620	20788	
21228	21701	21645	20790	**Wicomico**
21229	21703	21650	20791	ALL
21234	21704	21651	20792	
21236	21716	21661	20799	**Worcester**
21237	21718	21667	20912	ALL

APPENDIX 2. June 7, 2012 Department of Health and Mental Hygiene Letter to Clinicians on New CDC Guidance

STATE OF MARYLAND

DHMH

Maryland Department of Health and Mental Hygiene
201 W. Preston Street • Baltimore, Maryland 21201
Martin O'Malley, Governor – Anthony G. Brown, Lt. Governor – Joshua M. Sharfstein, M.D., Secretary

June 7, 2012

Dear Health Care Provider:

In May, 2012, the U.S. Centers for Disease Control and Prevention (CDC) responded to recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) to revise the guidelines for childhood lead poisoning.

This letter summarizes the Department of Health and Mental Hygiene's (DHMH) recommendations for the prevention, diagnosis, and management of lead poisoning in children. The letter also summarizes the CDC response and rationale, and the current activities of DHMH and the Department of the Environment (MDE) to respond to this change in guidelines.

The key questions for health care providers addressed in this letter are:

- *What are the recommendations of the Advisory Committee on Childhood Lead Poisoning Prevention, and what were CDC's responses to those recommendations?*
- *What blood lead level should trigger a response by a health care provider?*
- *What is the recommendation for children with blood lead levels between 5 and 9 microgram/deciliter (µg/dL)? For children with blood lead levels 10 µg/dL or greater?*
- *Are there changes in the recommendations for which children in Maryland should be screened or tested for possible lead exposure, the screening and testing procedures, or the ages of screening and testing?*

<u>Key Points of Advisory Committee's Recommendations and CDC's Response</u>

The recommendations from the ACCLPP were based on a thorough review of the science of childhood lead poisoning. The ACCLPP's recommendations were based on the weight of evidence from a growing body of studies showing that the effects of lead appear to be irreversible and can occur at levels < 10 µg/dL. Key points of the recommendations are as follows:

- The ACCLPP recommends that the term "level of concern" be eliminated from all future agency policies, guidance documents, and other CDC publications. CDC agreed that the emphasis should be on preventing even these low exposure levels.

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Web Site: www.dhmh.state.md.us

- CDC agreed that the agency should use a childhood BLL reference value based on the 97.5th percentile of the population BLL in children ages 1-5 (currently 5 µg/dL) to identify children and environments associated with lead-exposure hazards. The reference value should be periodically updated, based on the most recent population based blood lead surveys among children.

- Clinicians should monitor the health status of all children with a confirmed BLL $\geq$ 5 µg/dL for subsequent changes in BLL until all recommended environmental investigations and mitigation strategies have been completed, and should notify the family of all affected children of BLL test results in a timely and appropriate manner. Clinicians also should collaborate with local and state health agencies to ensure that the appropriate services and resources are provided to children and their families.

- Both the ACCLPP and CDC emphasized the importance of educating families, service providers, advocates, and public officials on the primary prevention of lead exposure in homes and other child-occupied facilities to ensure that lead hazards are eliminated before children are exposed.

Recommendations for Maryland Health Care Providers

Based on the new CDC recommendations, DHMH, in consultation with the Lead Poisoning Prevention Program at MDE, is taking the following steps. DHMH is currently recommending that all providers follow the guidelines below regarding lead poisoning prevention in children.

1. *There is no change in the recommendations for the age of testing for children in Maryland.* **The requirement remains that children living in zip codes identified as "at-risk") in the Maryland State Targeting Plan (view at-risk zip codes: http://fha.dhmh.maryland.gov/mch/Documents/Lead-revisedatriskareas2004a.pdf), and all children enrolled in Maryland Healthy Kids (EPSDT), should receive a lead test at ages 12 and 24 months.** In addition, all children should be screened for possible lead exposure with questions about peeling, flaking, or chipping paint, as well as other sources of lead exposure. Any child who has potential sources of lead exposure should be tested for lead.

2. *DHMH, consistent with the new CDC guidance, recommends that children with a lead level greater than the new reference level of 5 µg/dL should be retested within 3 months.* In addition, families whose children have a confirmed level greater than 5 µg/dL should receive lead and nutritional education, and be assessed for possible sources of lead exposure.

3. *There has been no change in the Maryland law related to housing and lead levels.* Maryland law still recognizes a level of 10 µg/dL as the level that triggers regulatory action related to rental housing.

Further Recommendations to Come

A number of important policy issues remain to be answered, including the referral and case management process for children with new blood lead tests between 5 and 9 µg/dL, whether and how far to "look back" for children who previously have had blood lead levels between 5 and 9 µg/dL, and the appropriate clinical and administrative management of children with historic blood lead levels between 5 and 9 µg/dL.

DHMH and MDE will work with local health departments to develop recommendations and guidelines for these questions, based on future CDC guidance and on input from key stakeholders. The agencies propose to solicit stakeholder and public input into these decisions through the Maryland Lead Poisoning Prevention Commission. The agencies anticipate updating state guidance this fall..

Resources for Providers

For further information, including resources for parents, providers, tenants, home owners, contractors, and rental owners, data on childhood lead tests in Maryland, and changes in recent laws affected lead, visit the Maryland Lead Poisoning Prevention Program website at: http://mde.maryland.gov/programs/Land/LeadPoisoningPrevention/Pages/Programs/LandPrograms/leadcoordination/index.aspx. You can also call the Childhood Lead Poisoning Prevention program at 410-537-3825. Questions for DHMH can be directed to the Environmental Health help line toll-free at 1-866-703-3266.

Sincerely,

Frances Phillips RN, MHA
Deputy Secretary for Public Health

Clifford S. Mitchell, MS, MD, MPH
Assistant Director for Environmental Health and Food Protection

APPENDIX 3. Methods

This section describes the analytic framework for the project, beginning with a description of the data sources followed by the methods used to prepare the data sets used for the analysis. Next, the methods used to assemble the data to test each of the three different options for a revised lead targeting strategy for Maryland are described.

Data Sources

Maryland childhood lead testing data were downloaded from the Childhood Lead Registry's Systematic Tracking of Elevated Lead Levels and Remediation (STELLAR) data base. Additional property data were obtained from the State Department of Assessments and Taxation (DAT) and MDE Rental Registry data sets. These data were cleaned, geocoded, and then merged using residential addresses. New variables for each address's latitude, longitude, census tract, and county were added using Centrus geocoding software. Detailed descriptions of these data sets and initial data cleaning procedures are in Appendix 6.

The resulting file included record-level information on the basic demographics (age, gender), blood lead test results (sample date, test type, blood lead level), address (street address, latitude, longitude, census tract) and housing characteristics (year of construction, assumed rental status) on each individual child tested in Maryland annually from 2005-2009. Children without valid addresses and children for whom age was unknown were excluded from the analyses. Each child was counted only once in the full project data set for the year in which she/he received a blood lead test, using the highest confirmatory or venous test.

To present a baseline description of lead testing and the characteristics of children tested in Maryland, descriptive statistics were computed on the full project data set. Tables and maps were generated to summarize the characteristics of children who received a blood lead test from January 1, 2005 through December 31, 2009. Both annual and five-year aggregate analyses were performed, retaining each child's highest venous, unknown, or capillary test result (in that order) for the specified time period. Venous samples were considered the most accurate. Samples with an "unknown" type were prioritized over capillary samples because it was possible that some proportion included venous samples. Any decimals in the reported blood lead levels were rounded *down* to the nearest whole number (e.g., a blood lead level of 9.9 would be rounded to 9), because legally, a blood lead level of 9.9 is still considered less than 10. For annual descriptive analyses, each child was counted once per year in the year they received a blood lead test. These results were presented stratified by year. For the 5-year aggregate analysis, each child was counted only once per 5-year period.

Data were prepared and analyzed with SAS Version 9.2. Maps were prepared using ArcGIS ArcMap 10. Tables were prepared using Microsoft Excel 2010.

Targeting Strategy Option 1 (Target Testing Based on the Distribution of Blood Lead Levels in Children Tested between 2005-2009, by ZIP Code)

The first targeting strategy involves testing all 1- and 2-year old children in the State residing in "at risk" areas, as well as all children receiving Medicaid. This strategy defines "risk" based on historically observed test results from the CLR for all children less than 72 months of age tested between 2005 and 2009. This approach assumes that the proportion of children with a test result of 5 mcg/dL or higher is representative of the entire ZIP code. The "expected" number of children with a blood lead level above the CDC reference level of 5 mcg/dL was then calculated based on this assumption.

This approach is based upon the assumption that the risk (probability) of having a blood lead level ≥5 mcg/dL in a population of children *tested* is the same as the *actual* risk (probability) in the population of children residing in that ZIP code. Unlike Strategy Option 2, below, it does not depend on housing characteristics or other predictors, but instead is based solely on the historically observed distribution of blood lead levels from the Maryland Childhood Lead Registry. This assumption is most accurate for areas of the state that already have relatively high testing rates, but is less accurate for areas that traditionally have relatively low rates of testing.

The full project data set was restricted to children less than 6 years of age. This data set was then aggregated over a 5-year period, and the test result of the highest venous, unknown, or capillary was retained, resulting in a data set that included a single record per individual child tested from 2005-2009. Next, the data set was aggregated by ZIP code, obtaining the total number of tests overall and the number of results ≤4 mcg/dL, 5-9 mcg/dL and ≥10 mcg/dL per ZIP code. The proportion of tests at, or above, the current reference level was calculated as the total number of tests with results ≥5 mcg/dL divided by all tests in each ZIP code (Equation 1).

Equation A-3.1. Proportion of Tests at or above CDC Reference Level of 5 mcg/dL

$$\text{Proportion} = \frac{Number\ Results \geq 5\mu g/dL}{Total\ Number\ of\ Tests}$$

The annual population of children residing in each ZIP code was estimated using the 2000 and 2010 U.S. Census counts of the total number of children less than six years of age in each ZIP code. Procedurally, U.S. Census ZIP Code Tabulation Areas (ZCTAs) were merged using a Geographic Information System (GIS) computer map so that each represented the boundary of each US Post Office ZIP Code. The 2000 Census data were obtained from the 2000 Census summary file compact disk, and Excel files of the 2010 Census data were obtained by MDE from the Maryland Department of Planning. These counts were interpolated to estimate the total annual number of children less than 6 years of age residing in each ZIP code for 2001-

2009. The annual counts of children for each intercensal year were calculated using the accepted premise of a linear change in annual population within the decade. This method, while not as accurate as the 2000 population count, is an accepted method to determine ZIP code population totals for intervening years. The total population change (increase or decrease) from 2000 to 2010 for each ZIP code was divided by 10 (10 years) and a 1/10 increment was added to the total population for the previous year, resulting in an annual estimate of the number of children less than 6 years of age.

The expected number of children with a blood lead level at or above the reference level was calculated by multiplying the proportion of tests at or above the reference level by the estimated population of children less than 6 years of age in each ZIP code.

The list of ZIP codes was sorted in descending order of the proportion of children with a blood lead level ≥5 mcg/dL, based on the 2010 population total, and the cumulative percent was calculated. Potential "at risk" ZIP codes were identified by summing the number of children less than 6 years old with an expected blood lead level ≥5 mcg/dL in each area, starting with areas with the largest number of children expected to have blood lead levels of 5 mcg/dL or greater, until the cumulative total number of cases amounted to 90%, 75%, or 50% of all cases expected in the State. The ZIP codes capturing 90%, 75%, or 50% of the State's total number of children were identified as "at risk."

The computed risk status measure of each ZIP code was merged with other information about each child (ZIP code to child match). The ZIP code polygon-child file was used to identify characteristics of individual children from "at risk" and "non-risk" ZIP codes. Further analyses of this file permitted assessments of the various risk definitions. The Chi-Square test was used to assess whether there were statistically significant differences in the demographic characteristics of "at risk" and "non-risk" areas.

Targeting Strategy Option 2 (Target Testing Based on Updated Maryland 2000 and 2004 Targeting Model)

The second targeting strategy involves testing all children enrolled in Medicaid and all 1- and 2-year old children in the State residing in "at risk" areas, with "risk" defined based on historically observed risk factors such as housing and other demographic data from the U.S. Census. Additional measures from the State Department of Assessments and Taxation (DAT), MDE Rental Registry, MDE Enforcements, and U.S. Census were analyzed to identify potentially new information that could differentiate residential ZIP codes on lead risk. This approach is based upon the assumption that historically identified risk factors (especially lead paint) continue to be the primary influence on a child's risk of lead poisoning in MD and utilizes more recent data to examine the current influence and distribution of these in the state. The assumption underlying this strategy is that a primary risk for lead exposure continues to be lead paint, as in other states in the Northeast United States.

As described above, the initial data consisted of one recorded test per child annually for all children tested from 2005 to 2009. As before, the highest venous, unknown, or capillary sample was used. The resulting data set was then aggregated by census tract. This data set differed from that in the first strategy in that it included counts of the total number of individual children less than 6 years of age tested and the total number of children with test results that were ≤4 mcg⁄dL and ≥5 mcg⁄dL for each census tract. The percentage of children with tests at or above the CDC reference level (5 mcg/dL) was calculated as the number of children with test results at or above 5 mcg/dL divided by the total number of children in each census tract and multiplied by 100 (Equation 2). The denominator was determined by computing the sum of total children with test results below the reference level (≤4 mcg⁄dL) with total children and those with test results at or above the revised lead reference level (5 mcg/dL) per census tract.

Equation A-3.2. Percentage of Tests At or Above CDC Reference Level

$$\text{Percentage of tests} = \frac{Number\ Results \geq 5\ mcg/dL}{Total\ Number\ of\ Tests} \times 100$$

The 2009 American Community Survey (ACS) 5-year estimate (2005-2009) data set, stratified by census tract, was used for the analysis. The following census tract characteristics were identified as critical to the analysis of the data for the 2000 and 2004 targeting models:

- total number of children less than 6 years of age
- total number of families with children less than 5 years of age below poverty level
- total number of female-headed households with children less than 6 years of age
- number of housing units by age, median housing values
- number of households with public assistance income
- total population by race
- number of occupied and vacant houses
- number of renter- and owner-occupied houses
- median household income

The median household income and housing value for each census tract were used to calculate percentages by census tract. The census tract demographics data were merged with the prepared CLR data containing the counts and the percentage of tests at or above the reference level by census tract number.

Because the CLR data set includes five years of data, the average annual proportion of children tested from 2005-2009 was computed for each census tract. This was the total number of individual children less than 6 years old tested each year divided by the estimated total population of children less than 6 years old per census tract (Equation 3). The ACS 5-year estimated population of children by census tract was used as the annual population estimate. Because the annual denominator came from the population census, each child was counted once per year. For consistency in the numerator, an individual child less than 6 years old was counted once for each year in which she/he received a lead test. For this measure, an individual child was counted only once per year, provided that the child received a lead test and was less than 6 years of age in that year.

Equation A-3.3. Mean Annual Percentage of Children <6 Years Old Tested

$$\text{Percentage} = \frac{NT\ 2005 + NT\ 2006 + NT\ 2007 + NT\ 2008 + NT\ 2009}{Population\ of\ children < 6\ years\ old} \times 100$$

NT=Number of Children Tested

The dependent variable of interest was census tract "at risk" area versus census tract "non-at risk" area. This census tract risk area was defined as the percentage of unique children with blood lead tests (one single lead test for each child) per census tract at or above the reference level of 5 mcg/dL. For census tracts in Maryland, this percentage ranged from 0 to 61%. Four dummy-variable binary measures were created: 25th, 50th, 75th, and 90th percentiles. These percentile cut points were selected to identify high-risk census tracts that included 3, 5, 9, and 17% of test results at or above the four reference cut off values, respectively. For example, using the 50th percentile cut-off, census tracts with greater than or equal to 5% of tests at or above the reference level would be considered "at risk" areas.

Census tract characteristics of areas identified as "at risk" and "non-at risk" were compared for each outcome. Risk and non-risk areas were compared using the two-sample t-test if the dependent variable was continuous. Correlations between the covariates were evaluated using the Pearson's correlation coefficient statistic. Based on the results of these comparisons and the observed correlations between the covariates, a "poverty scale" variable was created. This new poverty scale index was computed by summing the standardized proportion of female-headed households, the proportion of households with public assistance income, and the proportion of families below the poverty level. The mean and standard deviation of each of these variables were calculated and used to generate a "standardized value" (Equation 4 a-c). The standardized values were then averaged, resulting in the poverty scale variable used in the model (Equation 5).

Equation A-3.4. Census Tract Standardized Poverty Variables

a) Female-Headed Household (FHH): Standardized FHH = $\frac{\%FHH(tract) - Mean\%\ FHH(state)}{FHH\ Standard\ Deviation\ (state)}$

b) Public Assistance Income (PA): Standardized PA = $\frac{\%PA(tract) - Mean\%\ PA(state)}{PA\ Standard\ Deviation\ (state)}$

c) Families Below Poverty (FBP): Standardized FBP = $\frac{\%FBP(tract) - Mean\%\ FBP(state)}{FBP\ Standard\ Deviation\ (state)}$

Equation A-3.5. Mean Census Tract Poverty Scale Variable

$$\text{Poverty Scale} = \frac{\text{Standardized FHH} + \text{Standardized PA} + \text{Standardized FBP}}{3}$$

The relationship between the community variables (predictors) and the outcome (being a "risk area") was evaluated by computing crude odds ratios (ORs) and ORs adjusted for the average proportion of children less than 6 years of age tested through logistic regression. To calculate the ORs, census tracts were aggregated into tertiles consisting of low, medium, and high groups for each of the independent variables. To construct these groups, the census tracts were sorted with respect to the independent variable, then cut-off values were identified that divided the population of children into three groups, each containing approximately a third of the census population of children less than 6 years old.

Predictive models for each of the four outcomes (dependent variables) were developed and included covariates historically considered to be significant predictors of lead risk in Maryland, as identified in the earlier models. Logistic regression models were used to evaluate the association between each of these covariates and the dependent variable. Each of the four models was evaluated based on several model criteria. These model assessment criteria included the Hosmer-Lemeshow test, Somers' D statistic, and the area under the receiver operating characteristic (ROC) curve. The area under the ROC curve gives a quantitative indication of each model's ability to distinguish between risk and non-risk census tracts and can range from 0.5 (worst) to 1.0 (ideal). The ROC curve plots the probability of correctly detecting a risk area (sensitivity) and correctly detecting a non-risk area (1 minus specificity).

The results for the models were used to generate a predicted probability for each census tract. The predicted number of children was calculated as the predicted probability of that census tract multiplied by the total population of children less than 6 years of age living in that census tract. Census tracts were then ranked as high, moderate, low, or negligible risk based on the percentage of children predicted to have a blood lead level at or above the reference level in that area. The intervals used here are based on the previous State model; this was done to make the current findings comparable to those from the models used in the previous State targeting plans. For each outcome, census tracts containing 40-100% of the highest number of predicted "at risk" children were classified as high risk; tracts containing 11-39.9% were classified as moderate risk; tracts containing 2-10.9% were classified as low risk; and tracts containing less than 2% were classified as negligible risk. The rankings for each outcome measure were mapped to depict the distribution of risk areas across the state. Under the current State targeting plan, areas classified as high, moderate, and low risk are all targeted (Maryland Code Annotated, Health-General Article § 18-106; see also Maryland General Assembly House Bill 1221 (2000 Session)) .

Targeting Strategy Option 3 (Universal Testing)

The final option for a universal testing strategy would be to test every child in the state at the age of one and two years. The universal testing approach eliminates the need to identify "at risk" areas; rather, the expectation would be that all children in every jurisdiction would be tested at age one, and again at age two. Children older than two years of age who were not previously tested are not assumed to be retrospectively tested in this option.

APPENDIX 4. Results of the Analysis

Descriptive Statistics

The number of individual children (≤18 years old) tested in Maryland increased each year from 113,186 in 2005 to 119,866 in 2009, while the number of children with blood lead levels greater than or equal to 10 mcg/dL decreased. The 181 records for which the child was from a state other than Maryland, or the child's state of residence was unknown (0.01-0.09% annually), were excluded, as were reports for any persons older than 18 years of age. Annually, 59-65% of all children tested in the state were two years old or younger. Completeness of information about a child's race and ethnicity has improved each year. In 2009, however, ethnicity and racial data were still incomplete, with 38% and 46% of tested children's ethnicity and race, respectively, still unknown (these variables were still included, however, because of the importance of addressing historical disparities in lead exposure). Table A-4.1 summarizes the demographic information of all Maryland children who received a blood lead test from 2005-2009.

Of the children less than six years old tested in the State each year, most were from Prince George's County (17.1-18.2%), Baltimore City (16.7-17.7%) or Montgomery County (16.5-17.5%). Table A-4.2 summarizes, by county, the number and percentage of children less than six years old tested each year from 2005-2009. The average annual percentage of census-tract-defined children tested for lead ranged from 2-90% during this 5-year period (Figure A-4.1). The median percentage of blood lead tests at, or above, the reference level for all census tracts in the state was 5%. The percentage of test results at or above the reference level by census tract for all children less than six years old tested ranged from 0.5-61.9% (Figure A-4.2). Summary statistics of all children tested in the state, stratified by blood lead level (≤4, 5-9, and ≥10 mcg/dL), are presented in Table A-4.3.

Table A-4.1. Characteristics of Children Tested for Elevated Blood Lead Levels, Maryland 2005-2009

	2005		2006		2007		2008		2009	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Individual Children Tested:	113,186		115,922		118,197		118,893		119,866	
Sex										
Female	54,366	48.0	55,686	48.0	56,894	48.1	57,789	48.6	57,940	48.3
Male	56,840	50.2	58,377	50.4	60,443	51.1	60,521	50.9	61,212	51.1
Unknown	1,980	1.7	1,859	1.6	860	0.7	583	0.5	714	0.6
Age (years)										
<1	10,178	9.0	10,595	9.1	11,280	9.5	11,360	9.6	10,961	9.1
1	32,108	28.4	34,190	29.5	35,809	30.3	36,307	30.5	36,549	30.5
2	24,208	21.4	26,038	22.5	26,822	22.7	28,349	23.8	29,815	24.9
3	11,659	10.3	11,697	10.1	12,011	10.2	11,616	9.8	11,822	9.9
4	12,016	10.6	11,900	10.3	11,497	9.7	11,006	9.3	10,932	9.1
5	8,827	7.8	8,471	7.3	8,259	7.0	7,845	6.6	7,502	6.3
6-18	14,183	12.5	13,026	11.2	12,516	10.6	12,406	10.4	12,285	10.2
Race										
White	18,009	15.9	20,396	17.6	25,577	21.6	27,222	22.9	27,968	23.3
Black	19,840	17.5	23,601	20.4	27,742	23.5	31,011	26.1	32,371	27.0
Other*	2,198	1.9	2,757	2.4	3,453	2.9	4,231	3.6	3,992	3.3
Unknown	73,139	64.6	69,168	59.7	61,425	52.0	56,429	47.5	55,535	46.3
Ethnicity										
Hispanic	7,776	6.9	10,144	8.8	13,890	11.8	16,300	13.7	17,905	14.9
Non-Hispanic	31,848	28.1	38,112	32.9	46,426	39.3	52,408	44.1	56,428	47.1
Unknown	73,561	65.0	67,663	58.4	57,873	49.0	50,174	42.2	45,518	38.0
Race/ Ethnicity										
White, non-Hispanic	10,812	9.6	12,777	11.0	16,914	14.3	18,311	15.4	18,569	15.5
Black, non-Hispanic	15,421	13.6	18,863	16.3	22,689	19.2	25,877	21.8	27,098	22.6
Other*, non-Hispanic	1,340	1.2	1,596	1.4	2,016	1.7	2,645	2.2	2,619	2.2
Unknown, Non-Hispanic	4,275	3.8	4,876	4.2	4,807	4.1	5,575	4.7	8,142	6.8
Hispanic	7,776	6.9	10,144	8.8	13,890	11.8	16,300	13.7	17,905	14.9
Unknown	73,562	65.0	67,666	58.4	57,881	49.0	50,185	42.2	45,533	38.0
Year Child's Home Built										
Pre 1950	20,042	17.7	20,559	17.7	20,916	17.7	20,899	17.6	21,274	17.7
1950 to <1978	19,885	17.6	20,640	17.8	21,045	17.8	21,864	18.4	21,631	18.0
1978 or After	23,699	20.9	24,650	21.3	25,759	21.8	25,330	21.3	24,703	20.6
Unknown	49,560	43.8	50,073	43.2	50,477	42.7	50,800	42.7	52,258	43.6
Probable Rental Property**										
Yes	18,847	16.7	19,702	17.0	20,200	17.1	20,782	17.5	21,295	17.8
No	47,565	42.0	49,015	42.3	50,254	42.5	50,220	42.2	49,299	41.1
Unknown	46,774	41.3	47,205	40.7	47,743	40.4	47,891	40.3	49,272	41.1
Child Resides in 2004 Target Area										
Yes	65,085	57.5	67,341	58.1	67,688	57.3	68,067	57.3	69,228	57.8
No	47,820	42.2	48,563	41.9	50,493	42.7	50,755	42.7	50,621	42.2
Unknown	281	0.2	18	0.0	16	0.0	71	0.1	17	0.0
Sample Type										
Capillary	15,575	13.8	16,560	14.3	16,119	13.6	15,898	13.4	15,948	13.3
Venous	89,302	78.9	90,340	77.9	92,127	77.9	90,778	76.4	88,935	74.2
Unknown	8,309	7.3	9,022	7.8	9,951	8.4	12,217	10.3	14,983	12.5

* Other Includes Asian/Pacific Islander, Native American/Alaskan and Multiracial

** Probable Rental Properties Identified as those properties in the DAT file where the Owner's Mailing address is not the Property Address

Table A-4.2. Annual Lead Testing Counts and Percentages,* by County for Maryland Children <6 years of age, 2005-2009

	2005		2006		2007		2008		2009	
County	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Allegany	1,035	32.6	1,176	34.8	1,233	34.5	1,325	35.1	1,373	34.6
Anne Arundel	6,618	21.4	6,401	19.4	6,627	18.9	6,829	18.4	7,344	18.7
Baltimore County	15,229	35.7	15,621	34.2	16,511	33.9	15,889	30.8	16,178	29.6
Baltimore City	17,373	47.0	18,206	46.4	17,628	42.4	18,557	42.3	19,074	41.3
Calvert	743	16.1	734	14.9	784	15.0	767	13.8	697	11.9
Caroline	853	44.5	888	42.4	852	37.6	858	35.2	894	34.2
Carroll	1,441	16.4	1,356	14.6	1,422	14.5	1,344	13.1	1,341	12.5
Cecil	1,043	18.4	1,055	17.3	1,188	18.2	1,265	18.3	1,213	16.5
Charles	1,812	21.5	1,918	21.3	2,004	20.9	2,032	19.9	1,839	17.1
Dorchester	623	35.8	696	37.2	678	33.8	680	31.8	732	32.3
Frederick	3,021	22.5	3,121	21.8	3,455	22.7	3,379	20.9	3,183	18.6
Garrett	530	34.6	496	30.8	540	32.0	478	27.1	475	25.8
Harford	2,940	21.3	3,045	20.7	3,355	21.6	3,265	19.9	3,187	18.5
Howard	2,265	13.8	2,187	12.6	2,329	12.7	2,496	12.9	2,490	12.3
Kent	174	19.5	256	26.8	334	32.8	303	28.1	323	28.3
Montgomery	16,348	28.8	17,409	28.6	18,298	28.3	18,616	27.1	18,261	25.2
Prince George's	17,900	34.1	18,581	33.2	18,059	30.4	18,729	29.8	19,621	29.6
Queen Anne's	478	19.0	625	23.4	704	24.8	595	19.8	607	19.2
Somerset	492	45.6	514	44.0	528	42.0	522	38.8	497	34.6
St. Mary's	1,382	21.3	1,551	22.1	1,463	19.4	1,519	18.8	1,527	17.8
Talbot	572	34.9	637	36.1	701	37.0	609	30.1	617	28.7
Washington	3,241	40.5	3,016	35.1	3,069	33.5	3,041	31.2	3,003	29.1
Wicomico	2,097	39.6	2,430	42.5	2,974	48.5	2,419	37.0	2,247	32.3
Worcester	703	32.4	968	42.2	942	39.0	910	35.9	850	32.0

* Denominator used to calculate percentages based on U.S. Census population data.

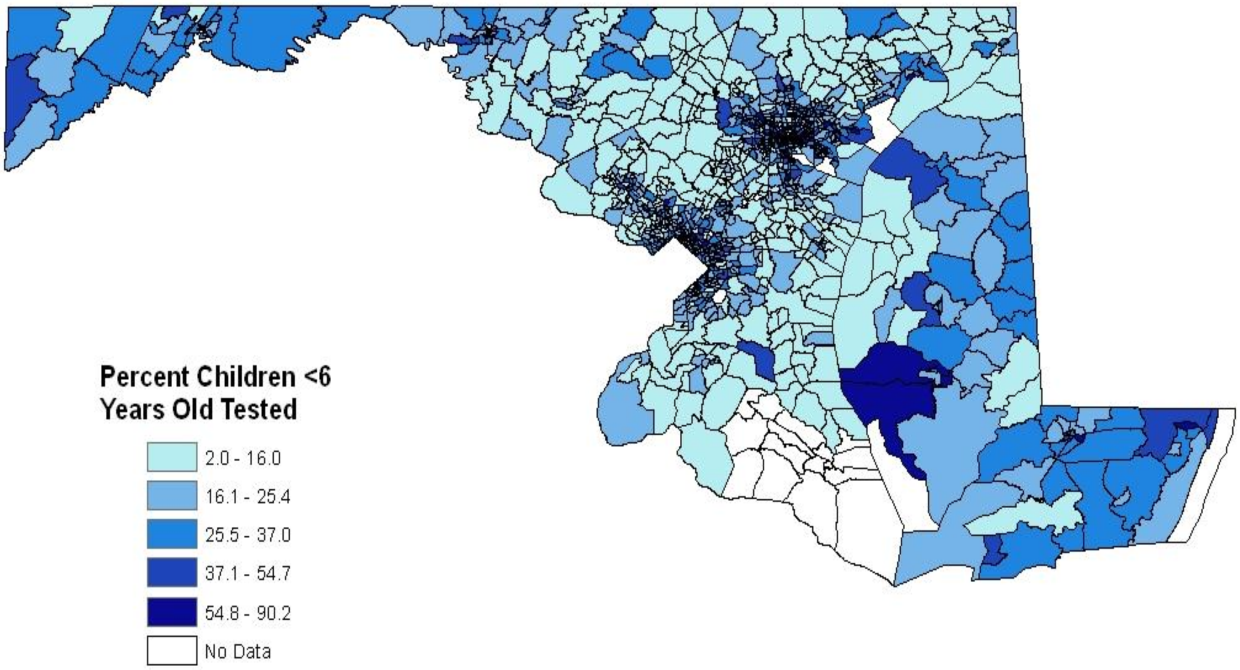


Figure A-4.1. Percent of Children <6 Years Old Tested, by Census Tract, Maryland 2005-2009

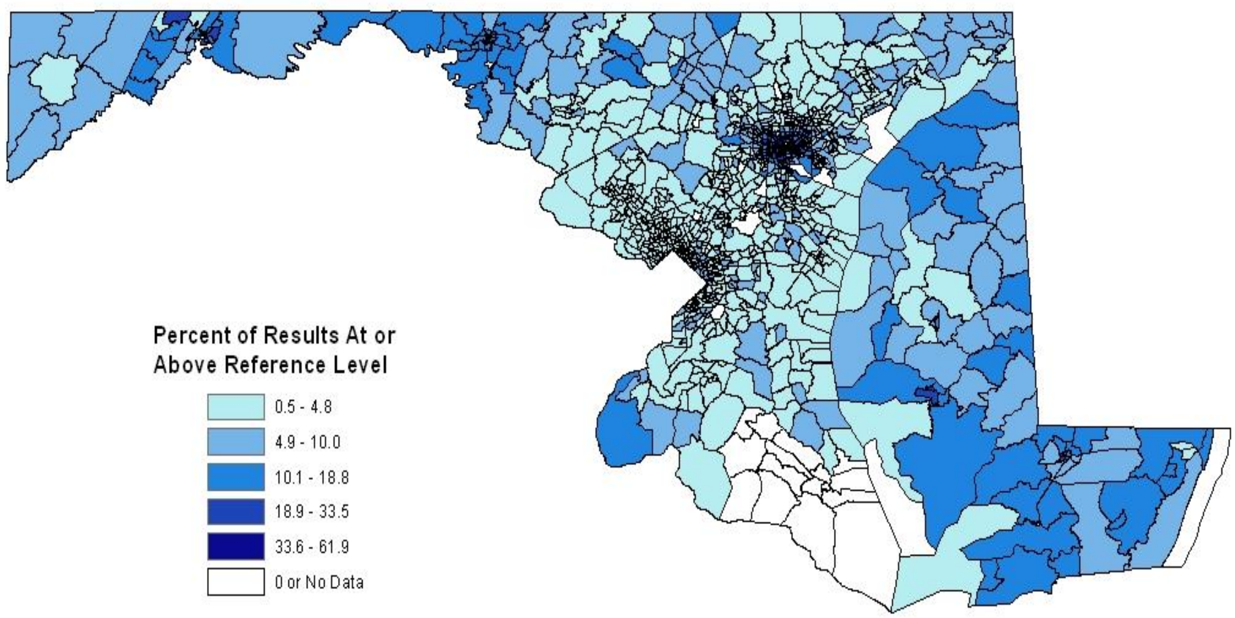


Figure A-4.2. Percent of Blood Lead Test Results ≥5 mcg/dL for Maryland Children <6 years old, by Census Tract, 2005-2009

Table A-4.3. Characteristics of Children Tested for Elevated Blood Lead Levels, by Year and Blood Lead Level, Maryland 2005-2009

Year	2005						2006						2007						2008						2009					
Blood Lead Level	≤ 4		5-9		10+		≤ 4		5-9		10+		≤ 4		5-9		10+		≤ 4		5-9		10+		≤ 4		5-9		10+	
	n	%	n	%	10+	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Individual Children :	103,243		8,428		1,515		104,886		9,692		1,344		109,688		7,546		963		112,598		5,523		772		114,313		4,947		606	
Sex																														
Female	49,815	48.3	3,881	46.0	670	44.2	50,593	48.2	4,504	46.5	589	43.8	53,111	48.4	3,384	44.8	399	41.4	54,961	48.8	2,485	45.0	343	44.4	55,422	48.5	2,267	45.8	251	41.4
Male	51,567	49.9	4,440	52.7	833	55.0	52,577	50.1	5,058	52.2	742	55.2	55,765	50.8	4,116	54.5	562	58.4	57,085	50.7	3,012	54.5	424	54.9	58,221	50.9	2,639	53.3	352	58.1
Unknown	1,861	1.8	107	1.3	12	0.8	1,716	1.6	130	1.3	13	1.0	812	0.7	46	0.6	2	0.2	552	0.5	26	0.5	5	0.6	670	0.6	41	0.8	3	0.5
Age (years)																														
<1	9,751	9.4	372	4.4	55	3.6	10,087	9.6	466	4.8	42	3.1	10,838	9.9	417	5.5	25	2.6	11,039	9.8	293	5.3	28	3.6	10,680	9.3	268	5.4	13	2.1
1	29,411	28.5	2,303	27.3	394	26.0	30,946	29.5	2,870	29.6	374	27.8	33,214	30.3	2,308	30.6	287	29.8	34,346	30.5	1,721	31.2	240	31.1	34,909	30.5	1,479	29.9	161	26.6
2	21,339	20.7	2,453	29.1	416	27.5	22,879	21.8	2,796	28.8	363	27.0	24,352	22.2	2,216	29.4	254	26.4	26,527	23.6	1,608	29.1	214	27.7	28,071	24.6	1,553	31.4	191	31.5
3	10,335	10.0	1,110	13.2	214	14.1	10,360	9.9	1,129	11.6	208	15.5	10,953	10.0	916	12.1	142	14.7	10,892	9.7	617	11.2	107	13.9	11,152	9.8	597	12.1	73	12.0
4	11,030	10.7	808	9.6	178	11.7	10,824	10.3	934	9.6	142	10.6	10,722	9.8	665	8.8	110	11.4	10,424	9.3	505	9.1	77	10.0	10,453	9.1	412	8.3	67	11.1
5	8,180	7.9	544	6.5	103	6.8	7,768	7.4	613	6.3	90	6.7	7,761	7.1	439	5.8	59	6.1	7,466	6.6	333	6.0	46	6.0	7,178	6.3	282	5.7	42	6.9
6-8	7,341	7.1	555	6.6	100	6.6	6,784	6.5	580	6.0	84	6.3	7,006	6.4	387	5.1	62	6.4	7,109	6.3	292	5.3	36	4.7	6,554	5.7	220	4.4	42	6.9
9-11	2,986	2.9	172	2.0	32	2.1	2,674	2.5	181	1.9	21	1.6	2,656	2.4	131	1.7	13	1.3	2,661	2.4	93	1.7	14	1.8	2,872	2.5	84	1.7	8	1.3
12-14	1,782	1.7	80	0.9	16	1.1	1,652	1.6	97	1.0	14	1.0	1,366	1.2	48	0.6	8	0.8	1,331	1.2	38	0.7	6	0.8	1,481	1.3	33	0.7	6	1.0
15-18	1,082	1.0	30	0.4	7	0.5	907	0.9	26	0.3	6	0.4	817	0.7	19	0.3	3	0.3	800	0.7	22	0.4	4	0.5	963	0.8	19	0.4	3	0.5
Race																														
White	16,716	16.2	1,169	13.9	124	8.2	18,787	17.9	1,476	15.2	133	9.9	24,151	22.0	1,295	17.2	131	13.6	26,073	23.2	1,031	18.7	118	15.3	26,849	23.5	1,019	20.6	100	16.5
Black	17,101	16.6	2,247	26.7	492	32.5	20,053	19.1	2,995	30.9	553	41.1	24,823	22.6	2,541	33.7	378	39.3	28,752	25.5	1,956	35.4	303	39.2	30,454	26.6	1,683	34.0	234	38.6
Other*	1,998	1.9	159	1.9	41	2.7	2,483	2.4	229	2.4	45	3.3	3,231	2.9	179	2.4	43	4.5	4,047	3.6	154	2.8	30	3.9	3,856	3.4	123	2.5	13	2.1
Unknown	67,428	65.3	4,853	57.6	858	56.6	63,563	60.6	4,992	51.5	613	45.6	57,483	52.4	3,531	46.8	411	42.7	53,726	47.7	2,382	43.1	277	35.9	53,154	46.5	2,122	42.9	259	42.7
Ethnicity																														
Hispanic	7,452	7.2	271	3.2	53	3.5	9,517	9.1	559	5.8	68	5.1	13,368	12.2	469	6.2	53	5.5	15,903	14.1	341	6.2	56	7.3	17,579	15.4	287	5.8	39	6.4
Non-Hispanic	28,160	27.3	3,018	35.8	670	44.2	33,245	31.7	4,139	42.7	728	54.2	42,527	38.8	3,367	44.6	532	55.2	49,427	43.9	2,529	45.8	452	58.5	53,507	46.8	2,538	51.3	383	63.2
Unknown	67,630	65.5	5,139	61.0	792	52.3	62,123	59.2	4,993	51.5	547	40.7	53,791	49.0	3,710	49.2	372	38.6	47,268	42.0	2,652	48.0	254	32.9	43,224	37.8	2,116	42.8	178	29.4
Race/Ethnicity																														
White, non-Hispanic	10,050	9.7	674	8.0	88	5.8	11,693	11.1	988	10.2	96	7.1	16,051	14.6	776	10.3	87	9.0	17,737	15.8	505	9.1	69	8.9	18,031	15.8	486	9.8	52	8.6
Black, non-Hispanic	13,246	12.8	1,777	21.1	398	26.3	15,868	15.1	2,512	25.9	483	35.9	20,262	18.5	2,094	27.7	333	34.6	24,021	21.3	1,597	28.9	259	33.5	25,529	22.3	1,375	27.8	194	32.0
Other*, non-Hispanic	1,222	1.2	96	1.1	22	1.5	1,435	1.4	132	1.4	29	2.2	1,896	1.7	96	1.3	24	2.5	2,555	2.3	75	1.4	15	1.9	2,528	2.2	82	1.7	9	1.5
Unknown, Non-Hispanic	3,642	3.5	471	5.6	162	10.7	4,249	4.1	507	5.2	120	8.9	4,318	3.9	401	5.3	88	9.1	5,114	4.5	352	6.4	109	14.1	7,419	6.5	595	12.0	128	21.1
Hispanic	7,452	7.2	271	3.2	53	3.5	9,517	9.1	559	5.8	68	5.1	13,368	12.2	469	6.2	53	5.5	15,903	14.1	341	6.2	56	7.3	17,579	15.4	287	5.8	39	6.4
Unknown	67,631	65.5	5,139	61.0	792	52.3	62,124	59.2	4,994	51.5	548	40.8	53,793	49.0	3,710	49.2	378	39.3	47,268	42.0	2,653	48.0	264	34.2	43,227	37.8	2,122	42.9	184	30.4
Year Child's Home Buil																														
Pre 1950	15,625	15.1	3,543	42.0	874	57.7	16,011	15.3	3,712	38.3	836	62.2	17,084	15.6	3,229	42.8	603	62.6	17,883	15.9	2,530	45.8	486	63.0	18,648	16.3	2,254	45.6	372	61.4
1950 to <1978	18,915	18.3	885	10.5	85	5.6	19,339	18.4	1,216	12.5	85	6.3	20,208	18.4	783	10.4	54	5.6	21,239	18.9	569	10.3	56	7.3	21,067	18.4	505	10.2	59	9.7
1978 or After	22,829	22.1	795	9.4	75	5.0	23,527	22.4	1,054	10.9	69	5.1	24,977	22.8	737	9.8	45	4.7	24,801	22.0	486	8.8	43	5.6	24,201	21.2	471	9.5	31	5.1
Unknown	45,874	44.4	3,205	38.0	481	31.7	46,009	43.9	3,710	38.3	354	26.3	47,419	43.2	2,797	37.1	261	27.1	48,675	43.2	1,938	35.1	187	24.2	50,397	44.1	1,717	34.7	144	23.8
Probable Rental Property**																														
Yes	15,624	15.1	2,604	30.9	619	40.9	16,260	15.5	2,840	29.3	602	44.8	17,386	15.9	2,396	31.8	418	43.4	18,577	16.5	1,887	34.2	318	41.2	19,375	16.9	1,664	33.6	256	42.2
No	44,255	42.9	2,852	33.8	458	30.2	45,185	43.1	3,407	35.2	423	31.5	47,381	43.2	2,557	33.9	316	32.8	48,077	42.7	1,855	33.6	288	37.3	47,368	41.4	1,709	34.5	222	36.6
Unknown	43,364	42.0	2,972	35.3	438	28.9	43,441	41.4	3,445	35.5	319	23.7	44,921	41.0	2,593	34.4	229	23.8	45,944	40.8	1,781	32.2	166	21.5	47,570	41.6	1,574	31.8	128	21.1
Child Resides in 2004 Target Area																														
Yes	56,998	55.2	6,765	80.3	1,322	87.3	58,600	55.9	7,556	78.0	1,185	88.2	60,804	55.4	6,029	79.9	855	88.8	62,825	55.8	4,571	82.8	671	86.9	64,629	56.5	4,084	82.6	515	85.0
No	45,990	44.5	1,639	19.4	191	12.6	46,270	44.1	2,134	22.0	159	11.8	48,870	44.6	1,515	20.1	108	11.2	49,707	44.1	947	17.1	101	13.1	49,667	43.4	863	17.4	91	15.0
Unknown	255	0.2	24	0.3	2	0.1	16	0.0	2	0.0	0	0.0	14	0.0	2	0.0	0	0.0	66	0.1	5	0.1	0	0.0	17	0.0	0	0.0	0	0.0

* Other Includes Asian/Pacific Islander, Native American/Alaskan and Multiracial

** Probable Rental Properties Identified as those properties in the DAT file where the Owner's Mailing address is not the Property Address

Targeting Strategy Option 1 (Target Testing Based on the Distribution of Blood Lead Levels in Children Tested between 2005-2009, by ZIP Code)

Estimating Expected Elevated Blood Lead Tests

There were 521,648 blood test results for children less than six years of age. When restricted to the single highest venous, unknown, or capillary test result (in that order) for each child, there were 396,951 individual test results from 2005-2009. In all cases, the highest venous test was used first. If no venous sample was available, the highest result from an unknown sample was used, and if no venous or unknown sample was available, the highest capillary blood lead test result for the given time period was retained. Of these, 78% were venous samples, the most accurate measure of blood lead level; 13% were capillary samples, the least accurate relative to venous tests; and 9% were unknown. An additional 362 records missing ZIP codes were excluded, leaving 396,588 test records for individual children from 595 unique ZIP codes throughout the state.

To calculate the number of children less than six years of age living in each ZIP code by year, annual intercensal estimates were calculated for each ZIP code using the U.S. Census for 2000 and 2010. This resulted in annual population estimates for 450 ZIP codes in the State. These estimates were merged with the aggregated number of tests per ZIP code, producing annual blood lead testing counts and estimated population counts for 450 ZIP codes in the State. A total of 1,991 blood lead tests in the CLR data could not be matched with a corresponding ZIP code and were excluded from further analyses. These ZIP codes may have been added by the U.S. Postal Service after the year 2000, or they may have been incorrectly entered into the STELLAR database and were not valid. For the ZIP codes included in analysis, the percentage of test results greater than, or equal to, the reference level of 5 mcg/dL among children less than 6 years of age ranged from 0.6 to 50% (Figure A-4.3).

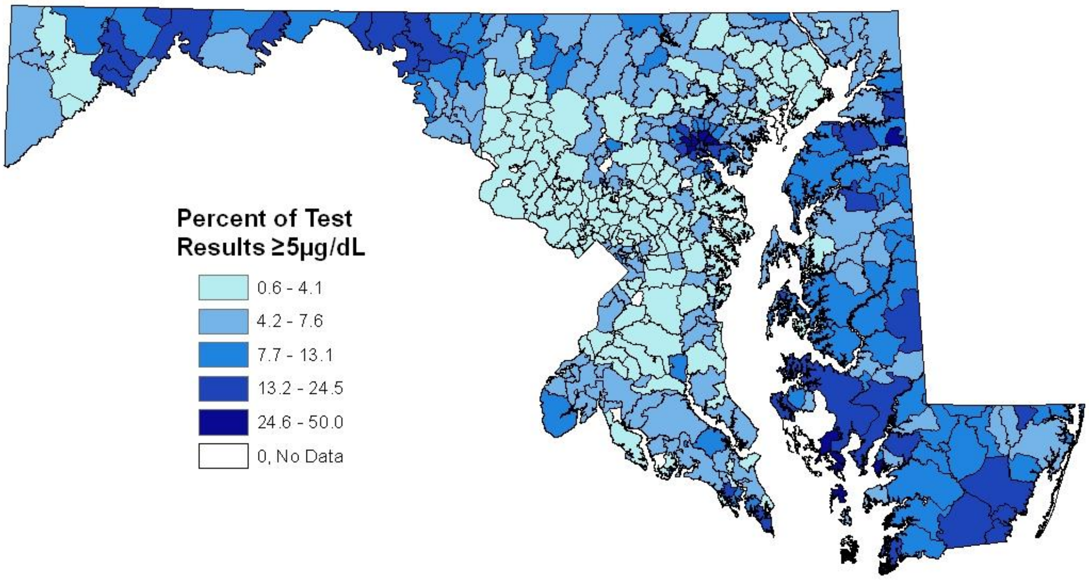


Figure A-4.3. Percent of Blood Lead Test Results ≥5 mcg/dL for Maryland Children <6 years old, by ZIP Code, 2005-2009

An estimate of the total number of children less than six years of age in MD with an elevated blood lead test was computed by applying the observed percentage of test results with levels at or above the reference level in each ZIP code from 2005-2009 to the total population of children in that ZIP code. Based on this analysis, an estimated 28,012 children were expected to have a blood lead level at or above the reference level of 5 mcg/dL. ZIP codes containing a cumulative 90%, 75% and 50% of the expected children with blood lead levels above reference in the State were identified as potential "at risk" areas. Depending on the risk area definition considered, 14,101 to 25, 342 of these children were captured in the identified ZIP code risk areas.

Identifying At Risk ZIP Codes

There were 173 "at risk" ZIP codes identified which would be expected to contain 90% of the children less than six years of age with blood lead levels at, or above, the reference level of 5 mcg/dL (Figure A-4.4, Table A-7.1). The observed percentage of test results at, or above, the reference level from 2005-2009 in these ZIP codes ranged from 1.7% to 38.6% and the total ZIP code populations ranged from 305 to 5,525 children under six years of age. Decreasing the percentage of children to 75% of those children expected to have blood lead levels at, or above, the reference level decreased the number of "at risk" ZIP codes to 95 (Figure A-4.5, Table A-7.2). The observed percentage of test results at, or above, the reference level ranged from 2.1% to 38.6% in these ZIP codes, and the total population of children less than six years of age ranged from 531 to 5,525. If the goal were to identify the "at risk" areas containing 50% of the children expected to have blood lead levels at, or above, the reference level of 5 mcg/dL, 32 ZIP codes were identified (Figure A-4.6, Table A-7.3). The observed percentage of children with test results at, or above, the reference level ranged from 4.7 to 38.6%, and the total population of children less than six years of age ranged from 1,067 to 5,051 in these ZIP codes.

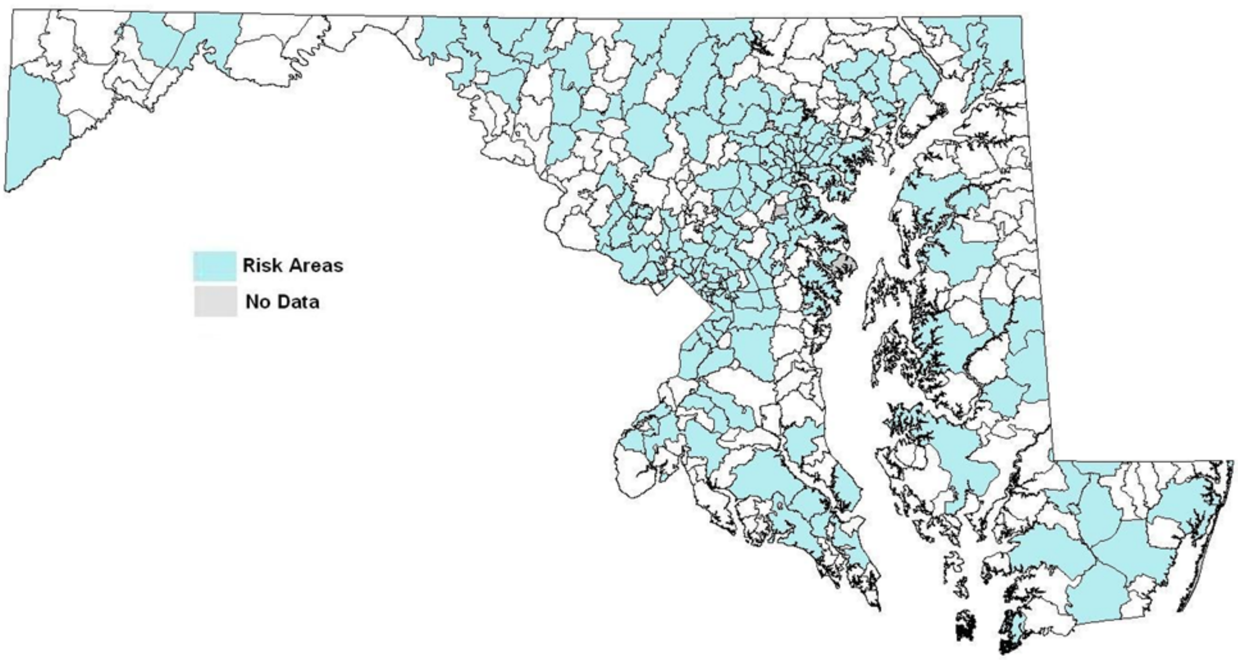


Figure A-4.4. ZIP Codes Capturing a Cumulative 90% of Children Expected to Have a Blood Lead Level ≥5 mcg/dL, Maryland

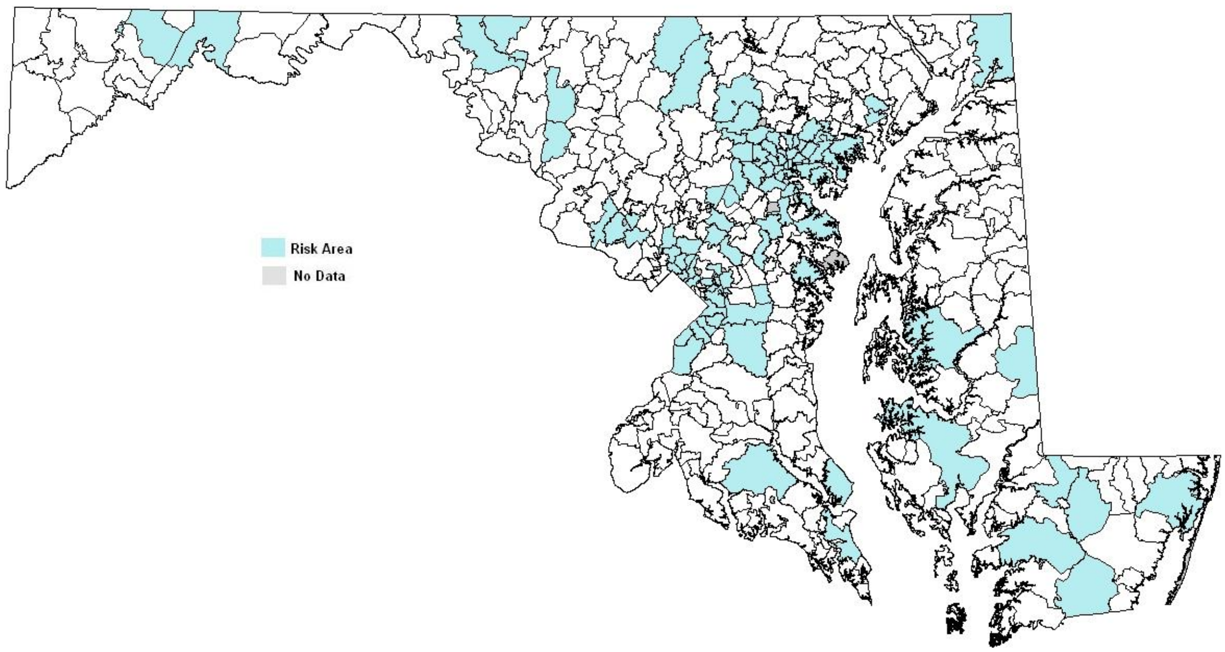


Figure A-4.5. ZIP Codes Capturing a Cumulative 75% of Children Expected to Have a Blood Lead Level ≥5 mcg/dL, Maryland

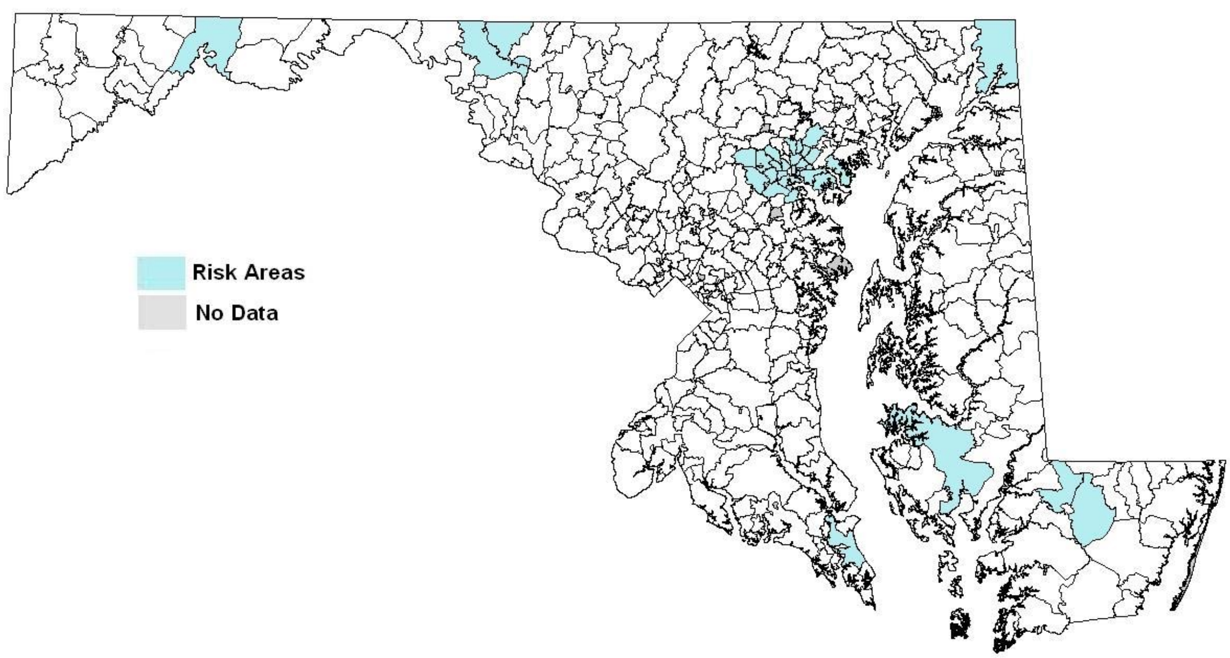


Figure A-4.6. ZIP Codes Capturing a Cumulative 50% of Children Expected to Have a Blood Lead Level ≥5 mcg/dL, Maryland

Comparison of At Risk and Non-Risk Areas

In all cases (90%, 75% and 50% capture areas), more children tested from "at risk" areas were: black (23%, 25%, 26%); resided in properties built before 1950 (16%, 19%, 34%); and resided in a probable rental properties (16%, 17%, 23%; Tables A-4.4, A-4.5, A-4.6). All of these characteristics were significantly associated with residence in a "risk area." Results of Chi-Square analyses are summarized in Table A-4.7. Limited demographic information from the U.S. Census Bureau was included for further comparison of the risk and non-risk ZIP codes (Tables A-7.4, A-7.5, A-7.6). Risk areas had a higher percentage of black residents and renter-occupied housing compared to non-risk areas.

Table A-4.4. Characteristics of Tested Children from Risk (90% of Expected) and Non-Risk Areas, Maryland 2005-2009

Characteristics	90% Expected		Outside Area	
	n	**%**	**n**	**%**
Total Children Tested 05-09	349,983	88.4	44,614	11.6
Characteristics of Children in Area				
Sex				
Female	169,998	48.6	21,419	48.0
Male	176,084	50.3	22,529	50.5
Unknown	3,901	1.1	666	1.5
Age (years)				
<1	34,415	9.8	4,436	9.9
1	112,489	32.1	15,386	34.5
2	91,582	26.2	11,655	26.1
3	39,382	11.3	4,473	10.0
4	41,040	11.7	4,608	10.3
5	31,069	8.9	4,053	9.1
Median Age	2.0	-	2.0	-
Race				
White	67,833	19.4	17,241	38.6
Black	80,234	22.9	4,085	9.2
Other*	10,388	3.0	1,032	2.3
Unknown	191,528	54.7	22,256	49.9
Ethnicity				
Hispanic	38,473	11.0	2,431	5.4
Non-Hispanic	131,872	37.7	17,557	39.4
Unknown	179,638	51.3	24,626	55.2
Year Child's Home Built				
Pre 1950	57,566	16.4	4,240	9.5
1950 to <1978	62,005	17.7	8,246	18.5
1978 or After	75,054	21.4	15,119	33.9
Unknown	155,358	44.4	17,009	38.1
Median Year Built	1965	-	1982	-
Probable Rental Property**				
Yes	56,832	16.2	4,885	10.9
No	146,604	41.9	22,817	51.1
Unknown	146,547	41.9	16,912	37.9
Sample Type				
Capillary	43,919	12.5	7,980	17.9
Venous	276,552	79.0	32,616	73.1
Unknown	29,512	8.4	4,018	9.0
Blood Lead Levels				
≤ 4	322,359	92.1	42,430	95.1
5 - 9	24,299	6.9	2,023	4.5
≥10	3,325	1.0	161	0.4

*Other = Sum of Other, Indian/Alaskan, Hawaiian/Pacific Islander and Multiple Race.
** Probable Rental Property = property assumed to be rental because the owner of the property resided at a different address than the property.

Table A-4.5. Characteristics of Tested Children from Risk (75% of Expected) and Non-Risk Areas, Maryland 2005-2009

Characteristics	75% Expected Cases		Outside Area	
	n	%	n	%
Total Children Tested 05-09	266,627	67.6	127,970	32.4
Characteristics of Children in Area				
Sex				
Female	129,654	48.6	61,763	48.3
Male	134,120	50.3	64,493	50.4
Unknown	2,853	1.1	1,714	1.3
Age (years)				
<1	24,294	9.1	14,577	11.4
1	86,163	32.3	41,712	32.6
2	70,734	26.5	32,503	25.4
3	30,275	11.4	13,580	10.6
4	31,525	11.8	14,123	11.0
5	23,632	8.9	11,490	9.0
Median Age	2.0	-	2.0	-
Race				
White	44,074	16.5	41,000	32.0
Black	67,109	25.2	17,210	13.4
Other*	7,343	2.8	4,077	3.2
Unknown	148,101	55.5	65,683	51.3
Ethnicity				
Hispanic	29,952	11.2	10,952	8.6
Non-Hispanic	99,211	37.2	50,218	39.2
Unknown	137,464	51.6	66,795	52.2
Year Child's Home Built				
Pre 1950	49,883	18.7	11,923	9.3
1950 to <1978	44,503	16.7	25,748	20.1
1978 or After	44,894	16.8	45,279	35.4
Unknown	127,347	47.8	45,020	35.2
Median Built Year	1958	-	1981	-
Probable Rental Property**				
Yes	45,788	17.2	15,929	12.4
No	100,831	37.8	68,590	53.6
Unknown	120,008	45.0	43,451	34.0
Sample Type				
Capillary	29,987	11.2	21,912	17.1
Venous	214,251	80.4	94,917	74.2
Unknown	22,389	8.4	11,141	8.7
Blood Lead Levels				
≤ 4	242,505	91.0	122,284	95.6
5 - 9	21,028	7.9	5,294	4.1
≥10	3,094	1.2	392	0.3

*Other = Sum of Other, Indian/Alaskan, Hawaiian/Pacific Islander and Multiple Race.
** Probable Rental Property = property assumed to be rental because the owner of the property resided at a different address than the property.

Table A-4.6. Characteristics of Tested Children from Risk (50% of Expected) and Non-Risk Areas, Maryland 2005-2009

Characteristics	50% Expected Cases		Outside Area	
	n	%	n	%
Total Children Tested 05-09	109,930	27.9	284,667	72.1
Characteristics of Children in Area				
Sex				
Female	53,336	48.5	138,081	48.5
Male	55,238	50.2	143,375	50.4
Unknown	1,356	1.2	3,211	1.1
Age (years)				
<1	6,993	6.4	31,858	11.2
1	37,054	33.7	90,821	31.9
2	32,098	29.2	71,139	25.0
3	12,673	11.5	31,182	11.0
4	11,923	10.8	33,725	11.8
5	9,188	8.4	25,934	9.1
Median Age	2.0	-	2.0	-
Race				
White	21,972	20.0	63,102	22.2
Black	28,702	26.1	55,617	19.5
Other*	2,152	2.0	9,268	3.3
Unknown	57,104	51.9	156,680	55.0
Ethnicity				
Hispanic	3,603	3.3	37,301	13.1
Non-Hispanic	41,646	37.9	107,783	37.9
Unknown	64,681	58.8	139,583	49.0
Year Child's Home Built				
Pre 1950	37,009	33.7	24,797	8.7
1950 to <1978	11,170	10.2	59,081	20.8
1978 or After	8,066	7.3	82,107	28.8
Unknown	53,685	48.8	118,682	41.7
Median Built Year	1930	-	1977	-
Probable Rental Property**				
Yes	25,635	23.3	36,082	12.7
No	33,095	30.1	136,326	47.9
Unknown	51,200	46.6	112,259	39.4
Sample Type				
Capillary	12,779	11.6	39,120	13.7
Venous	86,788	78.9	222,380	78.1
Unknown	10,363	9.4	23,167	8.1
Blood Lead Levels				
≤ 4	92,476	84.1	272,313	95.7
5 - 9	14,911	13.6	11,411	4.0
≥10	2,543	2.3	943	0.3

*Other = Sum of Other, Indian/Alaskan, Hawaiian/Pacific Islander and Multiple Race.
** Probable Rental Property = property assumed to be rental because the owner of the property resided at a different address than the property.

Table A-4.7. Chi-Square (X^2) Analysis, Comparison of Demographic Characteristics of Risk and Non-Risk Areas for 3 Proposed Risk-Area Definitions (90%, 75%, and 50% Capture Areas)

Risk Area Definition	Statistics	Race	Ethnicity	Year Home Built	Rental Property
Area Capturing 90% of Expected	X^2	9418.21	1151.86	3352.29	1322.14
	*df**	2	1	2	1
	p value	<.0001	<.0001	<.0001	<.0001
Area Capturing 75% of Expected	X^2	14483.70	687.22	15008.98	4200.17
	*df**	2	1	2	1
	p value	<.0001	<.0001	<.0001	<.0001
Area Capturing 50% of Expected	X^2	2015.29	6438.84	55137.43	11554.68
	*df**	2	1	2	1
	p value	<.0001	<.0001	<.0001	<.0001

*df, degrees of freedom

Targeting Strategy Option 2 (Target Testing Based on Updated Maryland Targeting Model)

The second option for a targeting strategy, an update of the targeting model used in the 2000 and 2004 MD lead targeting plans, was based on census tracts rather than ZIP codes. The U.S. Census demographic variables from the American Community Survey (ACS) used in the model were not available at the ZIP code level for the time period of interest (2005-2009). Census tracts were excluded from the analysis if the records contained either "0" or had no data (i.e., missing) for the number of households (n=23), number of families (n=28), number of houses (n=23), or number of children less than 6 years old (n=31). Census tracts were also excluded from if the median housing value was $0 or missing (n=39). After these census tracts were removed, 1,179 census tracts were retained for analysis.

Lead testing data from the CLR excluded children who did not live in the State and children six years of age or older. In addition, if a child was tested more than once in a single year, only the highest test result was used, as noted in previous sections. An additional 10% of remaining records were excluded because they could not be geocoded and, therefore, residential census tract was unknown. This data set was then used to determine the total number of tests for individual children per year per census tract (5-year total, n=469,603 tests) and the total number of individual children tested during the 5-year period per census tract (n=355,740 children). In all cases, the highest venous test was used first. If no venous sample was available, the highest result from an unknown sample was used, and if no venous or unknown sample was available, the highest capillary blood lead test result for the given time period was retained.

When merged by census tract, the CLR and U.S. Census data had 1,179 census tracts in common (Table A-4.8). The merged data set contained 12 census tracts in which the average annual testing rate from 2005-2009 exceeded 100% or was less than 1%. In areas where very few children are tested, the proportion of test results at or above the reference level is based on a small number of test results and is highly influenced by a single test result. A testing rate greater than 100% indicates that more children were tested in a given census tract than were reported to be living there according to the 2005-2009 ACS. Areas with a testing rate exceeding 100% are likely due to address misclassification or some other error. The proportion of children with a blood lead level at or above the reference level (outcome of interest) is unreliable for census tracts with extremely high or low testing rates; therefore these 12 census tracts, containing 2,381 children tested, were excluded from further analysis. After cleaning and variable preparation 1,167 census tracts, including a total of 346,201 test results for individual children, were retained for analysis (Table A-4.9).

Analysis of Lead Testing Data

The average annual testing rates for children in the 1,179 census tracts ranged from 2 to 90% (Table A-4.8). In a majority of census tracts (46%), the testing rates were 20% or less of the children in the census tract. Table A-4.9 shows the distribution of blood lead levels for 346,201 individual children less than six years of age with known census tracts of residence who were tested for blood lead in MD from 2005-2009.

Table A-4.8. Number of Census Tracts in the Analysis Data Set by Percent of Children Tested, Maryland 2005-2009

Percent of Children Screened	Number of Census Tracts	Percent of Census Tracts
0 to 0.9	2*	0.2
1 to 20	536	45.5
21 to 40	499	42.3
41 to 60	98	8.3
61 to 80	27	2.3
81 to 100	7	0.6
Over 100	10*	0.8

* Excluded from further analyses

Table A-4.9. Number of Individual Children < 6 Years Old Tested per Year, by Blood Lead Level, in the 1,167 Census Tracts Included in Models, Maryland, 2005-2009

Pb Result	Year of Blood Lead Test					Total Children Screened
	2005	2006	2007	2008	2009	
0-4	59,130	58,661	61,517	62,843	77,940	320,091
5-9	5,712	6,254	4,576	3,214	3,252	23,008
10+	1,017	751	528	428	378	3,102
Total	65,859	65,666	66,621	66,485	81,570	346,201

* Highest BLL per Child from 2005-2009. The highest BLL from a venous sample, if no venous then unknown sample type, if no unknown then capillary sample result retained

From 2005-2009, a total of 26,110 individual children tested had a blood lead level at or above the CDC reference level of 5 mcg/dL, of whom 3,102 (12%) had a blood lead level of 10 mcg/dL or greater. Of the 1,167 census tracts included in the analysis, 1,156 (99%) had at least one child with a blood lead level of 5 mcg/dL or above, and 11 (0.9%) census tracts did not have any reported children with a blood lead level at or above reference (Table A-4.10).

Table A-4.10. Census Tracts by Number of Individual* Children with a Blood Lead Level ≥5 mcg/dL, Maryland 2005-2009

Number of Blood Lead Test Results ≥5 mcg/dL	Number of Census Tracts in Model	Total Children With Blood Lead Levels ≥5 mcg/dL, 2005-2009	Total Children <6 Years Old In Tracts**
0	11	0	1,946
1 to 50	1,031	14,444	384,831
51 to 100	84	5,890	33,560
101 to 150	33	4,114	10,968
151 to 200	4	735	1,108
201 to 250	3	643	902
251 to 300	1	284	230
Total	1,167	26,110	433,545

* Highest annual BLL per Individual Child from 2005-2009. The highest BLL from a venous sample, if no venous then unknown sample type, if no unknown then capillary sample result retained.

** Total population of children per census tract based on the 2005-2009 American Community Survey 5-Year Estimate

Many of the covariates were strongly and positively correlated with each other, as might be expected (Table A-4.11). Because many of the covariates were markers of poverty, the percentage of families below poverty level with children less than five years old, percentage of female-headed households with children less than six, and percentage of households with public assistance income were combined into a single poverty scale to be included in the model (as in Sargent, 1995 and Center for Health Development and Management, 2000).

Table A-4.11. Pearson's Correlation Coefficient Values* for Data Set Covariates

	% Female Headed House	% Public Assist. Income	% Families in Poverty	Median House Value	% Houses Pre 50	% Houses 50-79	% Black	% Rental	% Vacant	Median Income	% Screened	% Results ≥5µg/dL
% Female Headed House	-	0.33 <.0001	0.43 <.0001	-0.34 <.0001	0.17 <.0001	0.02 0.4803	0.37 <.0001	0.47 <.0001	0.26 <.0001	-0.42 <.0001	0.16 <.0001	0.28 <.0001
% Public Assist. Income	0.33 <.0001	-	0.46 <.0001	-0.44 <.0001	0.43 <.0001	-0.09 0.0016	0.45 <.0001	0.42 <.0001	0.50 <.0001	-0.48 <.0001	0.34 <.0001	0.62 <.0001
% Families in Poverty	0.43 <.0001	0.46 <.0001	-	-0.38 <.0001	0.36 <.0001	-0.07 0.0107	0.30 <.0001	0.43 <.0001	0.43 <.0001	-0.45 <.0001	0.17 <.0001	0.50 <.0001
Median House Value	-0.34 <.0001	-0.44 <.0001	-0.38 <.0001	-	0.39 <.0001	0.03 0.2943	-0.41 <.0001	-0.39 <.0001	-0.39 <.0001	0.79 <.0001	-0.41 <.0001	-0.51 <.0001
% Pre 50 House	0.17 <.0001	0.43 <.0001	0.36 <.0001	-0.39 <.0001	-	-0.34 <.0001	0.14 <.0001	0.24 <.0001	0.48 <.0001	-0.41 <.0001	0.41 <.0001	0.69 <.0001
% 50-79 house	0.02 0.4803	-0.09 0.002	-0.07 0.01	0.03 0.29	-0.34 <.0001	-	0.10 0.0004	0.06 0.0450	-0.26 <.0001	-0.03 0.2503	0.06 0.0267	-0.28 <.0001
% Black	0.37 <.0001	0.45 <.0001	0.30 <.0001	-0.41 <.0001	0.14 <.0001	0.10 0.0004	-	0.43 <.0001	0.31 <.0001	-0.41 <.0001	0.34 <.0001	0.43 <.0001
% Rental	0.47 <.0001	0.42 <.0001	0.43 <.0001	-0.39 <.0001	0.24 <.0001	0.06 0.0450	0.43 <.0001	-	0.37 <.0001	-0.63 <.0001	0.34 <.0001	0.34 <.0001
% Vacant	0.26 <.0001	0.50 <.0001	0.43 <.0001	-0.39 <.0001	0.48 <.0001	-0.26 <.0001	0.31 <.0001	0.37 <.0001	-	-0.47 <.0001	0.37 <.0001	0.66 <.0001
Median Income	-0.42 <.0001	-0.48 <.0001	-0.45 <.0001	0.79 <.0001	-0.41 <.0001	-0.03 0.2503	-0.41 <.0001	-0.63 <.0001	-0.47 <.0001	-	-0.46 <.0001	-0.52 <.0001
% Screened	0.16 <.0001	0.34 <.0001	0.17 <.0001	-0.41 <.0001	0.41 <.0001	0.06 0.0267	0.34 <.0001	0.34 <.0001	0.37 <.0001	-0.46 <.0001	-	0.46 <.0001
% Results ≥5µg/dL	0.28 <.0001	0.62 <.0001	0.50 <.0001	-0.51 <.0001	0.69 <.0001	-0.28 <.0001	0.43 <.0001	0.34 <.0001	0.66 <.0001	-0.52 <.0001	0.46 <.0001	-

* Pearson's r value (correlation coefficient) is a measure of association indicating the degree to which two variables have a linear relationship, in which one variable varies directly with the other. This value, r, ranges from -1 to +1 with +1 representing a perfect positive linear relationship, and -1 representing a perfect negative linear relationship.

The outcome measure for the logistic regression model was "at risk" or "non-risk" census tract. Because no standard definition of an "at risk" census tract was identified considering the reference level of 5 mcg/dL, four possible definitions were evaluated based on the distribution of blood lead levels at or above reference in Maryland. Census tracts were defined as "at risk" if the percentage of blood lead test results greater than or equal to 5 mcg/dL was at or above the 25th (3%), 50th (5%), 75th (9%), and 90th (17%) percentiles. These represented four different outcome variables. The characteristics of risk and non-risk areas for each of these definitions were then compared (Table A-4.12). Results from the two sample t-test indicated that all measured characteristics of the risk and non-risk tracts were significantly different ($p<0.05$) across all outcome measures (data not shown).

Crude ORs and adjusted ORs for testing rates were calculated for each of the four outcome measures identified; each of the covariates was statistically significant across the different outcome measures (Table A-4.13). Similar to the findings in earlier versions of the Maryland Lead Targeting Plan, census tracts with a higher percentage of pre-1950 housing still showed a strong association with risk, and the magnitude of the correlation increased as the outcome measure (the proportion of lead tests above the reference level of 5 mcg/dL) increased. Census tracts with greater than 18% old (pre-1950) housing were 6 times more likely to have at least 3% (25^{th} percentile) of lead test results at or above the reference level, 14 times more likely to have at least 5% (50^{th} percentile) of test results at or above reference, and 62 times more likely to have at least 9% (75^{th} percentile) of test results at or above reference compared to census tracts with less than 5% old housing, adjusted for testing rates.

Table A-4.12. Select Census Tract Characteristics, Risk** Compared to Non-Risk Tracts, Maryland 2005-2009

	All Census Tracts	Outcome 1 ≥3% of Tests At or Above CDC Reference† (25th Percentile)		Outcome 2 ≥5% of Tests At or Above CDC Reference (50th Percentile)		Outcome 3 ≥9% of Tests At or Above CDC Reference (75th Percentile)		Outcome 4 ≥17% of Tests At or Above CDC Reference (90th Percentile)	
Characteristics		Non-Risk	Risk	Non-Risk	Risk	Non-Risk	Risk	Non-Risk	Risk
n children ‡	*433,545*	143,293	290,252	273,482	160,063	357,931	75,614	405,868	27,677
total n (%) tracts	*1,167*	*314 (27%)*	*853 (73%)*	*636 (55%)*	*531 (45%)*	*888 (76%)*	*279 (24%)*	*1,052 (90%)*	*115 (10%)*
Median House Value ($)	293,100	372,050	255,700	356,050	213,200	337,300	160,900	315,750	99,800
Median Income ($)	66,797	88,026	59,137	81,053	51,383	75,919	41,098	71,049	31,319
% Rental Properties	31.0	25.2	33.1	26.7	36.1	27.1	43.3	28.7	51.4
% Vacant Properties	9.0	5.1	10.4	5.7	12.9	6.4	17.4	7.3	24.7
% Poverty	3.9	2.0	4.6	2.2	5.9	2.4	8.5	2.9	12.8
% Female Headed Households	3.4	2.4	3.8	2.6	4.3	2.8	5.4	3.0	6.6
% Housing built before 1950	23.0	10.8	27.4	12.3	35.8	15.0	48.3	18.6	63.2
% Housing built 1950-1979	43.0	45.4	42.2	46.3	39.1	45.8	34.2	44.8	26.6
% Residents Black	30.9	15.7	35.4	23.9	39.2	25.4	48.4	26.7	68.6
% Public Assistance Income	2.1	1.0	2.5	1.1	3.3	1.3	4.6	1.6	6.9
% Tested	25.0	19.1	27.2	20.8	30.0	22.0	34.6	23.2	41.7

* Mean values presented, unless otherwise indicated

** Similar to the approach used in prior publications (CDC, 1997), 'Risk" is designated based on a percentage of tests at or above the reference. The prior studies were based on the action level of 10µg/dL and so we assess several levels. Based on CDC 1997 recommendations, tracts with ≥ 12% of blood lead test results ≥ 10 µg/dL were considered high risk areas for lead exposure and poisoning in children

† The CDC Reference level is 5 µg/dL

‡ Number of Children ≤5 years old from the 2005-2009 American Community Survey

Table A-4.13. Community Characteristics by Adjusted‡ Odds Ratios, for 4 Possible of Risk Area Definitions (≥3%, ≥5%, ≥9% and ≥17% of Test Results ≥5 mcg/dL)

Census Tract Characteristics	Aggregated Groups	Number of Tracts	Number of Children ≤5 Years Old in Population	Outcome 1 ≥ 3% of Tests ≥5µg/dL (25th Percentile)		Outcome 2 ≥ 5% of Tests ≥5µg/dL (50th Percentile)		Outcome 3 ≥ 9% of Tests ≥5µg/dL (75th Percentile)		Outcome 4 ≥ 17% of Tests ≥5µg/dL (90th Percentile)	
				Odds Ratio	(95% CI)	Odds Ratio	(95% CI)	Odds Ratio	(95% CI)	Odds Ratio	(95% CI)
Percent of Rental Units	0 - 16.3	394	144,318	1.00		1.00		1.00		1.00	
	16.4 - 38.4	372	144,252	1.18	0.86 , 1.62	1.50 *	1.10 , 2.04	2.80 **	1.76 , 4.44	6.42 *	1.88 , 21.96
	38.5 - 97.7	401	144,975	1.61 *	1.13 , 2.29	1.99 **	1.46 , 2.72	5.41 **	3.48 , 8.40	20.70 **	6.38 , 67.18
Percent of Vacant Housing Units	0 - 3.9	357	143,877	1.00		1.00		1.00		1.00	
	4.0 - 7.6	345	145,081	1.08	0.79 , 1.49	1.27	0.91 , 1.76	2.01 *	1.16 , 3.51	5.17	0.58 , 45.97
	7.7 - 85.7	465	144,587	2.58 **	1.81 , 3.67	4.05 **	2.95 , 5.55	9.78 **	6.01 , 15.92	84.34 **	11.37 , 625.61
Percent Families Below Poverty w/ Children ≤ 5	0	493	157,170	1.00		1.00		1.00		1.00	
	0.1 - 4.9	371	165,498	1.08	0.80 , 1.46	1.02	0.76 , 1.36	1.19	0.80 , 1.77	1.98	0.92 , 4.27
	5.0 - 77.7	303	110,877	2.33 **	1.58 3.42	2.89 **	2.11 , 3.95	4.77 **	3.33 , 6.84	12.92 **	6.80 , 24.53
Percent Female Headed Households w/ Children < 6	0 - 1	436	143,957	1.00		1.00		1.00		1.00	
	1.1 - 3.7	338	144,778	1.12	0.82 , 1.55	0.92	0.68 , 1.25	0.94	0.62 , 1.43	1.19	0.60 , 2.38
	3.8 - 41.4	393	144,810	1.92 *	1.37 , 2.70	1.97 **	1.47 , 2.65	2.90 **	2.04 , 4.12	4.30 **	2.46 , 7.49
Percent Housing Units Built from 1950 to 1979	1.4 - 29.8	350	144,430	1.00		1.00		1.00		1.00	
	29.9 - 50.2	413	144,417	1.54 *	1.09 , 2.18	1.00	0.73 , 1.35	0.58 *	0.41 , 0.83	0.31 **	0.19 , 0.51
	50.3 - 96.6	404	144,698	0.70 *	0.50 , 0.97	0.35 **	0.25 , 0.48	0.14 **	0.09 , 0.22	0.02 **	0.01 , 0.06
Percent Housing Units Built Before 1950	0 - 4.9	291	144,284	1.00		1.00		1.00		1.00	
	5.0 - 18.1	348	144,596	1.69 *	1.22 , 2.34	2.55 **	1.69 , 3.85	5.35 *	1.57 , 18.24	†	--
	18.2 - 91.7	528	144,665	5.51 **	3.79 , 8.01	13.60 **	9.13 , 20.25	61.82 **	19.47 , 196.33	†	--
Median Value of Housing Units	Low - 258,700	479	143,927	1.00		1.00		1.00		1.00	
	258,701 -	343	145,113	0.22 **	0.14 , 0.33	0.16 **	0.12 , 0.22	0.14 **	0.09 , 0.21	0.04 **	0.01 , 0.12
	368,801 - High	345	144,505	0.14 **	0.10 , 0.22	0.10 **	0.07 , 0.14	0.07 **	0.04 , 0.12	0.02 *	0.00 , 0.15
Percent of Black Population	0 - 9.8	433	144,491	1.00		1.00		1.00		1.00	
	9.9 - 34.3	344	144,175	0.89	0.65 , 1.21	0.83	0.61 , 1.13	1.09	0.73 , 1.63	0.80	0.35 , 1.82
	34.4 - 100	390	144,879	2.30 **	1.58 , 3.35	1.53 *	1.13 , 2.08	2.43 **	1.69 , 3.48	5.29 **	2.89 , 9.66
Percent On Public Assist Income	0 - 0.5	388	144,203	1.00		1.00		1.00		1.00	
	0.6 - 1.8	353	144,809	1.39 *	1.02 , 1.91	1.94 **	1.41 , 2.67	1.30	0.81 , 2.08	2.43	0.80 , 7.38
	1.9 - 24.4	426	144,533	2.66 **	1.87 , 3.79	3.68 **	2.69 , 5.03	5.79 **	3.88 , 8.64	17.06 **	6.70 , 43.45
Median Household Income	Low - 59,610	469	144,048	1.00		1.00		1.00		1.00	
	59,611-	366	143,688	0.20 **	0.13 , 0.30	0.21 **	0.16 , 0.29	0.14 **	0.10 , 0.21	0.02 **	0.01 , 0.10
	86,453 - High	332	145,809	0.11 **	0.07 , 0.17	0.09 **	0.06 , 0.14	0.03 **	0.01 , 0.06	†	--

* p<.05
** p<.0001
† '0' cells in the tables therefore OR cannot be calculated
‡ Adjusted for percentage of children screened

The Model

Based on these analyses and the 2000 and 2004 Maryland Targeting Models, the 2013 Maryland Models include the following variables: percentage of pre-1950 housing, median housing value, the constructed poverty scale, the percentage of homes built from 1950-1979 and the average annual percentage of children tested. Models were prepared for each of the four outcome variables described (Table A-4.14). For the more restrictive outcome measures, where risk areas were defined by increasing percentages of tests above the reference level, the area under the ROC curve, Hosmer-Lemeshow test, Somers' D statistic, AIC and SC were all indicative of a better fitting model. Characteristics of the risk and non-risk tracts generally became more homogeneous within each group as the definition of risk area became more restrictive.

Table A-4.14. Comparison of Possible 2013 Maryland Targeting Plan Models

Model Variables	2000 Model* "Original"		Outcome 1 (≥3% Tests ≥RL*)		Outcome 2 (≥5% Tests ≥RL)		Outcome 3 (≥9% Tests ≥RL)		Outcome 4 (≥17% Tests ≥RL)	
	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value
Percent Pre 1950 Housing	0.0162	0.0001	0.0369	<.0001	0.0458	<.0001	0.0488	<.0001	0.0724	<.0001
Poverty Scale	0.5229	0.0001	0.2076	0.2121	0.2992	0.0362	0.7182	<.0001	1.0174	<.0001
Median Housing Value	-0.0114	0.0001	-4.15E-06	<.0001	-0.000007	<.0001	-0.00000869	<.0001	-0.00001	<.0001
Percent 1950-1979 Housin	0.00206	0.0381	-0.00453	0.2124	-0.01260	0.0018	-0.0201	0.0019	-0.0216	0.2320
Percent of Screening	0.0389	0.0001	0.0170	0.0235	0.0121	0.0653	0.0285	0.0004	0.0489	<.0001
Intercept	-4.7097	0.0001	1.6512	<.0001	1.2534	0.0005	-0.3646	0.4979	-4.0775	0.0063
Area Under ROC Curve†	-		0.792		0.865		0.936		0.982	
Conclusion	Not Available		Very Good		Very Good		Excellent		Excellent	
Hosmer and Lemeshow §	-		p=0.0986		p=0.0399		P=0.3816		p=0.8120	
Conclusion	Not Available		Fail to Reject H0, no evidence of poor fit		Reject H_0, conclude poor fit		Fail to Reject H0, no evidence of poor fit		Fail to Reject H0, no evidence of poor fit	
Somers' D¶	0.82		0.583		0.731		0.872		0.965	
AIC ††	Not Available		1108.087		1077.236		640.321		236.747	
SC §§	Not Available		1138.46		1107.609		670.694		267.120	

* The outcome definition for the Original 2000 Maryland model is based on BLL ≥10µg/dL, however the percentage of elevated BLLs used to define a "Risk Area" in this model is unknown. It is assumed to be 12%, based on common practice when the model was developed.
** Reference level. In 2011 CDC defined the reference level for children's' exposure to lead as 5µg/dL.
† Receiver Operating Characteristic (ROC) Curve. The area under the ROC curve gives a quantitative indication of each model's ability to distinguish between risk and non-risk census tracts and ranges from 0.5 (worst) to 1.0 (ideal).
§ The Hosmer and Lemeshow test is a statistical test for goodness of fit for logistic regression models. It assesses whether or not observed rates match expected rates in subgroups of the modeled population.
¶ Somer's D is used to determine the strength and direction of relation between the predicted and actual values of the dependent variable. Its values range from -1.0 (all pairs disagree) to 1.0 (all pairs agree).
†† Akaike Information Criterion (AIC) is used for the comparison of models on the same sample. The model with the smallest AIC is considered the best. The AIC value itself is not meaningful.
§§ Schwarz Criterion (SC) is used to compare between models on the same sample. This measure penalizes for the number of predictors in the model and the model with the smallest SC is considered best. The value itself is not meaningful.

Predicting At-Risk Census Tracts

Logistic regression models were used to assess the risk of a child in a given census tract for having a blood lead level at or above reference, then used to estimate the number of children in that census tract with a blood lead level at or above reference. This analysis was performed for each of the outcomes described. Predicted probabilities based on each of the outcomes modeled ranged from 0 to 0.99, depending on the outcome modeled. When these were applied to the census tract population, the number of children expected to have a blood lead level at or above reference ranged from 0 to 1,179 children (Table A-4.15). Maps were prepared that displayed the level of risk for each census tract in Maryland (Figures A-4.7, A-4.8, A-4.9, A-4.10).

Table A-4.15. Number and Percentage of Census Tracts and Children for Each Level of Risk*, by Model

	Risk Level**	Number of Census Tracts	Percent of Census Tracts	Predicted Number Children at Risk	Total Number of Children Living in Tracts
Original Model Assumed ≥12% of tests 10 mcg/dL	**High**	46	4.0	266 - 666	-
	Moderate	77	6.7	73 - 265	-
	Low	288	20.7	13 - 72	-
	Negligible	790	68.6	0 - 12	-
Model 1 ≥3% of tests at or above RL*	**High**	421	36.1	276 - 1,179	249,657
	Moderate	414	35.5	153 - 275	126,913
	Low	231	19.8	81 - 152	43,588
	Negligible	101	8.7	8 - 81	13,387
Model 2 ≥5% of tests at or above RL*	**High**	347	29.7	179 - 746	174,945
	Moderate	384	32.9	83 - 178	136,873
	Low	255	21.9	36 - 83	74,067
	Negligible	181	15.5	1 - 36	47,660
Model 3 ≥9% of tests at or above RL*	**High**	184	15.8	136 - 618	64,995
	Moderate	293	25.1	37 - 136	109,028
	Low	327	28.0	11 - 37	136,601
	Negligible	363	31.1	0 - 11	122,921
Model 4 ≥17% of tests at or above RL*	**High**	76	6.5	157 - 494	25,491
	Moderate	103	8.8	44 - 154	22,833
	Low	179	15.3	4 - 43	58,246
	Negligible	809	69.3	0 - 4	326,975

* RL= Reference Level; CDC defines this as 5 mcg/dL

** Risk Level Definitions:

High Risk = 40% to 100% of the highest number of children predicted to be at risk;

Moderate Risk = 11% to 39.9% of the highest number of children predicted to be at risk;

Low Risk = 2% to 10.9% of the highest number of children predicted to be at risk; and

Negligible Risk = 0% to 1.9% of the highest number of children predicted to be at risk.

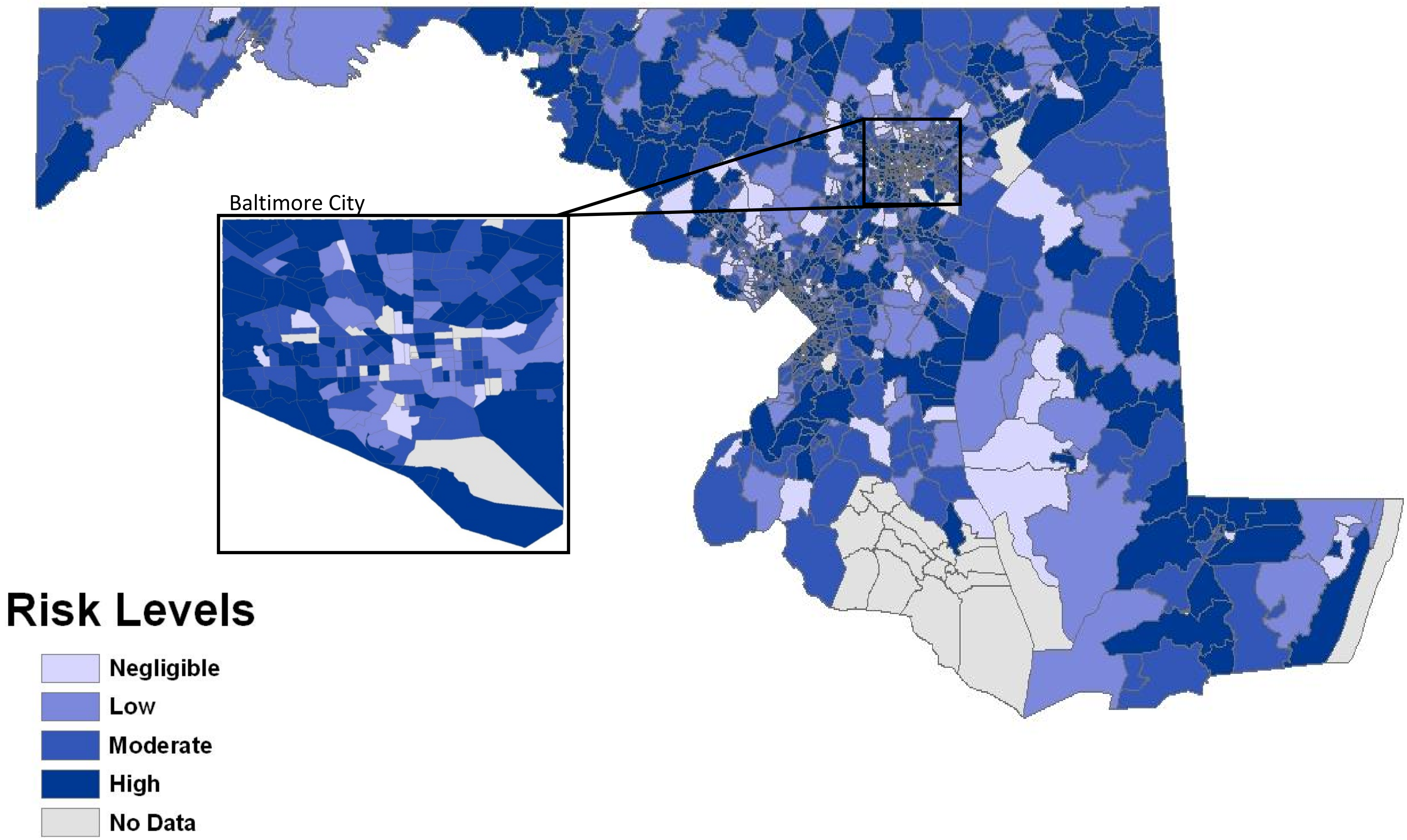


Figure A-4.7. Predicted Risk Areas, Model 1: Modeled risk area defined as a census tract with ≥3% of tests at or above the reference level

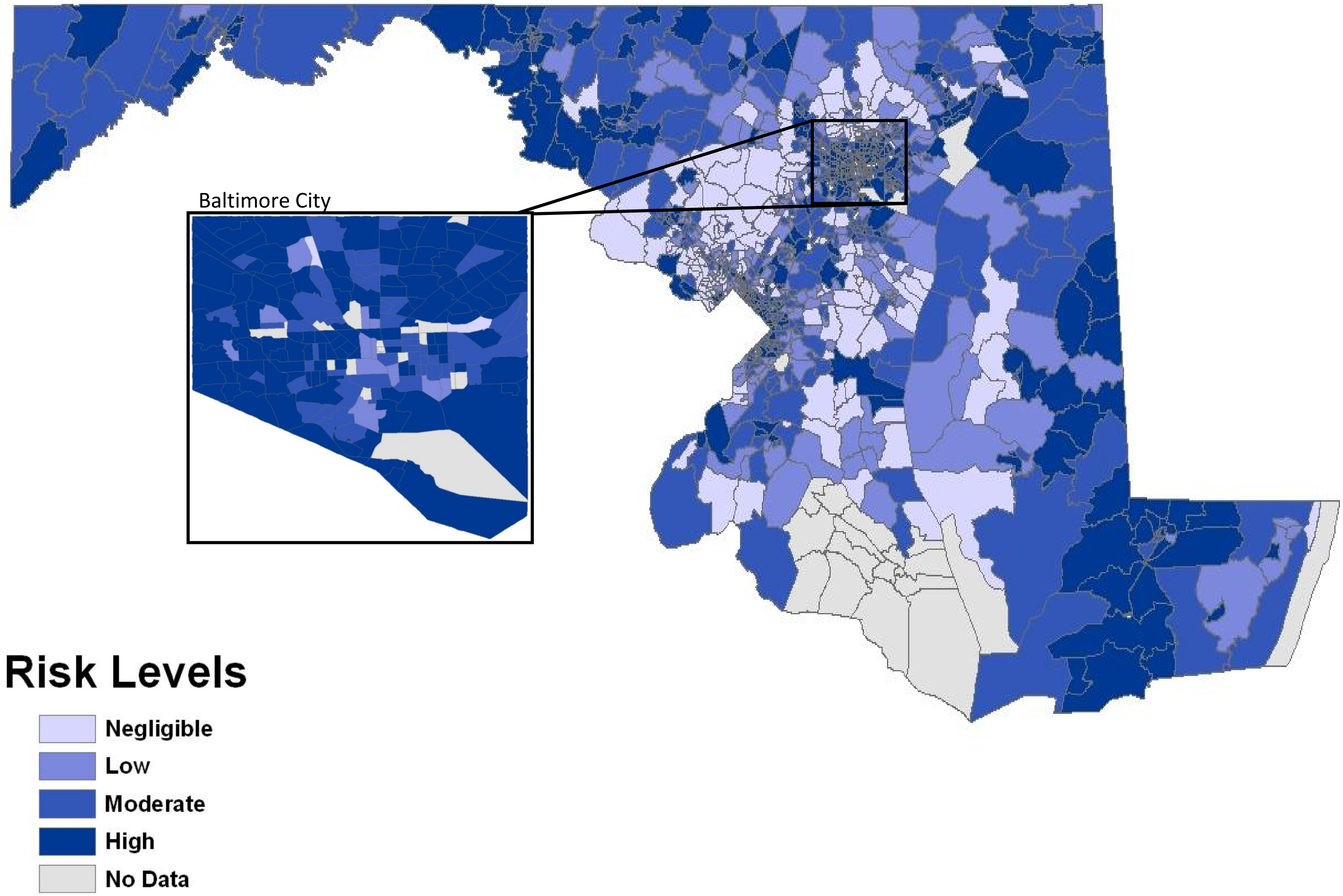


Figure A-4.8. Predicted Risk Areas, Model 2: Modeled risk area defined as a census tract with ≥5% of tests at or above the reference level

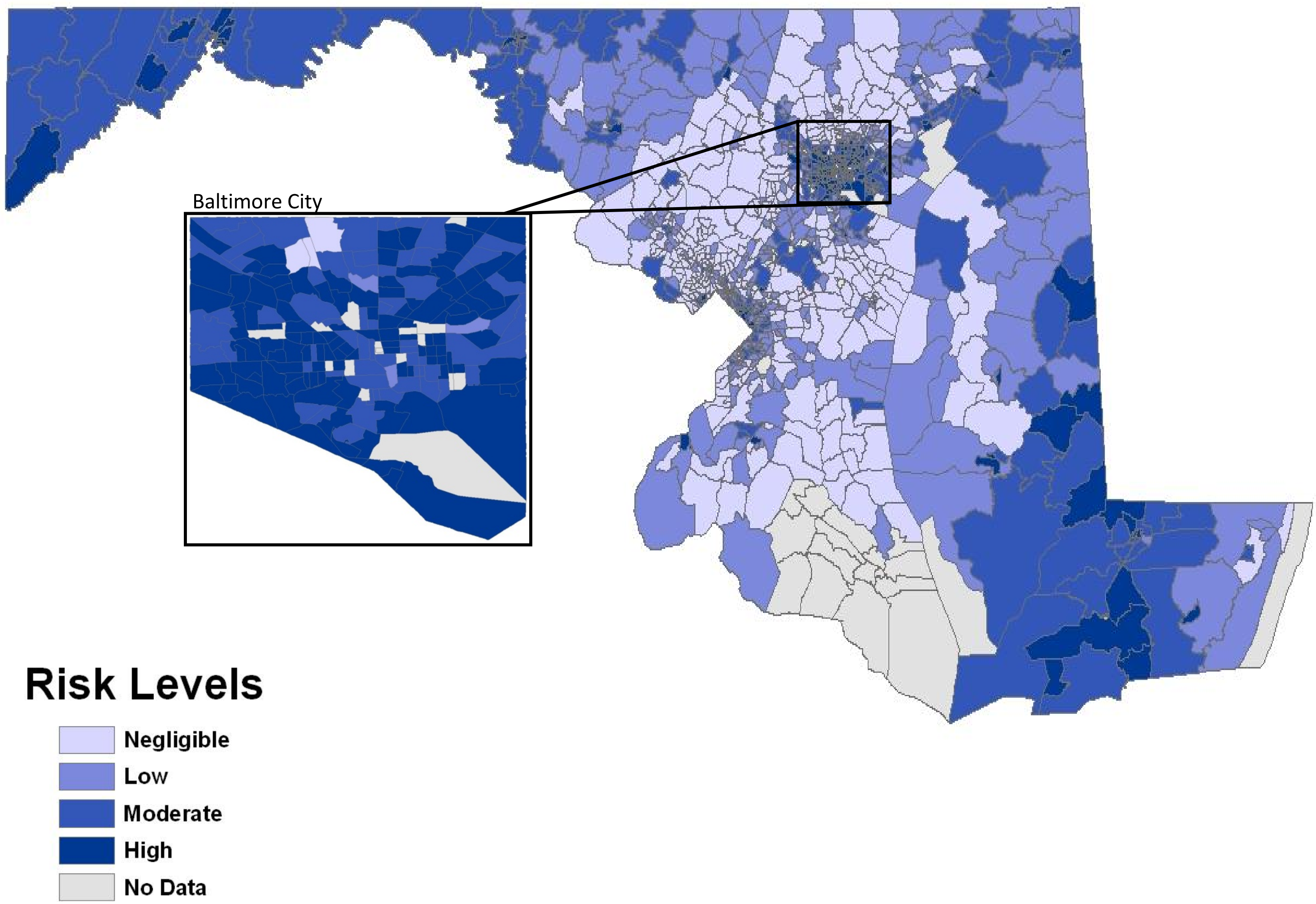


Figure A-4.9. Predicted Risk Areas, Model 3: Modeled risk area defined as a census tract with ≥9% of tests at or above the reference level

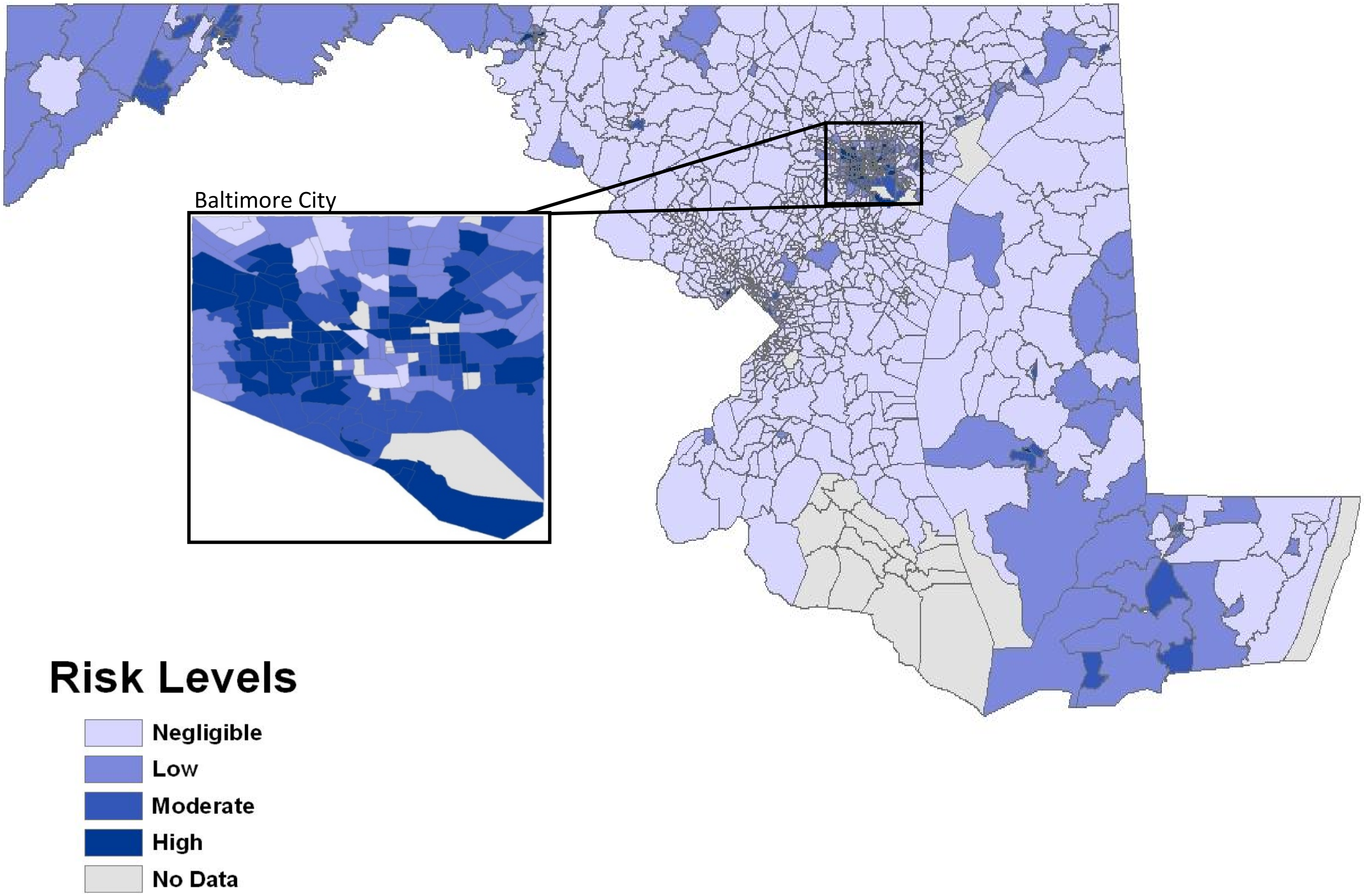


Figure A-4.10. Predicted Risk Areas, Model 4: Modeled risk area defined as a census tract with ≥17% of tests at or above the reference level

Targeting Strategy Option 3 (Universal Testing)

The third option for a targeting strategy would be universal testing for all children of appropriate age in Maryland. This strategy would require that all children be tested at one year and two years of age, regardless of place of residence or any other consideration. This strategy would be recommended for a period of *three years*, enough time to develop a more complete understanding of the actual distribution of blood lead levels throughout the State. This strategy requires no modeling or data analysis. Table A-4.16 lists the estimated number of 1- and 2-year old children living in each county and Baltimore City, based on the 2010 U.S. Census.

Table A-4.16. Estimated Number* of 1- and 2-Year Old Children to be Tested under a Universal Testing Strategy, by County

County	**Number**
Allegany	1,362
Anne Arundel	13,884
Baltimore	19,316
Calvert	1,939
Caroline	905
Carroll	3,529
Cecil	2,602
Charles	3,791
Dorchester	815
Frederick	5,857
Garrett	603
Harford	5,921
Howard	6,880
Kent	393
Montgomery	25,559
Prince George's	23,489
Queen Anne's	1,054
St. Mary's	2,969
Somerset	530
Talbot	795
Washington	3,592
Wicomico	2,486
Worcester	930
Baltimore City	16,836
Total	146,037

* Based on the 2010 U.S. Census

APPENDIX 5. Potential Costs of Testing Targeting Options

This section deals exclusively with the costs of implementing the lead testing strategies, not with potential benefits. The projected costs of the three options presented in this document are complex, and depend on numerous assumptions. One overarching complexity is the change in the global health care system brought about by implementation of the Affordable Care Act (ACA). This includes a significant increase in Medicaid enrollment as well as insurance coverage, in general. The increase in Medicaid coverage for children means that even without any change in "at risk" ZIP codes, more children should be tested by their providers. Other potential results of the ACA could be changes in hospitalization costs for children diagnosed with elevated blood lead levels, although it is impossible to predict what those changes might be. The cost estimates presented are therefore necessarily simplified and subject to considerable uncertainty.

The three options were compared as to their relative costs of implementation, using current reimbursement rates provided to DHMH by health care providers and organizations involved in lead prevention, as well as directly from Medicaid. The cost comparison included "typical" costs for blood lead testing, costs of follow-up, and an estimate of the percentage of capillary tests that would be confirmed by venous testing, based on the following assumptions (Table A-5.1):

- 13% of elevated capillary tests (≥10 mcg/dL) would be less than 10 mcg/dL when repeated by venous testing (false positives)
- Reimbursement rate for blood lead test is $15 - $25
- A "typical" environmental investigation for a child with a confirmed elevated blood lead (≥10 mcg/dL) would cost approximately $370 if performed by a public agency or $630 if conducted by a private firm.

In the first option, based on the distribution of test results at or above the reference level observed from 2005-2009, the different selection areas would potentially "miss" children estimated to be "at risk." To capture 100% of expected children with blood lead levels at or above the reference, all areas would have to be targeted (universal testing). Capturing 90% of expected children with blood lead levels at or above the reference would involve targeting 173 "at risk" ZIP codes. Adoption of this strategy would result in an estimated 126,016 1- and 2-year old children receiving a lead test the first year, with 10,042 (8.0% of tests) of these estimated to have a blood lead level at or above the reference level. This approach would "miss" an estimated 972 1- and 2-year old children living in non-targeted ZIP codes who, although not tested, would still be expected to have a blood lead level at or above the reference level. If, instead of 90%, the goal were to identify 75% of children expected to have a blood lead level at or above the reference level, 95 ZIP codes would be targeted as "at risk." This strategy would result in an estimated 91,201 1- and 2-year old children receiving a blood test, identifying an estimated 8,320

(9.1% of tests) children and “missing” an estimated 2,445 children expected to have a blood lead level at or above the reference level. Finally, a strategy based on identifying 50% of expected children with blood lead levels at or above the reference would target 32 ZIP codes as “at risk.” This strategy would result in an estimated 32,580 children being tested, identifying 5,274 (16.2% of tests) children estimated to have a blood lead level at or above the reference level and “missing” 4,925 children expected to have a blood lead level at or above the reference level.

Using the most conservative assumptions for the second targeted testing approach, census tracts with 3 or more percent of test results at or above the reference level were identified as “at risk.” The results of this model identified 421 “high” risk census tracts with a total of 179,681 children less than 6 years of age predicted to have a blood lead level ≥5 mcg/dL; 414 census tracts as “moderate” risk areas with a total of 86,740 children less than 6 years of age predicted to have a blood lead level ≥5 mcg/dL; 231 “low” risk census tracts with a total of 26,837 children less than 6 years of age predicted to have a blood lead level ≥5 mcg/dL; and 4 “negligible” risk census tracts with a total of 5,631 children less than 6 years of age predicted to have a blood lead level ≥ 5 mcg/dL. For the least conservative model, a risk area was defined as a census tract with greater than or equal to 17% of blood lead tests at or above the reference level. The results identified 76 “high” risk census tracts with a total of 19,570 children less than 6 years of age predicted to have a blood lead level ≥ 5 mcg/dL; 103 census tracts as “moderate” risk areas with a total of 9,303 children less than 6 years of age predicted to have a blood lead level ≥5 mcg/dL; 179 “low” risk census tracts with a total of 2,874 children less than 6 years of age predicted to have a blood lead level ≥5 mcg/dL; and 809 “negligible” risk census tracts with a total of 614 children less than 6 years of age predicted to have a blood lead level ≥5 mcg/dL. Details of the cost analysis are presented in Tables A-5.2, A-5.3, A-5.4.

Table A-5.1. Crude Projected Cost Analysis, Three Targeting Strategy Options, Maryland

Targeting Strategy Option	Estimated number of 1- and 2-year old children to be tested	Estimated number of children with EBL ≥10 mcg/dL§	Estimated number of children with EBL 5 – 9 mcg/dL§	Cost of Testing¶	Costs of Follow-Up for EBL ≥10 mcg/dL††	Cost of Follow-Up for EBL 5 – 9 mcg/dL§§	Total Estimated Cost
Option 1 – Target testing based on the distribution of 2005-2009 test results, by ZIP Code*	91,201 (79,983 Venous, 11,218 Capillary)	1,100 (1,040 Venous, 60 Confirmed Capillary)	7,108 (6,159 Venous, 949 Confirmed Capillary)	$1,320,146 - $2,324,713	$949,242 – $985,435	$308,513 - $543,549	$2,577,901 - $3,853,697
Option 2 – Target testing based on an updated MD Targeting Model**	108,245 (92,008 Venous, 16,237 Capillary)	1,148 (1,104 Venous, 44 Confirmed Capillary)	8,051 (6,809 Venous, 1,242 Confirmed Capillary)	$1,564,844 - $2,759,165	$990,702 - $1,028,436	$349,097 - $615,660	$2,904,642 - $4,403,261
Option 3 – Universal testing	146,037 (124,131 Venous, 21,906 Capillary)	1,548 (1,489 Venous, 59 Confirmed Capillary)	10,862 (9,186 Venous, 1,676 Confirmed Capillary)	$2,111,184 - $3,722,483	$1,335,895 - $1,386,776	$470,983 – $830,617	$3,918,061 – $5,939,876

* This estimate was prepared considering the area containing 75% of children expected to be "at risk," representing the "middle" estimate.
** This estimate was prepared based on model 3, with the modeled outcome of interest "risk area" defined as a census tract with ≥9% of tests at or above the reference level.
§ Represents venous test results and confirmed capillary results. 90% of capillary tests are assumed to be true positives in these analyses.
¶ The Cost per Test is based on Maryland Medicaid 2013 Clinical Diagnostic Laboratory Fee Schedule, with a low range of reimbursement assumed to be: Venous sample = $12.37 +$2.19 = $14.56; Capillary test =:$12.37 + $1.50= $13.87. The high range is assumed to be: Venous sample = $22.49 + $3.00 = $19.64; Capillary sample = $22.49 + $3.00 = $19.64.
†† Based on estimates of follow-up testing (3 tests/year), home inspection and testing ($715), nurse home visit ($48.75), case coordination ($55.63).
§§ Cost per Year: 3 follow-up tests per year (re-test every 3 months), following the initial screening test.
See Tables A-5.2 – A-5.4 for details.

Table A-5.2. Low and high range estimates for targeting strategy option 1.

Option 1* - Low Range					Option 1* - High Range			
	Estimated number of 1 and 2 year old children to be tested	Cost/Test	Total Screening Test Cost			Estimated number of 1 and 2 year old children to be tested	Cost/Test	Total Screening Test Cost
Venous	79,983	$15	$1,164,552		Venous	79,983	$25	$2,038,767
Capillary	11,218	$14	$155,594		Capillary	11,218	$25	$285,947
Cost of Screening	91201		$1,320,146		Cost of Screening	91201		$2,324,713
5-9 mcg/dL Follow-up X 1 year	Estimated number of children with EBL 5 – 9 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost		5-9 mcg/dL follow-up X 1 year	Estimated number of children with EBL 5 – 9 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost
Venous tests	6,159	$44	$269,025		Venous	6,159	$76	$470,979
Capillary tests	949	$42	$39,488		Capillary	949	$76	$72,570
Cost of 5-9 mcg/dL follow-up	7,108		$308,513		Cost of 5-9 mcg/dL follow-up	7,108		$543,549

≥10 mcg/dL follow-up X 1 year	Estimated number of children with EBL ≥ 10 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost		≥10 mcg/dL follow-up X 1 year	Estimated number of children with EBL ≥ 10 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost
Venous	1,040	$44	$45,427		**Venous**	1,040	$76	$79,529
Capillary	60	$42	$2,497		**Capillary**	60	$76	$4,588
MDE Inspection X1	1,100	$715	$786,500		**MDE Inspection X1**	1,100	$715	$786,500
MDE Case Coordination X1 year	1,100	$56	$61,193		**MDE Case Coordination X1 year**	1,100	$56	$61,193
Nurse visit X1	1,100	$49	$53,625		**Nurse visit X1**	1,100	$49	$53,625
Cost of ≥10 mcg/dL follow-up			$949,242		**Cost of ≥10 mcg/dL follow-up**			$985,435
Total Estimated Cost			**$2,577,901**		**Total Estimated Cost**			**$3,853,697**

Table A-5.3. Low and high range estimates for targeting strategy option 2.

Option 2** - Low Range					Option 2** - High Range			
	Estimated number of 1 and 2 year old children to be tested	Cost per Test	Total Screening Test Cost			Estimated number of 1 and 2 year old children to be tested	Cost per Test	Total Screening Test Cost
Venous	92,008	$15	$1,339,636		**Venous**	92,008	$25	$2,345,284
Capillary	16,237	$14	$225,207		**Capillary**	16,237	$25	$413,881
Cost of Screening	108,245		$1,564,844		**Cost of Screening**	108,245		$2,759,165
5-9 mcg/dL follow-up X 1 year	**Estimated number of children with EBL 5-9 mcg/dL**	**follow-up Cost per Year**	**Total Follow-up Testing Cost**		**5-9 mcg/dL follow-up X 1 year**	**Estimated number of children with EBL 5-9 mcg/dL**	**follow-up Cost per Year**	**Total Follow-up Testing Cost**
Venous	6,809	$44	$297,417		**Venous**	6,809	$76	$520,684
Capillary	1,242	$42	$51,680		**Capillary**	1,242	$76	$94,976
Cost of 5-9 mcg/dL follow-up	8,051		$349,097		**Cost of 5-9 mcg/dL follow-up**	8,051		$615,660
≥10 mcg/dL follow-up X 1	**Estimated number of children with EBL ≥ 10**	**follow-up Cost per Year**	**Total Follow-up Testing Cost**		**≥10 mcg/dL follow-up X 1**	**Estimated number of children with EBL ≥10**	**follow-up Cost per Year**	**Total Follow-up Testing Cost**

year (3 tests)	**mcg/dL**				**year (3 tests)**	**mcg/dL**		
venous	1,104	$44	$48,223		**venous**	1,104	$76	$84,423
Capillary	44	$42	$1,831		**Capillary**	44	$76	$3,365
MDE Inspection X1	1,148	$715	$820,820		**MDE Inspection X1**	1,148	$715	$820,820
MDE Case Coordination X1 year	1,148	$56	$63,863		**MDE Case Coordination X1 year**	1,148	$56	$63,863
Nurse visit X1	1,148	$49	$55,965		**Nurse visit X1**	1,148	$49	$55,965
Cost of ≥10 mcg/dL follow-up			$990,702		**Cost of ≥10 mcg/dL follow-up**			$1,028,436
Total Estimated Cost			**$2,904,642**		**Total Estimated Cost**			**$4,403,261**

Table A-5.4. Low and high range estimates for targeting strategy option 3.

Option 3 - Low Range					Option 3 - High Range			
	Estimated number of 1 and 2 year old children to be tested	Cost per Test	Total Screening Test Cost			Estimated number of 1 and 2 year old children to be tested	Cost per Test	Total Screening Test Cost
Venous	124,131	$15	$1,807,347		Venous	124,131	$25	$3,164,099
Capillary	21,906	$14	$303,836		Capillary	21,906	$25	$558,384
Cost of Screening	146,037		$2,111,184		Cost of Screening	146,037		$3,722,483
5-9 mcg/dL follow-up X 1 year	Estimated number of children with EBL 5 – 9 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost		5-9 mcg/dL follow-up X 1 year	Estimated number of children with EBL 5 – 9 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost
Venous	9,186	$44	$401,244		Venous	9,186	$76	$702,453
Capillary	1,676	$42	$69,738		Capillary	1,676	$76	$128,164
Cost of 5-9 mcg/dL follow-up	10,862		$470,983		Cost of 5-9 mcg/dL follow-up	10,862		$830,617

≥10 mcg/dL Follow-up X 1 year	Estimated # of children with EBL ≥ 10 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost		≥10 mcg/dL follow-up X 1 year	Estimated # of children with EBL ≥10 mcg/dL	follow-up Cost per Year	Total Follow-up Testing Cost
venous	1,489	$ 44	$65,040		**venous**	1,489	$76	$113,864
Capillary	59	$ 42	$2,455		**Capillary**	59	$76	$4,512
MDE Inspection X1	1,548	$715	$1,106,820		**MDE Inspection X1**	1,548	$715	$1,106,820
MDE Case Coordination X1 year	1,548	$56	$86,115		**MDE Case Coordination X1 year**	1,548	$56	$86,115
Nurse visit X1	1,548	$49	$75,465		**Nurse visit X1**	1,548	$49	$75,465
Cost of ≥10 mcg/dL follow-up			$1,335,895		**Cost of ≥10 mcg/dL follow-up**			$1,386,776
Total Estimated Cost			**$3,918,061**		**Total Estimated Cost**			**$5,939,876**

Cost Projection Assumptions for tables A-5.2 – A-5.4 – Low Range

1) Cost per Test: Based on Maryland Medicaid 2013 Clinical Diagnostic Laboratory Fee Schedule.
   Venous: $12.37 +$2.19 = $14.56
   Capillary: $12.37 + $1.50= $13.87
2) Cost per Year: 3 follow-up tests per year (i.e., a test every 3 months), following the initial screening test.
3) Inspection by MDE inspection is done if blood lead level is ≥10 mcg/dL
4) Follow-up testing process is constant, (i.e., all capillary testing or all venous testing)
5) Nurse visit is done in coordination with MDE investigation; of note, MD law requires only for levels ≥15 mcg/dL, but majority of counties perform visits in conjunction with MDE.
6) Excludes physician visit costs since tests are likely performed in conjunction with routine preventive care visits.
7) Total Estimated Cost: Σ Cost Tests + Cost 10 mcg/dL (follow-up) + Cost 5-9 mcg/dL (follow-up)
8) 100% utilization of Health Department and MDE services with no loss to follow-up.

* This estimate was prepared considering the area containing 75% of children expected to be "at risk," representing the "middle" estimate.
** This estimate was prepared based on model 3, with the modeled outcome of interest "risk area" defined as a census tract with ≥9% of tests at or above the reference level.

Cost Projection Assumptions for tables A-5.2 – A-5.4 – High Range

1) Cost per Test: Based on Medicare 2013 Clinical Diagnostic Laboratory Fee Schedule.
   Venous: $22.49 + $3.00=$19.64
   Capillary: $22.49 + $3.00=$19.64 (*code 36416 is N/A to Medicare)
2) Cost per Year: 3 follow-up tests per year (i.e., a test every 3 months), following the initial screening test.
3) Public MDE inspection is done if blood lead level is ≥10 mcg/dL
4) Follow-up testing process is constant, (i.e., all capillary testing or all venous testing)
5) Nurse visit is done in coordination with MDE investigation; of note, MD law requires only for levels ≥15 mcg/dL, but majority of counties perform visits in conjunction with MDE.
6) Excludes physician visit cost since tests are likely performed in conjunction with routine preventive care visits.
7) Total Estimated Cost: Σ Cost Tests + Cost 10 mcg/dL follow-up + Cost 5-9 mcg/dL follow-up
8) 100% utilization of Health Department and MDE services.

* This estimate was prepared considering the area containing 75% of children expected to be "at risk," representing the "middle" estimate.
** This estimate was prepared based on model 3, with the modeled outcome of interest "risk area" defined as a census tract with ≥9% of tests at or above the reference level.

APPENDIX 6. Detailed Description of Data Sources

1. Data Sets

The following data sets were used to assess the current picture of lead testing in MD and to make recommendations for revising the targeting plan. The Systematic Tracking of Elevated Lead Levels & Remediation (STELLAR) database was used to generate descriptive summary tables on the characteristics of children tested in MD. These fields were also aggregated by county, ZIP code, and census tract to be used for analysis in targeting strategy options 1 and 2.

- **Systematic Tracking of Elevated Lead Levels & Remediation (STELLAR) Database, MDE CLR:** The STELLAR database stores the results of all childhood blood lead tests in the State and includes information on actual blood lead level, as well as geographic and demographic information. Records of all tests performed in the 5-year period from January 1, 2005 through December 31, 2009 were extracted from the STELLAR database. Records for children receiving a blood lead test in multiple years, or who had multiple tests within a given year, were counted only once for each year in which they were tested. The record of venous test with the highest blood lead level annually was retained for each child who had multiple tests in a given year. For children with more than one test, of which there was no venous result, the highest result where the test type was "unknown" was retained. Unknown test types were retained as a second priority because some proportion of these is likely to be venous tests. Finally, for children who received multiple tests in a given year, none of which were venous or "unknown," the highest capillary result was retained. This selection process resulted in a total of 586,264 individual records in the project data set (Figure A-6.1). Note the resulting data set contains no more than one test per year for each of the 5 years included, for children of all ages. In later analyses, these individual records were further restricted to include only children less than 6 years of age and aggregated to determine a total incidence for the 5-year period. Table A-6.1 summarizes the variables included in this initial project data set.

Figure A-6.1. STELLAR Data Set Processing

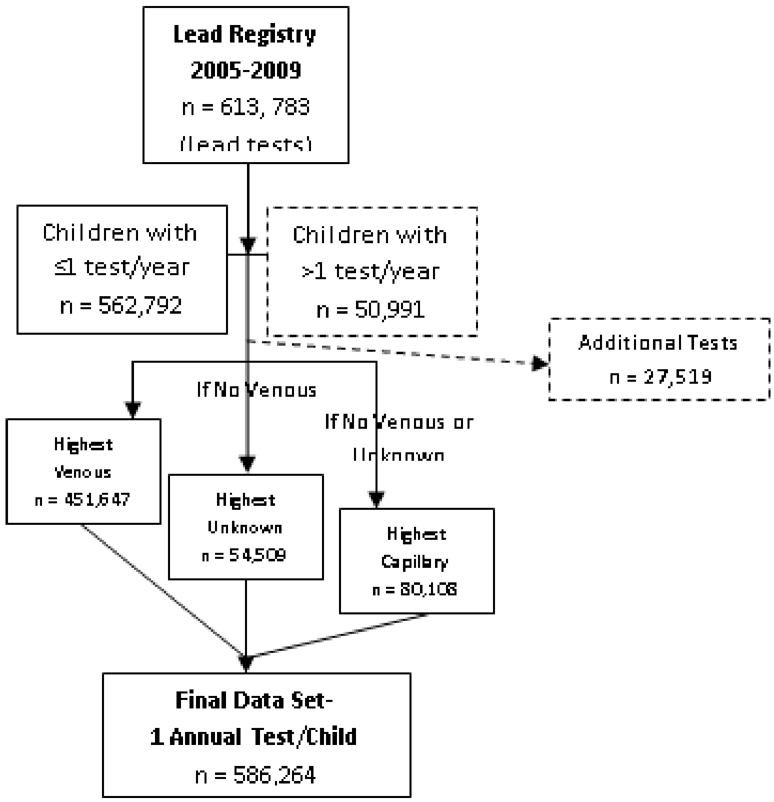


Table A-6.1. STELLAR Data Fields

Description	Field Name	Source	Notes
Stellar Id Number	CHILD_ID	STELLAR	Unique identifier for each child
Child's Address:			
- Street	ASSEMADDR	STELLAR	
- State	ADDRSTATE	STELLAR	
- City	ADDR_CITY	STELLAR	
- ZIP Code	ADDR_ZIP	STELLAR	
- County	ADDR_CNTY	STELLAR	
Child's Date of Birth	DOB_CHILD	STELLAR	
Child's Age (years)	SampleAgeY	STELLAR*	Calculated: sample date - DOB
Address-Latitude	LATITUDE	STELLAR*	Geocoded CLR addresses in Centrus
Address-Longitude	LONGITUDE	STELLAR*	Geocoded CLR addresses in Centrus
Address-Census Tract	CENSUSTRAC	STELLAR*	Geocoded CLR addresses in Centrus
Result (Blood Lead Level)	PBB_REST	STELLAR	
Child's race	RACE	STELLAR	
Date Test Sample Drawn	SAMP_DATE	STELLAR	
Sample Year	SampYear	STELLAR*	Year extracted from sample date
Sample (Venous, Capillary)	SAMP_TYPE	STELLAR	
Lab Id	LAB_ID	STELLAR	
Child's Sex	SEX	STELLAR	
Total number of tests per year for an individual child	count1	STELLAR*	Count number of records per child per year

* Fields added to data set. These were not exported from STELLAR but were created using fields from STELLAR.

- **American Community Survey (ACS), U.S. Census Bureau:** All demographic information utilized in the logistic regression analyses was obtained from the U.S. Census Bureau's ACS through the American FactFinder web tool. Excel files of select demographic characteristics by census tract were downloaded, modified, and utilized in the logistic regression model. The specific table for each of the variables is indicated under 'Notes' in the table. Variables were merged with a census tract level-aggregated CLR data set based on census tract ID number. Table A-6.2 summarizes the fields included in this data set.

Table A-6.2. American Community Survey Data Fields

Description	Field Name	Source	Notes
Census Tract ID Number	CensusTract	ACS	
Total number of residents ≤ 5 years old	LE5yo	ACS*	B09001: POPULATION UNDER 18 YEARS BY AGE
Number of renter-occupied housing units	nRenterOcc	ACS	B25002: OCCUPANCY STATUS
Number of occupied housing units	nOccupied	ACS	B25032: TENURE BY UNITS IN STRUCTURE
Percent Rental Housing	PercRental	ACS*	PercRental=(nRenterOcc/nOccupied)*100
Number of vacant housing units	nVacant	ACS	B25002: OCCUPANCY STATUS
Total number of housing units	nAllHouses	ACS	B25032: TENURE BY UNITS IN STRUCTURE
Percent vacant housing units	PercVacant	ACS*	PercVacant=(nVacant/nAllHouses)*100
Total number of families	TotalFam	ACS	B17006: POVERTY STATUS IN THE PAST 12 MONTHS OF RELATED CHILDREN UNDER 18 YEARS BY FAMILY TYPE BY AGE OF RELATED CHILDREN UNDER 18 YEARS
Sum of all family types below poverty with children <5 years old	povWChLT5	ACS*	Sum (married couple, male-headed household, female-headed household) below poverty with children less than 5 years old (B17006)
Percent of families below poverty level with children >5	PercPov	ACS*	PercPov=(povWChLT5/TotalFam)*100
Number female-headed households with children >6	FHHn	ACS	B11004: FAMILY TYPE BY PRESENCE AND AGE OF RELATED CHILDREN UNDER 18 YEARS
Percent female-headed households with children >6	PercFHH	ACS*	PercFHH=(FHHn/TotalFam)*100
Number housing units built from 1970 - 1979	Npre50	ACS*	B25034: YEAR STRUCTURE BUILT [Sum number built 1939 and before and from 1940-1949]
Number housing units built pre-1950	N50_79	ACS*	B25034: YEAR STRUCTURE BUILT [Sum number built 1950-1959, 1960-1969 and 1970-1979]
Percent housing units built from 1970 - 1979	Perc50_79	ACS*	Perc50_79=(N50_79/nAllHouses)*100

Table A-6.2. American Community Survey Data Fields –CONTINUED

Description	Field Name	Source	Notes
Percent housing units built pre-1950	PercPre50	ACS*	PercPre50=(Npre50/nAllHouses)*100
Median value of housing units	MedHousVal	ACS	B25077: MEDIAN VALUE (DOLLARS)
Number of black persons	nBlack	ACS	B02001: RACE
Total number of persons (all races)	nAllRaces	ACS	B02001: RACE
Percent black population	PercBlack	ACS*	PercBlack=(nBlack/nAllRaces)*100
Number households with public assistance income	PA_INCn	ACS	B19057: PUBLIC ASSISTANCE INCOME IN THE PAST 12 MONTHS FOR HOUSEHOLDS
Total number of households	TotalHHn	ACS	B19057: PUBLIC ASSISTANCE INCOME IN THE PAST 12 MONTHS FOR HOUSEHOLDS
Percent households with public assistance income	PercPaInc	ACS*	PercPaInc = (PA_INCn/TotalHHn)*100
Median household income	MedianInc	ACS	B19013: MEDIAN HOUSEHOLD INCOME IN THE PAST 12 MONTHS (IN 2009 INFLATION-ADJUSTED DOLLARS)

* Fields added to data set. These were not directly exported from FactFinder but were created/calculated using fields from the data sets downloaded.

- **2010 Decennial Census, U.S. Census Bureau:** A limited selection of demographic characteristics of ZIP codes is available from the 2010 U.S. Census tables. These characteristics were used for comparing the ZIP codes identified as risk and non-risk under targeting strategy option 1 (identification of expected risk areas based on observed test results). Excel files of select demographic characteristics by ZIP code were downloaded using the U.S. Census American FactFinder web tool. These files were prepared and merged into the ZIP code level-aggregated project data set based on ZIP code. Table A-6.3 summarizes the Census variables included in this data set.

Table A-6.3. 2010 Decennial Census Data Fields

Description	Field Name	Source	Notes
Number residents white	White	2010 SF1	P3: RACE
Number residents black	Black	2010 SF1	P3: RACE
Number residents other race	OthRace	2010 SF1[*]	P3: RACE—Sum of Other, Indian/Alaskan, Hawaiian/Pacific Islander and Multiple Race
Number residents all races (total)	AllRaces	2010 SF1	P3: RACE
Percent residents white	pWhite	2010 SF1[*]	pWhite=(nWhite/nAllRaces)*100
Percent residents black	pBlack	2010 SF1[*]	pBlack=(nBlack/nAllRaces)*100
Percent residents other race	pOther	2010 SF1[*]	pOther=(nOther/nAllRaces)*100
Number occupied housing units	OccupiedUnit	2010 SF1	H3: OCCUPANCY STATUS
Number vacant housing units	VacantUnit	2010 SF1	H3: OCCUPANCY STATUS
Number housing units	TotalUnit_V	2010 SF1	H3: OCCUPANCY STATUS
Percent occupied housing units	pOccupied	2010 SF1[*]	pOccupied=(OccupiedUnit/TotalUnit_V)*100
Percent vacant housing	pVacant	2010 SF1[*]	pVacant=(VacantUnit/TotalUnit_V)*100
Number owner occupied housing units	OwnerOccUnits	2010 Demographic Profile	DP21: HOUSING TENURE
Number rental housing units	pRentrOc	2010 Demographic Profile	DP21: HOUSING TENURE
Number housing units	TotalUnits_R	2010 Demographic Profile	DP21: HOUSING TENURE
Percent owner occupied housing	pOwnerOcc	2010 Demographic Profile[*]	pOwnerOc=(OwnerOccUnits/TotalUnits_R)*100
Percent rental housing	pRentrOc	2010 Demographic Profile[*]	pRentrOc=(RenterOccUnits/TotalUnits_R)*100
Males/females <1 year old	MLT1/FLT1	2010 Census	2010 Population of Children <5 years old
Males/females 1 year old	M1/F1	2010 Census	2010 Population of Children <5 years old
Males/females 2 years old	M2/F2	2010 Census	2010 Population of Children <5 years old
Males/females 3 years old	M3/F3	2010 Census	2010 Population of Children <5 years old

Table A-6.3. 2010 Decennial Census Data Fields (Continued)			
Description	**Field Name**	**Source**	**Notes**
Males/females 4 years old	M4/F4	2010 Census	2010 Population of Children <5 years old
Males/females 5 years old	M5/F5	2010 Census	2010 Population of Children <5 years old
Total number males ≤5 years old	MLE5	2010 Census*	MLE5= MLT1+M1+M2+M3+M5+M5
Total number females ≤5 years old	FLE5	2010 Census*	FLE5= FLT1+F1+F2+F3+F5+F5
Total number children ≤5 years old	TotLE5	2010 Census*	TotLE5= MLE5+ FLE5

* Fields added to data set. These were not directly exported from FactFinder, but were created/calculated using fields from the data sets downloaded.
SF= Summary File

2. Exploratory Data Sets

The following data sets were evaluated as potential data sources to be used in assessing and revising the MD lead targeting plan. Due to noted limitations, these sources were used only to provide limited descriptive information on children in the CLR or were eliminated from these analyses.

- **Department of Assessments & Taxation (DAT) Real Property Data, 2011, Obtained from MDE:** The State DAT Real Property database contains records of all residential and non-residential properties in MD and is created and intended to be used for taxation purposes. The variables in this file, including year of construction and property use, and the feasibility of merging the data with the CLR data, were explored to determine whether this data set could be used as a more robust source of information on the housing characteristics in MD. The file was used for two purposes: (1) to provide a detailed summary of housing characteristics in the State and (2) to provide specific housing information on all children in the CLR. This would allow a comparison of blood lead levels by the specific housing characteristics of individual children.

  Data files from DAT were obtained from MDE, which receives updated files from DAT on a monthly basis. The files were stored as '.txt' files by MDE, and the project team contacted the DAT for the data schematic to enable further use of these data. Fields in this data set on the year of construction, the most recent transfer date, owner occupancy, and property use were investigated further.

  The files used were received by MDE in 2011. The .txt files were converted to SAS data sets, and efforts were made to eliminate non-residential properties (e.g. parking garages, undeveloped land, boat slips, etc.). Following data set cleaning, the file was geocoded in Centrus to include latitude, longitude, and census tract for each property. Of the 1,841,023 records remaining after cleaning, 1,463,558 (79.5%) were successfully geocoded in Centrus. Although attempts were made to remove non-residential properties, some may not have been captured by the exclusion criteria used and remained in the data set.

Following discussions with representatives at the DAT, the project team concluded that it would not be possible to use the DAT files to create a detailed summary of the housing stock in MD, as there was no way to definitively identify occupied residential properties or renter- versus owner-occupied properties using the fields available in the data set. Limited information on the construction year was merged with the CLR data in order to provide more specific information on the age of properties inhabited by individual children who had received a blood lead test in MD. Variables merged into the project data set are summarized in Table A-6.4. Further attempts at using these data were abandoned.

The DAT file was matched with the CLR data set using a multi-tiered approach, first by matching based upon geocoded latitude and longitude (57 % of overall data matched), and then matching the remaining observations by the address fields ZIP code, street number, and street name (1.4 % of overall data matched). Finally, the address fields for the remaining fields were cleaned and re-geocoded in Centrus, and a final merge by latitude and longitude was done (0.20 % of remaining addresses matched). This approach resulted in an overall 58.9% match of CLR records to an address in the DAT file. The processes for this merge are outlined in Figure A-6.2, and Table A-6.5 summarizes the overall results for the three data matching methods. The percentage of STELLAR addresses in each ZIP code that failed to match to a DAT record was mapped to assess whether there appeared to be a geographic pattern to addresses that failed to match (Figure A-6.3).

Table A-6.4. DAT Data Fields

Description	**Field Name**	**Source**	**Notes**
Property Latitude	N_LAT	DAT*	Geocoded property addresses in Centrus
Property Longitude	N_LON	DAT*	Geocoded property addresses in Centrus
Year property was built	YEARBUILT	DAT	
Rental property estimate	RENTALest	DAT*	Assume rental property if owner's mailing address is different that the property address
* Fields added to data set. These were not included in the original file but were created using fields from the file.			

Figure A-6.2. CLR - DAT Merge Process

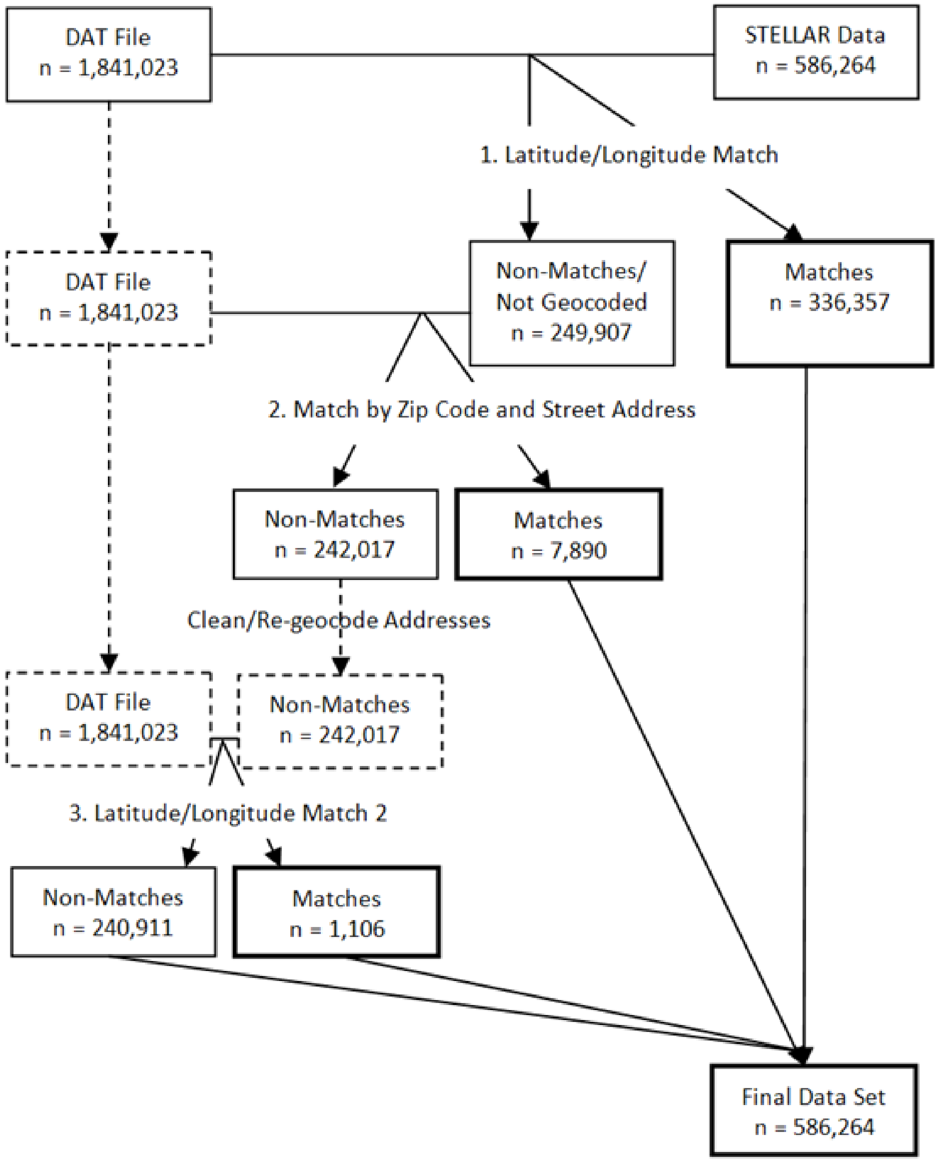
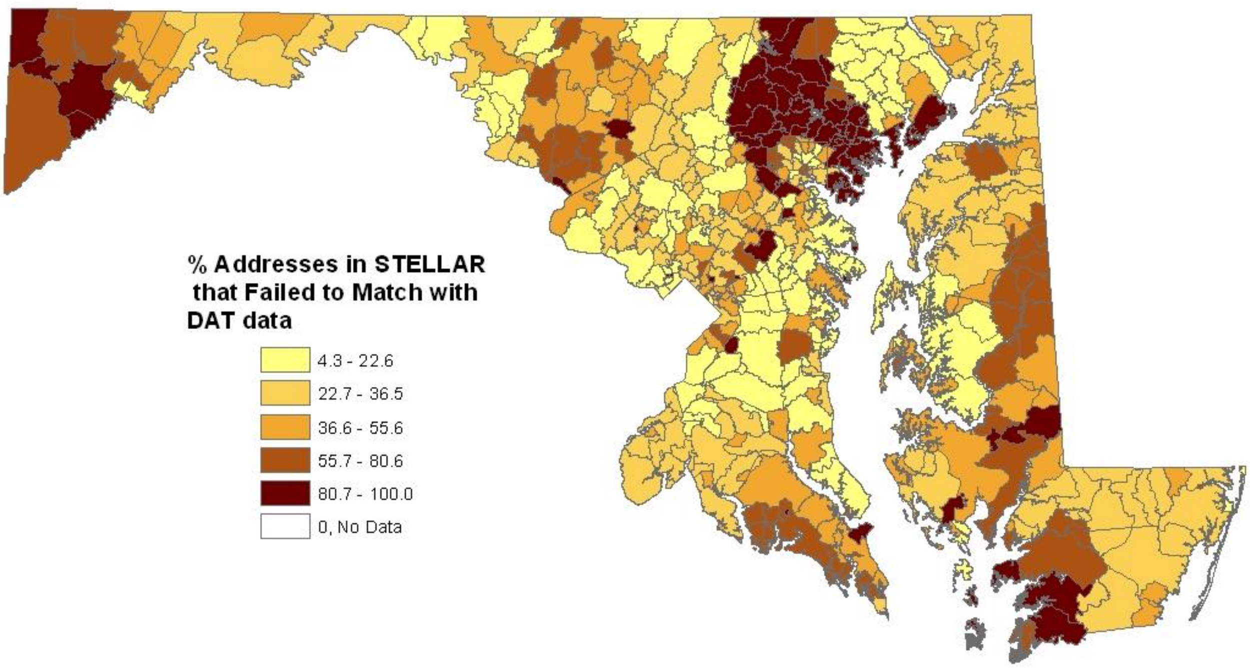


Table A-6.5. CLR - DAT Merge Results

Merge Approach	Matches	
	N	%
Attempt 1: Latitude/Longitude Merge	334,742	57.1
Attempt 2: Address Field Merge	312,721	53.3
Attempt 3: Combination of 1 & 2	345,353	58.9

Figure A-6.3. Percent of Childhood Lead Registry Addresses that Failed to Match to a DAT Address Record, by ZIP Code, Maryland 2005-2009



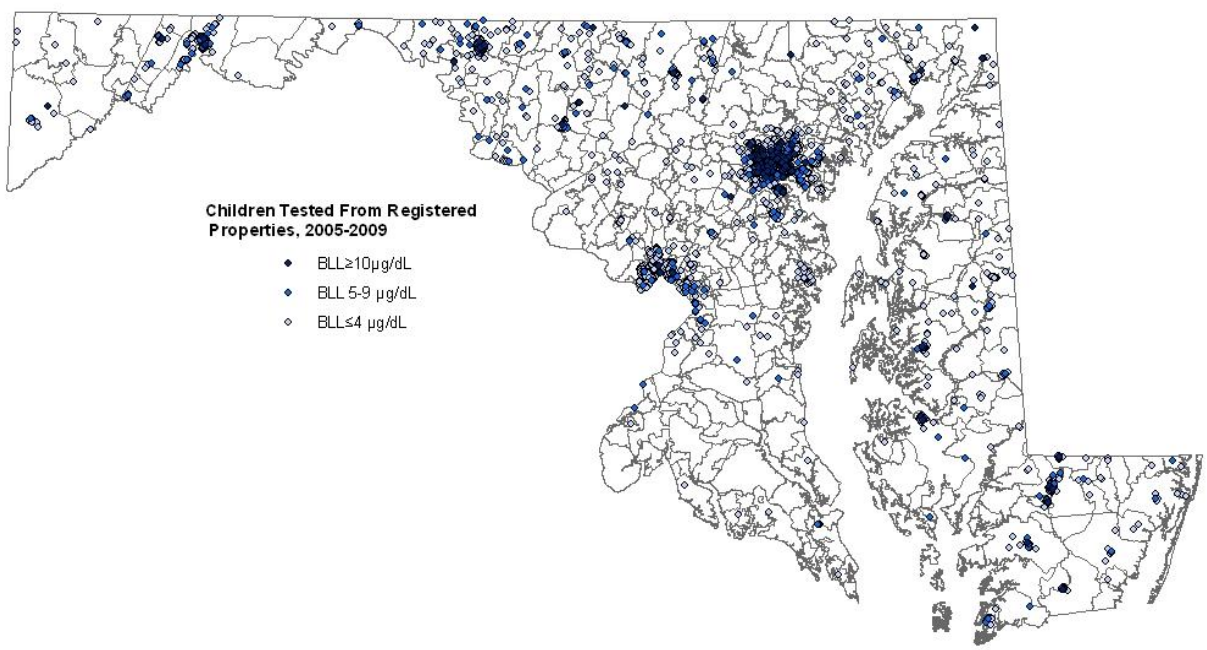
- **Rental Registry, MDE**: Information on registered rental properties in the State was obtained from MDE and used to determine the percentage of children in the CLR residing in registered rental properties and to assess the blood lead levels of these children.

  Excel files of properties annually registered with MDE's Rental Registry from 2005-2009 were obtained. These files included the address, construction year, and identification number for all registered properties. The data sets provided had one noted limitation: only those properties currently registered as of September 2012 were included. If a property had been registered between 2005 and 2009 and later removed in a subsequent year, it was not included in the provided data sets. This limitation could potentially lead to error when retrospectively estimating the number of properties registered annually.

The addresses provided were matched to the addresses of children tested in the CLR by ZIP code, street name, and street number. This match was done separately for each year (i.e. addresses of children tested in 2005 were matched to the addresses of properties registered in 2005, and so on). Therefore, only properties registered in the year a child was tested would have matched. Annually, 2.3-3.3% of individual addresses with children tested matched to a property in the Rental Registry.

This data set was used to identify additional rental properties in the CLR-DAT file. Blood lead levels of individual children from registered rental properties were mapped (Figure A-6.4), but no further uses for this data set were identified.

Figure A-6.4. Children from Registered Rental Properties and Blood Lead Levels, Maryland 2005-2009 *(all children)*



- **Environmental Investigations Enforcement Database, MDE:** This data set was investigated to provide further information on sources of exposure for children with elevated blood lead levels. As efforts have succeeded in reducing exposures to children from pre-1950 rental housing, other sources, including owner-occupied housing, imported potteries, home remedies, or other exposures have become more prevalent. The MDE enforcements data contained information on the source(s) of lead exposure identified for investigated cases (Table A-6.6).

  Data sets containing records of all enforcements investigations from 2005-2009 were obtained from the Lead Poisoning Prevention Program's Lead Enforcement Division at MDE. This data contained records of 702 inspections for different sites/children, representing an estimated 570 unique children (in some cases, there were multiple addresses inspected for a single child). Upon preliminary analysis, several limitations to these data were identified. These data represented only a small subset of the population of the children in the State—from 2005-2009, investigations were performed only for cases with a blood lead level at or above 15 mcg/dL. Since this data set captured exposure information only for those children with the most elevated blood levels, it may not accurately represent lead exposures for all children in the State. Further, this data set provided no information on the source of exposure for children with blood lead levels from 5 to 14 mcg/dL. Due to this limitation, the investigations data set was unable to be utilized in any of the targeting models assessed.

The records in the enforcements data set also did not contain an identifier that allowed them to be directly matched to a record in STELLAR. Therefore, matching the two data sets was based on the open text fields containing the child's name and/or address information. A child with records at different addresses or with different names or name spellings may not be identified as matching. Due to the limitations previously identified, this match was not attempted.

The data in this system may be used as anecdotal information; however, due to the limited subset of children for whom this information in available, the difficulties matching records to individual children in STELLAR, and other characteristics of this system, further attempts to utilize this data source for any quantitative analysis were abandoned.

Table A-6.6. Lead Exposure Sources* Identified by MDE Investigations, 2005-2009

Source Identified	Non-Paint Source	Defective Paint	Blinds	Dust	Ceramics	Hobbies	Industry	Make-up	Occupation	Renovations	Soil	Toys	Other**
Yes	375	81	42	252	15	3	1	19	18	29	40	25	159
No	327	621	660	450	687	699	701	683	684	673	662	667	-

* Multiple sources may have been identified at one address. Also, multiple addresses may have been inspected for a single child.
** "Other" includes Other (155), Bullets (1), Sinkers (3)

- **Baltimore City STELLAR, Baltimore City Health Department, Obtained from MDE:** Baltimore City utilizes their own version of STELLAR and captures additional environmental information on cases for which they perform an investigation. While Baltimore City accounts for the largest number of individuals with elevated blood lead levels, this data set still represents only a subset of children in the state and not the state overall.

- **Medicaid Data:** A list of Medicaid enrolled children would have been used to determine the percentage of children in the project data set who had received a lead test. Unfortunately, we were unable to obtain this information for these analyses.

APPENDIX 7. Supplemental Data Tables

Table A-7.1. Targeted Areas Containing 90% Expected "At-Risk" Children

Zip Codes with 90% of Expected					
Allegany	**Baltimore City**	**Cecil**	**Howard, *Cont.***	**Prince**	**Somerset**
21502 *	21201 *	21901	21043	**Georges, *Cont.***	21817 *
21532 *	21202 *	21911	21044	20708	21853 *
	21205 *	21921	21045	20710 *	
Anne Arundel	21206 *		21046	20712 *	**Talbot**
20724	21209 *	**Charles**	21075	20715	21601
21012	21210 *	20601		20716	
21037	21211 *	20602	**Kent**	20720	**Washington**
21060 *	21212 *	20603	21620 *	20721	21713 *
21061 *	21213 *	20640 *		20722 *	21722 *
21108	21214 *	20646	**Montgomery**	20735	21740 *
21113	21215 *		20814	20737 *	21742 *
21114	21216 *	**Dorchester**	20815 *	20740 *	21783 *
21122	21217 *	21613 *	20817	20743 *	21795 *
21144	21218 *	21643 *	20832	20744	
21226 *	21223 *		20850	20745	**Wicomico**
21401	21224 *	**Frederick**	20852	20746 *	21801 *
21403	21225 *	21701 *	20853	20747	21804 *
	21229 *	21702	20854	20748 *	21826 *
Baltimore Co.	21230 *	21703 *	20866	20770 *	21875 *
21030	21231 *	21771	20871	20772	
21093 *	21239 *	21788	20874	20774	**Worcester**
21117	**Calvert**		20876	20781 *	21811 *
21133 *	20657	**Garrett**	20877	20782 *	21842 *
21136	20678	21550 *	20878	20783 *	21851 *
21204 *			20879	20784 *	21863 *
21207 *	**Caroline**	**Harford**	20886	20785 *	
21208 *	21629 *	21001 *	20901		
21219 *	21632 *	21009	20902	**Queen Annes**	
21220 *		21014	20903	21617 *	
21221 *	**Carroll**	21015	20904		
21222 *	21048	21040 *	20906	**Saint Marys**	
21227 *	21074	21047	20910	20619	
21228 *	21102	21050	20912	20636	
21234 *	21157	21078 *		20650	
21236 *	21158		**Prince Georges**	20653	
21237 *	21784	**Howard**	20705	20659	
21244 *	21787 *	20723	20706		
21286 *	21791 *	21042	20707		

* Zip Code Considered "At Risk" in the 2004 Targeting Plan

Table A-7.2. Targeted Areas Containing 75% Expected "At-Risk" Children

Zip Codes with 75% of Expected					
Allegany	**Baltimore, *Cont.***	**Calvert**	**Harford**	**Prince George's**	**Saint Marys**
21502 *	21236 *	20657	21009	20706	20653
21532 *	21237 *		21040 *	20707	20659
	21244 *	**Caroline**		20708	
		21632 *	**Howard**	20716	
Anne Arundel	**Baltimore City**		20723	20737 *	**Somerset**
21061 *	21201 *	**Carroll**	21043	20743 *	21853 *
21113	21202 *	21157	21044	20744	
21122	21205 *	21158	21045	20745	
21144	21206 *			20746 *	**Talbot**
21226 *	21209 *	**Cecil**	**Kent**	20747	21601
21401	21211 *	21921	-	20748 *	
	21212 *			20770 *	
	21213 *	**Charles**	**Montgomery**	20772	**Washington**
Baltimore	21214 *	-	20850	20774	21740 *
21117	21215 *		20874	20782 *	21742 *
21133 *	21216 *	**Dorchester**	20877	20783 *	
21136	21217 *	21613 *	20878	20784 *	**Wicomico**
21207 *	21218 *		20901	20785 *	21801 *
21208 *	21223 *	**Frederick**	20902		21804 *
21220 *	21224 *	21702	20903	**Queen Annes**	
21221 *	21225 *	21703 *	20904	-	
21222 *	21229 *		20906		**Worcester**
21227 *	21230 *	**Garrett**	20910		21811 *
21228 *	21231 *	-	20912		21851 *
21234 *	21239 *				

* Zip Code Considered "At Risk" in the 2004 Targeting Plan

Table A-7.3. Targeted Areas Containing 50% Expected “At-Risk” Children

Zip Codes with 50% of Expected					
Allegany	**Baltimore City**	**Baltimore City,**	**Cecil**	**Howard**	**Somerset**
21502 *	21202 *	***Cont.***	21921	-	-
	21205 *	21225 *		**Kent**	**Talbot**
Anne Arundel	21206 *	21229 *	**Charles**	-	-
-	21212 *	21230 *	-	**Montgomery**	**Washington**
Baltimore	21213 *	21231 *	**Dorchester**	-	21740 *
21207 *	21214 *	21239 *	21613 *	**Prince Georges**	21742 *
21221 *	21215 *			-	
21222 *	21216 *	**Calvert**	**Frederick**	**Queen Annes**	**Wicomico**
21227 *	21217 *	-	-	-	21801 *
21228 *	21218 *	**Caroline**	**Garrett**	**Saint Marys**	21804 *
21234 *	21223 *	-	-	20653	
21244 *	21224 *	**Carroll**	**Harford**		**Worcester**

* Zip Code Considered "At Risk" in the 2004 Targeting Plan

Table A-7.4. Comparison of ZIP Codes containing 90% of Expected Children with Blood Lead Levels ≥5 mcg/dL to other ZIP Codes

Characteristics	90% Expected Cases Area		Outside Area	
	n	**%**	**n**	**%**
Total Zip Codes	173	38.4	277	61.6
Total Children In ≤5 Zip Codes*	374,621	86.0	61,018	14.0
Zip Code Characteristics				
Sex, Total Children*				
Female	183,725	49.0	29,882	49.0
Male	190,896	51.0	31,136	51.0
Age (years), Total Children*				
<1	62,224	16.6	9,062	14.9
1	62,271	16.6	9,546	15.6
2	63,745	17.0	9,978	16.4
3	63,355	16.9	10,437	17.1
4	61,860	16.5	10,740	17.6
5	61,166	16.3	11,255	18.4
Race, by Median Percent**				
White	-	63.3	-	88.5
Black	-	22.0	-	6.1
Other	-	8.4	-	4.0
Median Percent Occupied**				
Occupied	-	93.3	-	90.8
Vacant	-	6.7	-	9.2
Median Percent Rentals***				
Owner Occupied	-	67.3	-	83.2
Renter Occupied	-	66.2	-	16.8

* 2010 Population of children ≤5 years old
** 2010 Census, Summary File 1
*** 2010 Census, Demographic Profile

Table A-7.5. Comparison of ZIP Codes containing 75% of Expected Children with Blood Lead Levels ≥5 mcg/dL to other ZIP Codes

Characteristics	75% Expected Cases Area n	%	Outside Area n	%
Total Zip Codes	95	21.1	355	78.9
Total Children In ≤5 Zip Codes*	267,247	61.3	168,392	38.7
Zip Code Characteristics				
Sex, Total Children*				
Female	135,988	50.9	82,348	48.9
Male	131,259	49.1	86,044	51.1
Age (years), Total Children*				
<1	45,481	17.0	25,805	15.3
1	45,301	17.0	26,516	15.7
2	45,900	17.2	27,823	16.5
3	44,912	16.8	28,880	17.2
4	43,288	16.2	29,312	17.4
5	42,365	15.9	30,056	17.8
Race, by Median Percent**				
White	-	51.6	-	87.0
Black	-	28.9	-	6.5
Other	-	9.1	-	4.4
Median Percent Occupied**				
Occupied	-	93.1	-	92.4
Vacant	-	6.9	-	7.6
Median Percent Rentals***				
Owner Occupied	-	61.2	-	81.9
Renter Occupied	-	38.8	-	18.1

* 2010 Population of children ≤5 years old
** 2010 Census, Summary File 1
*** 2010 Census, Demographic Profile

Table A-7.6. Comparison of ZIP Codes containing 50% of Expected Children with Blood Lead Levels ≥5 mcg/dL to other ZIP Codes

Characteristics	50% Expected Cases Area n	%	Outside Area n	%
Total Zip Codes	32	7.1	418	92.9
Total Children In ≤5 Zip Codes*	95,116	21.8	340,523	78.2
Zip Code Characteristics				
Sex, Total Children*				
Female	46,904	49.3	166,703	49.0
Male	48,212	50.7	173,820	51.0
Age (years), Total Children*				
<1	16,308	17.1	54,978	16.1
1	16,207	17.0	55,610	16.3
2	16,373	17.2	57,350	16.8
3	16,042	16.9	57,750	17.0
4	15,250	16.0	57,350	16.8
5	14,936	15.7	57,485	16.9
Race, by Median Percent**				
White	-	54.4	-	84.9
Black	-	37.6	-	8.2
Other	-	6.8	-	4.9
Median Percent Occupied**				
Occupied	-	90.1	-	92.8
Vacant	-	9.9	-	7.2
Median Percent Rentals***				
Owner Occupied	-	57.2	-	80.7
Renter Occupied	-	42.8	-	19.3

* 2010 Population of children ≤5 years old
** 2010 Census, Summary File 1
*** 2010 Census, Demographic Profile

APPENDIX 8. Acronyms and Abbreviations

mcg/dL – micrograms/deciliter

ACS – American Community Survey

CDC – U. S. Centers for Disease Control and Prevention

CLR – Childhood Lead Registry

DAT – Maryland State Department of Assessment and Taxation

DHMH – Maryland Department of Health and Mental Hygiene

MDE – Maryland Department of the Environment

STELLAR – Systematic Tracking of Elevated Lead Levels and Remediation

APPENDIX 9. Cost-Benefit Analysis of Lead Testing Strategy

This section estimates the lifetime cost-benefits of reducing blood lead levels in 100% of Maryland children, ages 1 and 2, who have a blood lead level ≥5 mcg/dL, in a three-year period. Many studies have detailed the economic expenses associated with lead exposures. This analysis estimates the cost-benefits associated with a decrease in lead exposure in the following areas: lifetime earnings, tax revenue, special education, and criminal justice. A recent nationwide study found a return of $17-$221 for every dollar spent on lead hazard controls (Gould, 2009).

Lifetime Earnings

Lead poisoning is linked to cognitive and behavioral impairment, even at levels below 10 mcg/dL (Canfield, 2003). The loss of IQ points is considered irreversible and is calculated once rather than yearly. Lost IQ points are associated with both fewer years of schooling and a lower probability of participation in the workforce (Salkever, 1995). The lifetime earnings saved are the total savings if 100% of Maryland children are tested, and children with a EBL ≥5 mcg/dL have their blood lead levels reduced to the 'background' level of 1.36 mcg/dL (2012 geometric mean blood lead level in Maryland children ages 1-2).

Lanphear et al. estimate that children with a blood lead level between 2-10 mcg/dL, 10-20 mcg/dL, and 20-30 mcg/dL lose 0.513, 0.19, and 1.1 IQ points per 1 mcg/dL blood lead level respectively (Lanphear, 2005). In Table A-9.1 Lanphear's IQ estimate is used with Gould's IQ value estimate of $21,014 per one IQ point (adjusted for inflation to 2015 USD) to find total savings of $183,505,165. All inflation adjustments in this analysis have been done using the Bureau of Labor Statistics (BLS) Consumer Price Index inflation calculator.

Table A-9.2 shows a second method for calculating lost future income. Landrigan et al. calculated the economic consequences of lead exposure at the national geometric mean blood level using an analysis by Salkever (Landrigan, 2002; Salkever, 1995). In Maryland the geometric mean blood lead level is 1.37 mcg/dL for boys and 1.35 mcg/dL for girls ages 1-2. Table A-9.2 uses the calculation from Schwartz et al. of 0.245 IQ points lost per 1 mcg/dL; and 2.1% and 3.6% lifetime earnings lost for boys and girls respectively (Schwartz, 1994; Salkever, 1995). Grosse et al. calculated the expected lifetime earnings by sex and age in the United States in 2007 (Grosse, 2009). The expected lifetime earnings for children 0-4 years old by sex was adjusted to 2015 U.S. dollars. The estimate of total lifetime earnings saved using the Landrigan method is $130,595,692. Using an IQ loss estimate from a newer study by Canfield et al. instead of the Schwartz estimate the total lifetime earnings estimate increases to $512,077,044 (Canfield, 2003). Canfield estimates, the IQ loss per 1 mcg/dL to be 1.22 points for children with an EBL <10 mcg/dL and 0.35 for all children.

The estimates for the lifetime earnings saved in Maryland children range from $130-$512 million. Assuming an average income tax rate of 5%, eliminating high lead exposure (blood lead level ≥5 mcg/dL) in Maryland would save the state $7-$26 million per cohort in tax revenue.

Table A-9.1. Lifetime Earnings Saved, in Maryland Children 1-2 years of age

EBL	MD Children per EBL Group	Geometric Mean EBL*	Average Reduction in blood lead level	Average IQ Point Loss Avoided per 1 mcg/dL	Total Avoided IQ Loss	Total lifetime earnings
5-9	3,327	6.0	4.7	0.513	7,966	$167,396,367
10-20	359	12.6	11.2	0.19	767	$16,108,798
≥20	108	27.2	25.8	0.11	307	$6,449,481
Total	3,794				8,732	**$183,505,165**

* Maryland 2012 lead data, Children 1-2 years of age

Table A-9.2. Lifetime Earnings Saved, in Maryland Children 1-2 years of age, Landrigan Method

	MD Children with EBL ≥5	Geometric Mean EBL*	Average Reduction in Blood Lead Level	Average IQ Point Loss Avoided per Person	Average Gain in Lifetime Earnings	Average Lifetime Earnings per Person	Total Lifetime Earnings
Boys	1,897	6.84	5.48	1.34	2.8%	$1,213,225	$64,672,653
Girls	1,897	6.81	5.46	1.34	4.9%	$715,669	$65,923,040
Total	3,794						**$130,595,692**

* Maryland 2012 lead data, Children 1-2 years of age

Special Education

The cognitive impairment associated with lead is also linked to the need for special education. It is estimated that 20% of children with a blood lead level ≥25 mcg/dL and 10% of children with a blood lead level ≥10 mcg/dL require special education (Schwartz, 1994; Pichery, 2011). The annual cost of additional special education used in Table A-9.3 is from the Maryland Special Education Expenditure project, which calculated the total education spending in Maryland in the 2001-2002 school year to be $1.8 billion (Parrish, 2003). Table A-9.3 shows the cost of three years of special education discounted by 3% for five years. The total education savings of $1,934,767 are discounted for five years to match the age that children start school (Stefanak, 2005).

Table A-9.3. Special Education Savings

Maryland children with EBL ≥ 25	51
Estimated percent of children with EBL ≥ 25 mcg/dL who require special education	20%
Maryland children with EBL 10-25	416
Estimated percent of children with EBL ≥ 10 mcg/dL who require special education	10%
Estimated number of children needing special education	52
Cost of special education per school-aged student in the 2001-2002 school year in Maryland	$14,440
Discounted cost per year	$12,456
Total discounted savings for three years of special education for one cohort of children	**$1,934,767**

Criminal Justice

Levin's Population Attributable Risk (Equation A-9.1) was used to estimate juvenile justice expenditures (Gordis, 2009). In a study of adolescents arrested as delinquents, the adjusted odds ratio for having bone lead levels ≥25 ppm was: OR=4.0 (95% CI, 1.4-11.1) (Needleman, 2002). It is assumed that children with a blood lead level ≥10 mcg/dL have neurological damage comparable to the adolescents in Needleman's study (Stefanak, 2005). The expected number of children with a blood lead level ≥10 mcg/dL in Maryland is used along with Needleman's odds ratio to calculate Levin's Population Attributable Risk (Equation A-9.1). The estimated cost of juvenile services used here may be an underestimation; the calculated attributable risk (1.0%) is much lower than risks cited in other studies (10% in Korfmacher, 2003; 11% in Stefanak, 2005). Table A-9.4 shows the cost of state operated juvenile facilities due to lead exposure using the calculated attributable risk (Maryland Department of Juvenile Services, 2014). The final estimate of $2,080,395 is discounted by 3% for 15 years. The 15 year discounting period and the three years of facility costs are a reflection of the majority of juvenile justice costs incurring between the ages of 15-18 (Stefanak, 2005).

Equation A-9.1. Levin's Population Attributable Risk

a) Risk in total population= $(Risk\ in\ exposed \times Prevalence\ in\ target\ population) + [Risk\ in\ unexposed \times (1 - Prevalence\ in\ target\ population)]$

$$=(4 \times 0.003) + [1 \times (1 - 0.003)] = 1.01$$

b) Percent population attributable risk= $\left(\frac{Risk\ in\ total\ population - Risk\ in\ unexposed}{Risk\ in\ total\ populaation}\right) \times 100$

$$= \left(\frac{1.01-1}{1.01}\right) \times 100 = 1.0\%$$

Studies have also estimated the cost of violent crimes due to lead exposure. Gould et al. calculates the lead linked crimes per 100,000 residents that could be prevented with a 1 mcg/dL reduction in average preschool blood lead level (Gould, 2009). The number of lead linked crimes shown in Table A-9.5 are adjusted from Gould using the rate of each type of crime in Maryland (Governor's Office of Crime Control & prevention, 2013). Instead of calculating the savings of a 1 mcg/dL reduction, the savings were calculated as if all Maryland children ages 1-2 with a blood lead level ≥5 mcg/dL were reduced to the geometric mean blood lead level of 1.36 mcg/dL. This reduction changes the geometric mean blood lead level from 1.36 mcg/dL to 1.30 mcg/dL (ΔBlood lead level=0.06). McCollister et al. calculates tangible costs from victim costs, criminal justice costs, and crime career costs (McCollister, 2010). Crime career costs were removed from this analysis since they are calculated from lost future earnings and that calculation is done separately in this analysis (Table A-9.1 and Table A-9.2). McCollister also does a calculation for intangible costs that include indirect losses suffered by crime victims, including pain and suffering, decreased quality of life, and psychological distress. In Maryland the tangible costs are estimated to be $2.2 million, and the total tangible and intangible costs are estimated to be over $14 million (Table A-9.5).

Table A-9.4. Savings from Reductions in Juvenile Delinquency

2014 Costs of MD Department of Juvenile Services State Operated Facilities	$111,659,988
Fraction of juvenile delinquents attributable to lead poisoning	1.0%
Lead poisoning attributable cost per year adjusted to 2015 USD	$1,080,396
Total discounted savings for three years (3% for 15 years)	**$2,080,395**

Table A-9.5. Savings from Reductions in Violent Crime

Crime	Crimes per 100,000 MD Residents in 2013	Lead-linked Crimes per 100,000 MD Residents	Total Avoided Lead Linked Crimes	Tangible Costs per Crime in 2015 USD	Total Tangible Costs Avoided Annually
Burglaries	537.9	0.94	55	$5,489	$336,114
Robberies	170.1	0.04	2	$17,126	$44,455
Aggravated assaults	271.3	0.83	49	$17,341	$937,595
Rape	19.7	0.04	3	$32,035	$91,666
Murder	6.5	0.01	1	$1,129,869	$827,428
Totals			110	$1,201,860	**$2,237,258**

Cost-Benefit Analysis Summary

The total savings of reducing blood lead levels in 100% of one cohort of Maryland children, ages 1 and 2, that have a blood lead level ≥5 mcg/dL is in the range of $143-$556 million (Table A-9.6). The long term health effects and behavioral problems resulting from lead are an additional cost to society not included in this estimate. These include attention deficit-hyperactivity disorder (ADHD), adult hypertension, stroke, and osteoporosis. Quantifying the cost of these diseases due to lead has not been done for this analysis due to a lack of research and data, but is assumed to be high. Using the estimated cost of universal testing and the range of savings in the cost-benefit analysis (Table A-9.6) the return for each dollar invested ranges from $24-$142 (low range of this estimate excludes intangible crime savings).

Table A-9.6. Summary of Cost-Benefits

Benefit	Estimated Savings for One Cohort of Children
Lifetime Earnings	$131-$512 million
Tax Revenue	$7-$26 million
Special Education	$1.9 million
Juvenile Delinquency	$2 million
Violent Crime Tangible Costs	$2.2 million
Violent Crime Intangible Costs	$12 million
Total savings	**$143-$556 million**