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# How Does the 2017 Lead Grant Program Change Lead Poisoning in Lewiston, Maine?

## Abstract

Using lead testing, screening, and housing data in Maine, this paper explores changes in lead contamination following the Lead Grant program implemented in Lewiston and Auburn in 2017. With a focus on the program's effects on Lewiston, we hypothesize that there will be a more significant drop in the lead contamination rate in Lewiston compared to other high-risk areas in Maine as a result of the Lead Grant program. We expect that there has been no baseline difference between the rate of change in lead contamination rate between Lewiston and other high-risk areas in Maine over time, as towns are all subject to the same statewide and federal policies. Using a difference-in-difference model, we found that the program has a statistically significant impact on the lead contamination rate in Lewiston. In other words, the program effectively reduced the lead contamination rate in Lewiston over time.

## Introduction

In this paper, we're exploring the change in lead contamination in Lewiston from 2004 to 2021. This paper aims to inform the City of Lewiston on how effective their 2017 Lead Grant program has been effective in decreasing the lead contamination rate.

For years, Lewiston has been trying to address the issue of lead contamination with several lead abatement programs and encourage their population to get tested. The city is identified as one of the high-risk areas in Maine in terms of lead poisoning.

As the City Council has just received a grant for the Healthy Neighborhood Program in 2023, they want to see how they should spend this amount of money in the most cost-effective way possible. This paper serves as a policy recommendation for the City of Lewiston, focusing on the outcome of the 2017 Lead Grant Program.

The 2017 Lewiston-Auburn Lead Grant Program outlines the comprehensive lead hazard reduction process in investment and owner-occupied properties. The program, managed by Travis Mills, involves a detailed application through an intake provider, Community Concepts Inc., and subsequent health and safety inspections. If issues are identified, the owner is advised on corrections before proceeding. Lead inspections and risk assessments are conducted, creating lead control work designs. Contractors bid on projects, with the lowest qualified bidder awarded the project. Funding breakdowns are presented, and for investment owners, a $10,000 lead grant with a 10% minimum match is allowed, while owner-occupied housing can receive up to $20,000 without a match requirement. The grant process includes closing agreements, mortgage requirements, and ongoing inspections, emphasizing maintaining safe housing conditions. The program also offers training, resident education, and community outreach to address lead hazards comprehensively. We want to determine if this Lead Grant Program is worth being re-introduced to the Lewiston community to address the lead poisoning issue further.

**Data**

The data used in this paper comes from two sources. The primary data source is lead poison testing and screening data from Maine Tracking Network, a non-profit funded by the Maine CDC. The supplementary source is Maine Housing, also known as Maine State Housing Authority. This is an independent authority created by the Maine State Legislature in 1969 to address problems of unsafe, unsuitable, overcrowded, and unaffordable housing. Since the Maine Tracking Network links poverty and housing (specifically pre-1950s) with lead contamination, omitting information on median income and the housing market of each town is likely to cause bias to our estimates.

The combined dataset covers six high-risk towns in Maine, which includes Bangor, Biddeford, Lewiston, Portland, Saco, and Westbrook from 2004 to 2021. There are 108 observations in the sample, with 18 observations for each town. The individuals in this dataset are 0-3 year-olds, who are most vulnerable to lead contamination and, therefore, are subject to lead testing mandates. We excluded Auburn from the dataset even though it is also a high-risk area to better look at the program's effect on Lewiston as the program was implemented in both Lewiston and Auburn. Having Auburn in the dataset is likely to bias our estimate as Auburn is also in the treated group, so to isolate the effect of the program in Lewiston, we needed to remove Auburn from the dataset.

Table 1 shows that 16.7% of our observations were in Lewiston, and the average lead contamination rate from 2004 to 2021 in 6 high-risk areas in Maine, excluding Auburn, is 6.245 percent.

The key independent variable is "*Lewiston*," a dummy variable used to identify observations in Lewiston. The use of this variable allows us to both examine the difference between Lewiston and the average of other high-risk towns as well as other towns individually. This variable was coded based on the "*Location*" variable, which consists of the town's name for each observation in the string format. This variable is recoded in integer form as "*town_numeric*," with 1 representing Lewiston and the rest in Alphabetical order.

The primary dependent variable is the lead contamination rate, coded as "*percent_poisoned*," determined by the ratio of lead poisoning cases and the number of people tested. Under Maine law, lead poisoning is defined as having a confirmatory blood lead level at or above five micrograms per deciliter (µg/dL).

We also used five control variables to prevent endogeneity, including the number of people tested and screened, births, population, and median income. The number of people tested, coded as "*Num_tested*," measures the town-level total number of children born in a specific year and tested by a particular age (e.g., 36 months or three years old) in a given town in a given year. This can also represent having multiple tests at specific ages (e.g., testing at 1 and 2 years before turning three). The number of people tested or the "*Num_screened*" variable represents the total number of children tested for blood lead with no prior history of a confirmed blood lead test ≥5 µg/dL in a given town in a given year. "*Births*" and "*Population*" indicate the size of the birth cohort and total number of residents in an area in a given year. "*Median_income*" is measured in USD of a town in a year recorded.

**Empirical Results of Lead Contamination Rate in Lewiston**

To estimate the difference between lead contamination rate in Lewiston compared to other high-risk areas, we use the following basic econometric model:

$$percent\_poisoined_{it} = \alpha + \beta Lewiston_{it} + \varepsilon_{it}$$

where $percent\_poisoined_{it}$ is the percent of 0-3 year-olds that are lead poisoned per town in a given year $t$. The dummy variable indicates if the observation is in Lewiston (=1) or other high-risk towns (=0).

The regression results in Table 2 show that, on average, Lewiston showed a 2.507 percentage point higher lead contamination rate than the average of other high-risk towns in

Maine from 2004 to 2021. The p-value is less than 0.05, indicating the coefficient is statistically significant.

Since the percent of lead poisoning is calculated based on the number of people tested, omitting median income (which affects the number of people exposed to lead as we asusme poverty is closely linked with lead contamination) and variables such as the number of children tested (which bias the denominator) and number of births can cause omitted variable bias. After controlling for median income, number of births, and number of people tested, Lewiston has a statistically significant 4.655 percentage point higher rate of lead poisoning with a p-value of less than 0.05 than other high-risk towns in Maine, excluding Auburn, from 2004 to 2021. After adding median income, number of births, and number of people tested to our model, our regression model is as follows:

$$percentpoisoned_{it} = \alpha + \beta_1 Lewiston_{it} + \beta_2 Medianincome_{it} + \beta_3 Births_{it} + \beta_6 Numbertested_{it} + \varepsilon_{it}$$

Since the coefficient became more negative as we added controlled variables, the 2.148 decrease in our correlation coefficients on the Lewiston variable after adding median income, births, population, number of people screened, and number of people tested as control variables show that omitting these variables created a positive omitted variable bias.

The previous estimation, however, only compared Lewiston to the average of the other towns during the 2004-2021 period. To compare each town individually, we created a dummy variable for each area and ran a new regression model with the baseline group of Lewiston. This will also give us a sense of where Lewiston rank in terms of lead poisoning rate. Our multivariate regression model is:

$$percent\_poisoned_{it} = \alpha + \beta_1 Bangor_{it} + \beta_2 Biddeford_{it} + \beta_3 Portland_{it} + \beta_4 Saco_{it} + \beta_5 Westbrook_{it} + \varepsilon_{it}$$

Our specific bivariate regression model indicated in Table 3 shows a lower average contamination rate in Bangor, Biddeford, Portland, Saco, and Westbrook than in Lewiston over the 13 years, making Lewiston the highest in the state of Maine as Auburn has lower rates among the high-risk group. Further hypothesis testing shows a statistically significant difference among high-risk towns in Maine over 13 years, with a p-value of 0.0186.

These findings are consistent with Janet Mill's statement reported by Flaherty (2018) that Lewiston recorded the highest contamination rate in Maine, making lead a top priority concern to be addressed by the City Council. Comparison to other non-high-risk areas in Maine wouldn't be necessary to draw this conclusion, as the comparison groups consist of areas with the highest average contamination rates in Maine over 13 years.

**Efficiency of the 2017 Lead Grant Program**

Using a difference-in-difference model, we hope to compare the contamination rates before and after 2017 to evaluate the program's impact on lead poisoning. Since the program is implemented explicitly in Lewiston-Auburn and no known similar program exists in other towns in Maine, we use Lewiston as the treated group and other high-risk areas in Maine without Auburn as the comparison group. We can reasonably assume that the lead contamination rate in Lewiston and other high-risk towns in Maine develop at a relatively similar rate, and the only difference is the citywide implementation of the Lead Grant Program in Lewiston in 2017. We implemented a difference-in-difference model to examine the efficiency of the program in reducing lead contamination rate change:

$$percent\_poisoned_{it} = \alpha + \beta_1 Lewiston_{it} + \beta_2 after_{it} + \beta_3 Lewiston\_after_{it} + \varepsilon_{it}$$

with $Lewiston\_after_{it}$ as an indicator of Lewiston in the post-2017 period after implementing the Lead Grant program. Table 4 shows that there is a 3.440 percentage-point higher lead poisoning rate in Lewiston on average compared to other high-risk towns in Maine over the given time period. After 2017, changes in lead contamination rates even further dropped 2.710 percentage points, which is consistent with the statewide policies implemented to eradicate the issue. Following the implementation of the Lead Grant Program in 2017, the lead poisoning rate showed a statistically significant decrease of 3.089 percentage points relative to the change in lead poisoning rate for other high-risk towns in Maine across time. This result is statistically significant with a p-value of less than 0.01.

After accounting for changes in median income, number of births, and testing numbers over time, we can adjust our model to:

$$percent\_poisoned_{it} = \alpha + \beta_1 Lewiston_{it} + \beta_2 after_{it} + \beta_3 Lewiston\_after_{it}$$

$$+ \beta_2 Medianincome_{it} + \beta_3 Births_{it} + \beta_6 Numbertested_{it} + \varepsilon_{it}$$

Our results showed that controlling for median income, births, and number of people tested, the coefficient on the "*Lewiston_after*" variable became -2.164. Omitting these variables actually showed a negative omitted variable bias to our estimate. The addition of these variables in fact also made the correlation between the program and decrease in lead contamination no longer statistically significant.

These results show that generally, contamination rate generally decreased across the board, Lewiston showed a much sharper decline following the program, illustrating the program's efficiency in bringing down the lead contamination rate. However, the difference is less significant as we control for median income, births, and number tested.

Since we suspect that there are other differences that can bias our estimates outside of these control variables, we want to account for year and location fixed effects which include characteristics that are static over time at each location. Therefore, we adjust our model to:

$$percent\_poisoned_{it} = \alpha + \beta_1 Lewiston_{it} + \beta_2 after_{it} + \beta_3 Lewiston\_after_{it} + \delta_i + \delta_t + \varepsilon_{it}$$

Table 5 illustrates that accounting for both location and year fixed effects decreased the coefficients on our interaction term "*Lewiston_after*" by 1.491 percentage points. This means that, even after controlling for differences in contamination in each town over time and differences in towns, on average, the program contributed to a statistically significant decline of 3.394 percentage points in Lewiston contamination rate changes relative to the general trend in the other high-risk communities. Not accounting for location and year fixed effects would have caused a positive omitted variable bias.

The validity of this model lies in the assumption that there is no difference between the towns in question that might result in different trends in contamination rates over time. Since all of these towns are subject to the same statewide testing mandates and we can reasonably assume that new testing technology was being implemented at relatively the same rate, we can reasonably assume that the only difference between Lewiston and other towns in the comparison group is the implementation of the Lead Grant program.

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**Omitted Variable Bias**

According to Russo (2019), refugees from African nations are more vulnerable communities to lead hazards. The lead prevention program in Maine does not adequately protect this population from the threat of lead. Lewiston has disproportionately accepted more Somali immigrants as residents over the years, as illustrated by the establishment of the fast-growing Somali Bantu refugee population in the community. With this information, we expect the number of Somali refugees to correlate positively with the Lewiston variable.

Since these communities are more vulnerable to lead contamination, as they have been subjected to lower-quality housing that might increase exposure to lead paint, we also expect a positive correlation between the number of Somali refugees and the lead contamination rate.

Therefore, we expect the omission of the Somali refugees' number to result in a positive omitted variable bias to our estimate.

**An Overview of Lead Testing and Screening**

Graph 1 illustrates that overall, the lead contamination rate decreased in aggregate over time in all high-risk areas in Maine. This trend aligns with the results of our difference-in-difference model (the coefficient on the "*after*" variable was negative) and our expectations as the lead contamination rate is expected to fall in response to statewide programs to eradicate lead contamination, such as lead abatement programs. Furthermore, new housing and the demolition of pre-1950s houses are also expected to contribute to the declining rate of lead contamination. These programs to limit exposure to lead, combined with a higher amount of testing, with efforts such as statewide mandate testing in 2019, would bring down the lead contamination rate over time.

Graph 2 shows that while the number of children tested for lead generally increased, there were a lot of fluctuations. A relevant concern is that the data on the number of children tested for lead were unavailable post-2018, which might indicate a potential source of bias in our estimate. The dataset could be of better quality as there are a lot of missing data points, and no testing numbers were recorded beyond 2017. This raises concerns over our regression results as the number of people tested can heavily bias the contamination rate.

However, this concern is generally addressed after we examine the average number of children screened for lead in the population. Graph 3 shows a positive trend in the number of children screened. Since this variable is expected to positively correlate with the number of children tested for lead, this consistent increase in the number of children screened provides some confidence that the number of children tested also increased in the same period, even with missing data from the last three years.

**Conclusions and Limitations**

We found statistically significant evidence that Lewiston's 2017 Lead Grant program effectively reduced the lead poisoning rate. Therefore, we are happy to recommend the City Council re-introduce this program as part of their upcoming effort to address lead poisoning issues in our community.

However, we also recognize that these analyses have certain drawbacks. Since the lead poisoning rate is calculated by dividing the number of people with lead poisoning over the total number tested, the declining contamination rate could also indicate that the number of people that efforts to eliminate lead exposure has seen some progress along with a higher number of people tested. However, the City should also focus its plans on increasing testing numbers in the population so that we can ensure a more consistent increase in testing over time.

Maine implemented universal testing in 2019, mandating lead testing for all children ages 1 and 2. Due to the altered testing regulations and technology, lead testing conducted before 2019 might differ. This indicates the contamination rate might be erroneous as inaccurate test results might be present utilizing antiquated technologies. Moreover, unless their healthcare physician determines they are not at risk, Maine law mandates that all children between the ages of one and two be tested for blood lead. We are unsure if the data accurately depicts the complete picture of lead exposure since we do not know how many children are actually at risk in the population. Additionally, the child's home at the time of the test is the basis for contamination records, even if this may not match the location of the child's lead exposure. For instance, the results will not accurately reflect the rate for all Maine residents as some living near the border may have chosen to get tested out-of-state.

**Tables and graphs**

**Table 1. Summary Statistics of Key Variables**

| | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Lead contamination (percent) | 86 | 6.245 | 3.089 | 1.7 | 16.6 |
| Lewiston | 108 | .167 | 0.374 | 0 | 1 |
| Median income | 108 | 203699.33 | 65749.003 | 115000 | 454900 |
| Births | 90 | 381.733 | 207.505 | 155 | 821 |
| Population | 108 | 1129.667 | 613.668 | 498 | 2439 |
| Number screened | 108 | 358.667 | 188.583 | 110 | 808 |

| | | | | | |
|---|---|---|---|---|---|
| Number tested | 90 | 264.389 | 147.373 | 89 | 554 |

**Table 2. Bivariate Regression Results**

| VARIABLES | Lead poisoning (Percent) | Lead poisoning (Percent) |
|---|---|---|
| Lewiston | 2.507*** | 4.655*** |
| | (0.895) | (0.887) |
| Median Income | | 9.45e-08 |
| | | (6.74e-06) |
| Births | | 0.0168*** |
| | | (0.00488) |
| Number Tested | | -0.0259*** |
| | | (0.00736) |
| Constant | 5.721*** | 6.360*** |
| | (0.334) | (1.257) |
| Observations | 86 | 74 |
| R-squared | 0.110 | 0.283 |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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**Table 3. Multivariate Regression Results**

| Lead contamination (percent) | **Coef.** | **St.Err.** | **t-value** | **p-value** | **[95% Conf** | **Interval]** | **Sig** |
|---|---|---|---|---|---|---|---|
| Bangor | -3.697 | 1.046 | -3.53 | .001 | -5.778 | -1.615 | *** |
| Biddeford | -2.306 | 1.16 | -1.99 | .05 | -4.614 | .003 | * |
| Portland | -2.4 | 1.019 | -2.36 | .021 | -4.428 | -.372 | ** |
| Saco | -.728 | 1.433 | -0.51 | .613 | -3.579 | 2.123 | |
| Westbrook | -2.394 | 1.035 | -2.31 | .023 | -4.454 | -.335 | ** |
| Constant | 8.228 | .85 | 9.67 | 0 | 6.535 | 9.92 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 6.245 | SD dependent var | 3.089 |
| R-squared | 0.167 | Number of obs | 86 |
| F-test | 2.899 | Prob > F | 0.019 |
| Akaike crit. (AIC) | 433.322 | Bayesian crit. (BIC) | 448.049 |

**** p<.01, ** p<.05, * p<.1*

**Table 4. Basic Difference-in-difference Regression Results**

| VARIABLES | Lead poisoning (Percent) | Lead poisoning (Percent) |
|---|---|---|
| Lewiston | 3.440*** | 4.351*** |
| | (0.825) | (0.954) |
| After | -2.710*** | -2.152*** |
| | (0.492) | (0.661) |
| Lewiston After | -3.089*** | -2.164* |
| | (1.128) | (1.097) |
| Median Income | | 1.09e-05 |
| | | (7.78e-06) |
| Births | | 0.0100* |
| | | (0.00520) |
| Number Tested | | -0.0175** |
| | | (0.00754) |
| Constant | 6.398*** | 5.157*** |
| | (0.395) | (1.309) |

| VARIABLES | Lead poisoning (Percent) | Lead poisoning (Percent) |
|---|---|---|
| Observations | 86 | 74 |
| R-squared | 0.376 | 0.353 |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

**Table 5. Difference-in-difference Regression Results with Year and Town Fixed Effects**

| Lead contamination (percent) | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| After | -7.976 | 1.235 | -6.46 | 0 | -10.445 | -5.507 | *** |
| Lewiston After | -3.394 | .668 | -5.08 | 0 | -4.729 | -2.059 | *** |
| Lewiston | 0 | . | . | . | . | . | |
| Bangor | -4.833 | .513 | -9.43 | 0 | -5.857 | -3.808 | *** |
| Biddeford | -3.248 | .572 | -5.67 | 0 | -4.393 | -2.104 | *** |
| Portland | -3.343 | .551 | -6.06 | 0 | -4.445 | -2.24 | *** |
| Saco | -3.75 | .866 | -4.33 | 0 | -5.48 | -2.019 | *** |
| Westbrook | -4.61 | .935 | -4.93 | 0 | -6.48 | -2.741 | *** |
| 2004 | 0 | . | . | . | . | . | |
| 2005 | -.783 | 1.328 | -0.59 | .557 | -3.438 | 1.871 | |
| 2006 | -1.133 | 1.514 | -0.75 | .457 | -4.159 | 1.892 | |

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| Lead contamination (percent) | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| 2007 | -2.917 | 1.131 | -2.58 | .012 | -5.178 | -.655 | ** |
| 2008 | -4.267 | 1.081 | -3.95 | 0 | -6.428 | -2.105 | *** |
| 2009 | -4.05 | 1.088 | -3.72 | 0 | -6.225 | -1.874 | *** |
| 2010 | -4.75 | 1.151 | -4.13 | 0 | -7.05 | -2.45 | *** |
| 2011 | -5.45 | 1.119 | -4.87 | 0 | -7.686 | -3.213 | *** |
| 2012 | -5.7 | 1.135 | -5.02 | 0 | -7.968 | -3.432 | *** |
| 2013 | -5.575 | 1.119 | -4.98 | 0 | -7.811 | -3.338 | *** |
| 2014 | -6.55 | 1.284 | -5.10 | 0 | -9.117 | -3.982 | *** |
| 2015 | -7.425 | 1.186 | -6.26 | 0 | -9.794 | -5.055 | *** |
| 2016 | -6.55 | 1.141 | -5.74 | 0 | -8.831 | -4.268 | *** |
| 2017 | 2.009 | .852 | 2.36 | .022 | .306 | 3.711 | ** |
| 2018 | 2.794 | .84 | 3.33 | .001 | 1.116 | 4.473 | *** |
| 2019 | 1.6 | .653 | 2.45 | .017 | .294 | 2.906 | ** |
| 2020 | .244 | .799 | 0.31 | .761 | -1.353 | 1.842 | |
| 2021 | 0 | . | . | . | . | . | |
| Constant | 14.081 | 1.191 | 11.83 | 0 | 11.701 | 16.461 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 6.245 | SD dependent var | 3.089 |
| R-squared | 0.850 | Number of obs | 86 |

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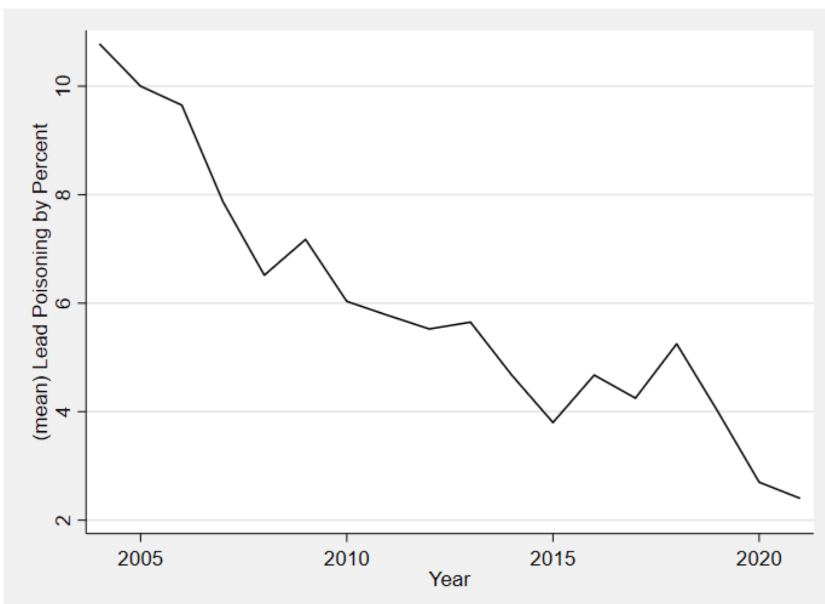
| Lead contamination (percent) | **Coef.** | **St.Err.** | **t-value** | **p-value** | **[95% Conf** | **Interval]** | **Sig** |
|---|---|---|---|---|---|---|---|
| F-test | 18.428 | | Prob > F | | 0.000 | | |
| Akaike crit. (AIC) | 321.669 | | Bayesian crit. (BIC) | | 380.573 | | |

**** p<.01, ** p<.05, * p<.1*

**Graph 1. Lead poisoning rate in high-risk areas in Maine (2004-2021)**



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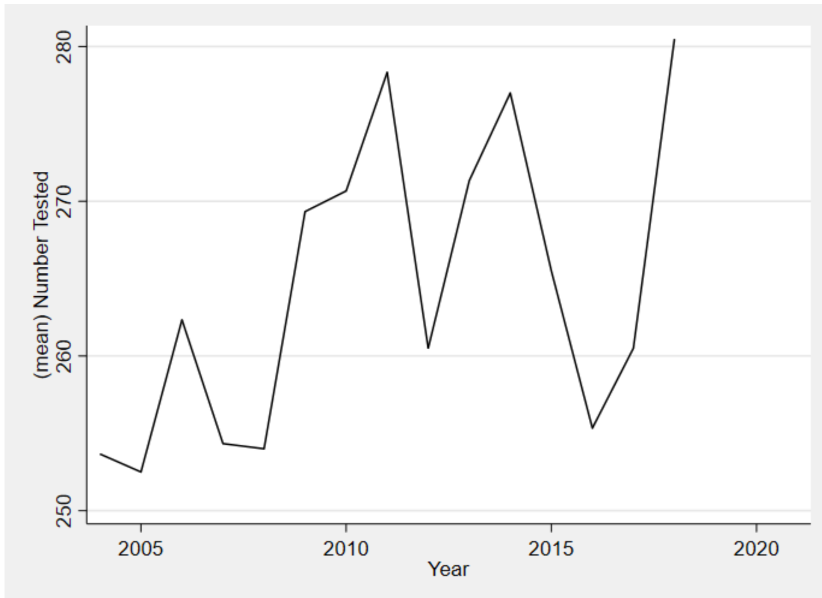
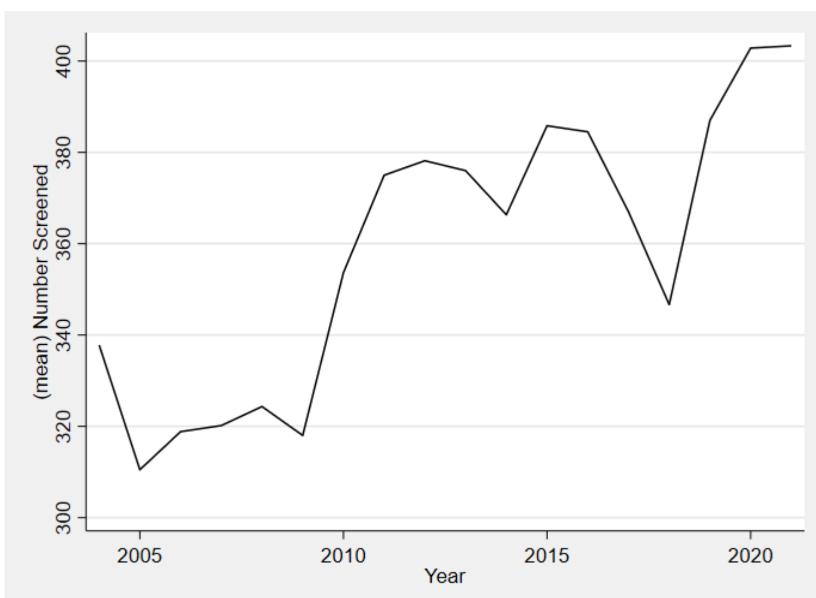
**Graph 2. Year Average Number of Children Aged 0-3 Tested (2004-2018)**




**Graph 3. Year Average Number of Children Screened (2004-2021)**



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