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Door Hanger Outreach and Incentives Did Not Induce Water System Customers to Participate in Lead Water Pipe Inspections

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Abstract

The Environmental Protection Agency has finalized regulations to require water systems to replace millions of lead pipes with safer alternatives for carrying drinking water into U.S. homes. Before replacing them, public water systems must first identify where these lead service lines are located due to incomplete inventories and a lack of historical records. We conducted a randomized controlled trial to evaluate an intervention that targeted properties with unknown pipe material in Trenton, New Jersey—a community with older housing stock and a high concentration of people of color, renters, and households experiencing poverty. The intervention included two treatments: door hangers with information about a self-inspection process that allowed residents to submit a photo of their service line; and similar door hangers offering gift card incentives upon submission of a self-inspection photo. These treatments did not motivate residents to participate in a self-inspection of their service lines. Well under 1% of treated addresses participated in a self-inspection, including those offered the highest gift card incentive of $100.

Introduction

While federal law banned the installation of new lead service lines (LSLs) in 1986, an estimated 9 to 10 million of these pipes still connect water mains to homes in the United States (EPA 2024a). LSLs can expose residents to lead in drinking water (Brown et al. 2011; EPA 2006; Triantafyllidou and Edwards 2012). The harms of LSLs were highlighted by the crisis in Flint, Michigan, where the switch to a corrosive water source caused elevated lead exposure and severe public health consequences (Edwards et al, 2015). Lead exposure in children is associated with reduced IQ (Crump et al. 2013; Ferrie et al. 2012), lower educational attainment (Aizer et al. 2018; Grönqvist et al. 2020; Reyes 2015b), and increased risk of criminal activity (Aizer and Currie 2019; Feigenbaum and Muller 2016; Reyes 2007, 2015a). In adults, lead exposure manifests in cognitive, cardiovascular, renal, reproductive, and hematological damages, as well as increased risk of mortality (EPA 2024b; Hollingsworth and Rudik 2021). Exposure to lead is estimated to generate $200 billion in societal costs over the lifetime of each birth cohort (Reyes 2014), including reduced tax revenues and increased expenditures on special education, crime, and health care.

Failure to identify and replace LSLs also likely exacerbates inequalities in environmental exposures and children's health. LSLs are more common in areas with older housing and high concentrations of families in poverty (GAO 2020; EPA 2023). Black children and children living below the poverty line are more likely to be subjected to lead exposure and have persistently higher blood lead levels than White children and children not in poverty (Egan et al. 2021).

To address the widespread dangers from lead in drinking water infrastructure, the Environmental Protection Agency (EPA) has finalized requirements for water systems to create service line inventories and to replace most LSLs by the end of 2037 (US EPA 2021; US EPA 2024a). Data from the EPA's (2024a) regulatory impact analysis suggest that the inventory requirements will cost water systems $1.6 billion, and the replacement requirements will cost on the order of $40 to $50 billion. Some states, such as New Jersey and Rhode Island, have earlier deadlines for LSL replacement (EPA 2024a). Accurate knowledge of where LSLs are located is essential for cost-effective replacement programs to take advantage of economies of scale. Because the infrastructure is buried underground and historical records are often incomplete, many utilities across the country have significant gaps in their inventories. The EPA (2024a) estimated that about forty percent of service lines nationally are of unknown material, and that, of these, about 4 million are likely to contain lead, highlighting the need for reliable approaches to identify LSLs (Hensley et al. 2021).

Identification and eventual replacement of LSLs requires inspections. Most service lines include a utility side (from the water main to the curb) and a private side (from the curb to the home), with lead hazards occurring on either or both sides. While water systems can directly inspect the utility side of a line, they typically require the owner's or resident's permission to inspect and ultimately replace the private side. When technicians do not have access to a home's interior, utilities may need to excavate exterior sidewalks or lawns to inspect a service line, a practice that can cost over $700 dollars (EPA 2024a). In addition to the costs for utilities to conduct in-person inspections by staff or contractors, residents may find these programs costly or inconvenient due to scheduling difficulties, lack of trust in government, lack of information on LSL hazards, and other barriers. As observed in other direct outreach programs, such as the Census, such barriers can result in fewer responses from areas with lower incomes, higher rates of renting, or more noncitizens (US Census 2021; Rothbaum et al. 2021; Bruce and Robinson 2003).

In this paper, we present findings from a field experiment to evaluate the impact of providing door hanger outreach with and without financial incentives to encourage non-intrusive self-inspection methods.[1] The self-inspection process entails identifying the water service line, photographing it, and submitting the photo via an online form. We conducted the experiment in Trenton, New Jersey, a community with a high proportion of renters and low-income residents who may face outsized barriers to participation in service line inspection and LSL replacement programs. Prior to the experiment, the water utility had already contacted most property owners in Trenton to encourage participation in the service line inspection and LSL replacement program. This experiment targeted properties where the service line material remained unknown. Thus, we characterize our target population of households who had not responded to previous outreach as "hard-to reach."

Our field experiment was designed to answer two research questions: (1) Do non-intrusive do-it-yourself inspection approaches increase take-up of service line inspections in hard-to-reach populations? (2) When combined with these inspection approaches, do financial incentives increase take-up of service line inspections in hard-to-reach populations?

Households were randomly assigned to one of three groups: a control group, an outreach-only group receiving a door hanger describing the self-inspection program and linking to the online form, and a group receiving the door hanger with an incentive for submission of the self-inspection form. The door-hanger-plus-incentive group was subdivided into four sub-groups based on the incentive amount: $10, $25, $50, or $100. The intervention included both owner occupants and tenants, in contrast with previous efforts focusing only on homeowners. We find that neither outreach in the form of door hangers nor financial incentives in the form of gift cards increased self-inspection rates. Submission rates were too low to allow for heterogeneity analysis.

This paper helps inform the design of policies and programs to reduce the burden of lead exposure from drinking water. Self-inspection programs potentially lower participation barriers because they do not require scheduling and are less invasive compared to in-person inspections, and they are also cost-effective for utilities. However, no study has estimated the elasticity of demand for service line inspections or tested whether this method is sufficient to overcome participation barriers in "hard-to-reach" populations. A prior field experiment with TWW showed that mailed postcards advertising subsidies offered by the Trenton Housing Department to fully defray the cost of LSL replacement for low-income homeowners who demonstrate eligibility had no effect on program sign-ups (Klemick et al. 2024). Secondary data analysis identified greater participation in response to a different subsidy program run by a local community organization that employed multiple modes of outreach (including in-person canvassing

[1] This experiment was conceived and pre-registered as the first part of a two-phased intervention. Due to changes in partners' priorities, it was only possible to implement phase one.

and online meetings) and did not require proof of low income for eligibility. Results suggest that lowering barriers to participation and combining subsidies with other forms of outreach can increase LSL replacement take-up.

This paper also provides evidence on the role of monetary and non-monetary barriers to take-up of public programs more generally. Previous studies have found that information barriers, enrollment costs (Finkelstein and Notowidigdo 2019), social stigma (Lasky-Fink and Linos 2022), and the "bandwidth tax" imposed by poverty (Mullainathan and Shafir 2013) can impede take-up of public programs. Interventions to encourage participation in water testing and other environmental programs have found mixed results, (e.g., Renaud et al. 2011; Fowlie et al. 2015; MacDonald and Tippett 2020; Lade et al. 2024). There is evidence from other contexts that interventions can increase participation in public benefit programs, but barriers remain higher for low-income individuals (Finkelstein and Notowidigdo 2019; Dutz et al. 2023). This study adds to this literature by focusing on a program with universal eligibility and low stigma.

Trenton, New Jersey Context

Trenton Water Works (TWW) is a publicly owned utility serving the New Jersey communities of Trenton, Hamilton, Ewing, Lawrence, and Hopewell. In 2019, TWW initiated a Lead Service Line Replacement program replacing private-side LSLs for a subsidized cost of $1,000 and utility-side lines at no cost to the homeowner.[2] Although TWW has replaced more than 9,000 LSLs through this program, private side service line material is still unknown in roughly 60% of residential properties across all five municipalities. Lack of accurate information hinders TWW's efforts to replace all LSLs by 2031 as required by New Jersey law (2021; NJ Bill A5343/S3459).

The field experiment targeted the municipality of Trenton, which has the highest concentration of residents of color, rental housing, and residents experiencing poverty in the service area. The EPA's environmental justice screening tool shows that Trenton has higher levels of socioeconomic disadvantage, measured by indicators such as race/ethnicity, income, and education, than 80% of the country. These factors make LSL replacement both more urgent and more challenging in Trenton, where, despite previous outreach attempts by the city, about 11,000 out of 20,000 properties have unknown service line material. Notably, 80% of Trenton customers with unknown service line material had already received at least one mailing about the LSL replacement program since 2018, and 25% had received multiple mailings prior to the field experiment.

Utility personnel or contractors had conducted over 7,000 in-person inspections in Trenton prior to the field experiment (Klemick et al. 2024), comprising the vast majority of inspections. However, since the COVID-19 pandemic, the utility has also offered customers the opportunity to conduct a self-inspection by emailing or submitting online a photo for a water utility employee to visually identify the service line

[2] Most service lines that TWW classified as lead are actually lead-lined galvanized steel and pose similar risks as solid lead service lines. New Jersey law states that galvanized service lines are presumed to include lead and must be replaced. For convenience, we refer to these pipes as LSLs.

material.[3] Photo verification is thought to have "medium to high" accuracy compared to water quality sampling and excavation methods (Hensley et al., 2021). Data from TWW show 78% agreement between photo and contractor inspections at properties where both inspection types occurred. Only about 600 residents had participated in a self-inspection prior to the field experiment.

Methods

Water account records, which were obtained through a Data Use Agreement with TWW, provided information on service line material (if known) and inspection status at the individual address level. Mercer County property tax assessor records provided building characteristics including property type, year built, assessed value, owner occupancy, and number of dwellings.[4] The 2020 US Decennial Census was used to determine block group boundaries. Self-inspection response data, including photos, address, contact information, homeowner versus tenant, and willingness to be contacted with further information about protecting their home against lead were submitted to the University of Chicago by residents who responded to treatment. The study team also tracked door hanger delivery data (see Appendix for more details).

We constructed the study sample by identifying all addresses served by TWW that met the following criteria: they were located in the city of Trenton; they were non-vacant, residential properties; they had a single, active water account with TWW; TWW records indicated that the service line material was unknown; we were able to link the address to Mercer County property tax assessor records[5]; and tax assessor records indicated that the address contained no more than four dwellings. Of 61,677 addresses served by TWW, 9,110 addresses met these criteria. We stratified on Census block group and owner occupancy when randomizing addresses. After stratifying, we removed eight properties from the sample because they were in strata that included only a few properties, thus yielding a final sample of 9,102 properties.

Each address was randomly assigned to one of the following study arms:

Treatment 1: An informational door hanger including instructions on how to self-inspect and submit photo of service line material to TWW.

Treatment 2: An informational door hanger similar to that in treatment 1 but with the offer of a gift card incentive with different randomized amounts ($10, $25, $50, or $100) in return for submitting a service line inspection.

Control: No door hanger or additional information beyond materials distributed in past years.

[3] Similar programs have been implemented in cities like Washington DC, Alexandria, VA, Bethlehem, NY, and Norridge, IL.
[4] Owner-occupied properties were identified by using the first seven characters of the property address and the owner address; if they matched, the home was considered owner-occupied.
[5] Water system data was matched to assessor records using the property addresses in each dataset, of which 93.7% of the properties were matched.

We assigned 3,037 properties to receive a door hanger with no monetary incentive, 3,076 to receive a door hanger with a monetary incentive, and 2,989 to the control group (Figure 1). Detailed power analysis is presented in the Appendix.

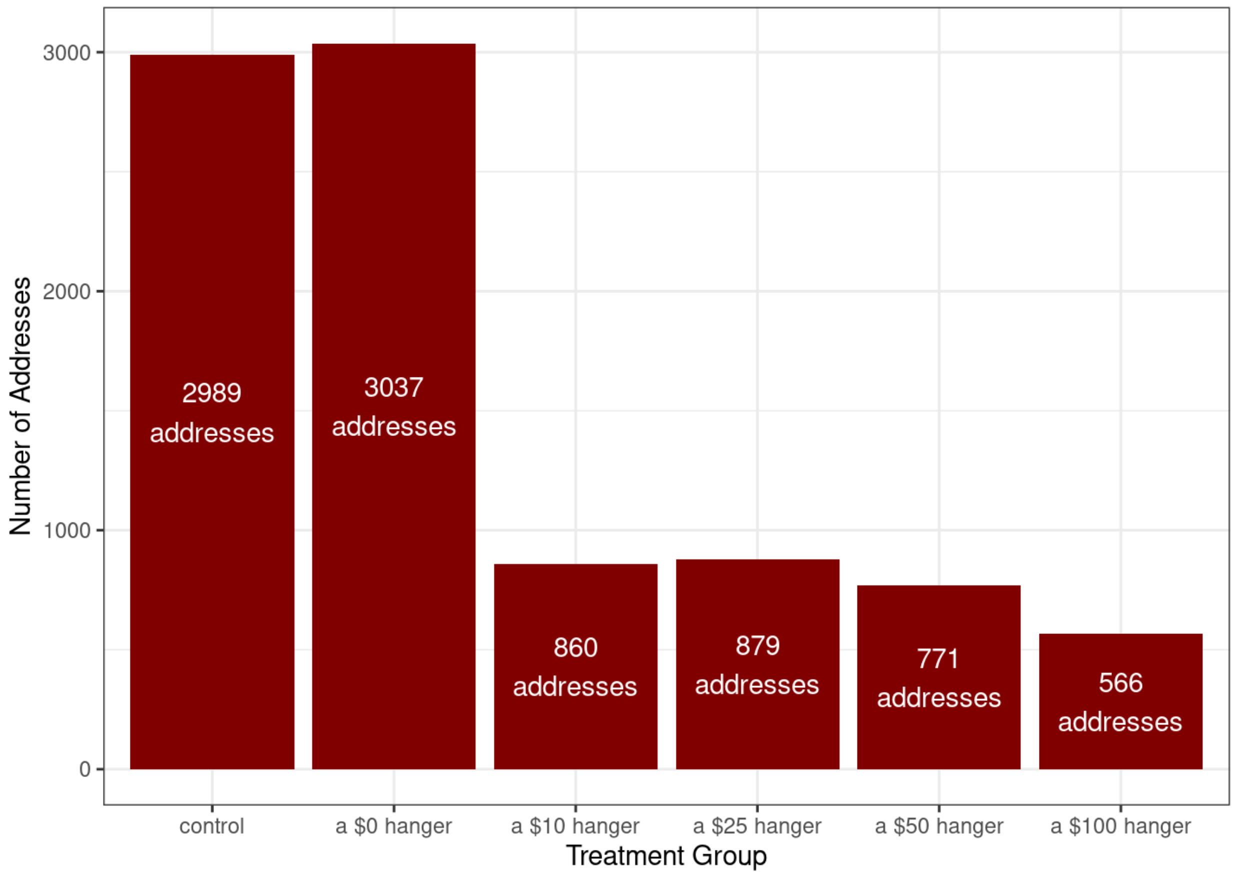

Figure 1. Number of Trenton properties assigned to control and treatment groups

Properties in the control and treatment groups were balanced on key characteristics that could affect propensity to participate in service line inspections, including owner occupancy; construction prior to 1950, when LSLs were more common; an indicator for multi-family properties (2-4 residential units), an indicator for the presence of lead in the utility-side service line; and assessed value (Table 1).

Table 1. Key characteristics of addresses assigned to each group

Covariate	Control	A $0 Hanger	A $10 Hanger	A $25 Hanger	A $50 Hanger	A $100 Hanger
Property built prior to 1950	88%	88%	86%	88%	87%	87%
Owner occupied property	44%	44%	44%	44%	44%	45%
Multi-family property (2-4 dwellings)	12%	13%	12%	13%	11%	11%
Utility-side service line contains lead	32%	33%	32%	31%	34%	30%
Assigned property value	$61,796	$62,263	$61,954	$61,819	$60,767	$61,389

Door hangers included language suggesting that households might be at risk of lead exposure, which could cause health problems, due to the unknown material of their service line. They highlighted that households could easily and quickly (within 10 minutes) find out the service line material and outlined the steps to perform a self-inspection, including a QR code and website linking to the form. For households in the incentive groups, they showed the value of the gift card available upon submission of the self-inspection form and indicated that households would have a choice among several major retailers. The utility's contact number was provided for clarifications or households without internet access.[6] Hangers were printed on both sides, with one side in English and the other side in Spanish (Figure 2). Door hangers were distributed by staff from a local community organization between July 27 and August 22, 2023.

[6] As of 2021, 91 percent of households in urban areas of the Northeast US had internet access, and 89 percent had a smart phone (Mejia 2024).

Figure 2. Door hanger designs with and without incentives (English language version)

Results

Of the 9,102 addresses included in the study sample, only 12 submitted self-inspections between July 27, 2023, and December 31, 2023.[7] Of these, one was in the control group, three were in the no-incentive door hanger group, and eight received a door hanger with a gift card incentive. The participation rate was lowest in the control group (0.03%), next highest in the no-incentive door hanger group (0.1%), and highest in the group that received a door hanger with a gift card incentive (0.3%).[8] Given that participation was well under 1% in all groups, we conclude that the intervention was not successful in motivating enough self-inspections to be a viable approach to collect service line inventory data in this community (Figure 3).

[7] Submissions were tracked by the research team until March 26, 2024. Two self-inspections were submitted outside of the study sample between December 31, 2023 and March 26, 2024.

[8] In addition to the 12 self-inspections received from the study sample, 28 addresses from the rest of the TWW service area submitted self-inspections. While this is a greater total number of inspections than in the study area, the self-inspection rate as a percentage of all accounts is similar to the self-inspection rate among the control group in the study sample and lower than the self-inspection rate among the treatment groups. While these addresses did not receive door hangers directing them to TWW's self-inspection website, the website has been publicly available and accessible through an internet search since 2020 and had been promoted by TWW in the past (prior to the study period). Of the 28 self-inspections received from outside of the study area, 26 were copper or plastic, and 2 were lead or galvanized steel.

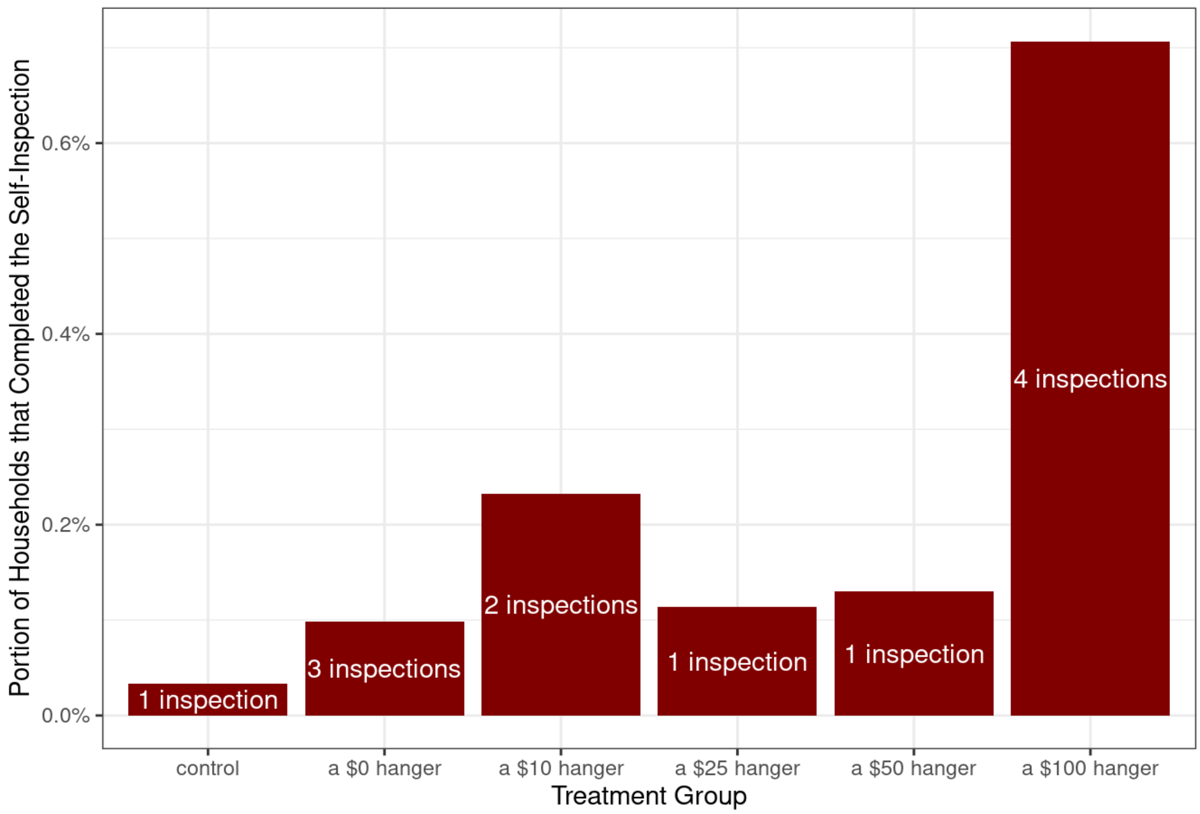

Figure 3. Number of self-inspections received from properties in control and treatment groups

Among these self-inspections, 10 were determined to be copper, one contained lead, and one could not be determined based on the photos (Figure 4). Self-inspections were not spatially clustered in any one neighborhood (Figure 5). Residents who submitted self-inspections were notified of their service line material by email.

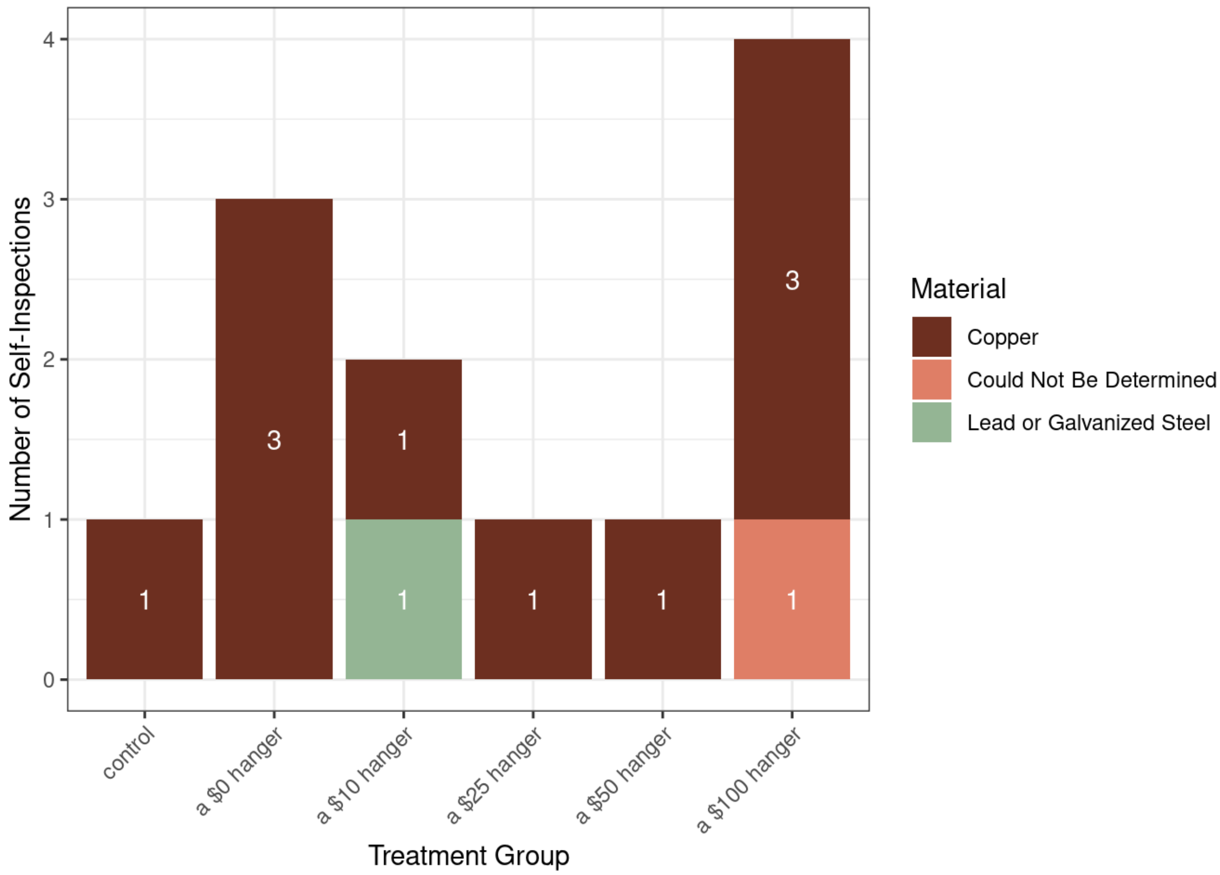

Figure 4. Service line material in self-inspections received from control and treatment groups

Figure 5. Map of Trenton self-inspections submitted during study period

Discussion and Conclusions

This study evaluated an intervention aimed at providing water systems and residents with a potentially cost-effective approach to identify lead service lines, which will ultimately have to be replaced. However, the door hanger outreach alone or in combination with the offer of a gift card did not motivate customers in a "hard to reach" population to participate in self-inspections. This lack of success is consistent with the small or null results of some interventions to encourage participation in well water testing and energy efficiency programs (Renault et al. 2011; MacDonald and Tippett 2020; Fowlie et al. 2015).

As described in the pre-analysis plan, we originally intended to conduct a second phase of the field experiment. The second phase would have delivered another round of door hangers with the same gift card offers, but with the addition of a face-to-face visit by a staff person from a community organization for a randomized subset of residents to encourage completion of the self-inspection. This would have provided a reminder to treated households and allowed us to evaluate the relative effectiveness of print and in-person outreach approaches. Due to changes in staffing and priorities at TWW and the community organization, it was not possible to conduct phase 2. The lack of follow-up outreach reminding residents about the self-inspection likely contributed to the minimal uptake.

We cannot determine whether the intervention failed due to the mode of outreach, the messenger, the type and size of incentives, or a combination of factors. However, because the intervention offered gift card amounts up to $100 for an activity estimated to take 10 minutes, we hypothesize that the door hangers were an ineffective outreach approach in this context. Residents would need to receive, read, understand, and believe the information provided on the door hangers before deciding whether the gift card made the self-inspection worth their time. While the door hangers were intended to be highly visible and easy to understand, people have many competing demands on their time and attention. This result echoes that of the previous field experiment in Trenton relying on postcards to deliver information about subsidies, which was ineffective in improving participation in lead service line inspection and replacement, and it contrasts with those from a subsidy program offered by a neighborhood organization using multiple modes of outreach, which significantly increased uptake in the target population (Klemick et al. 2024).

This field experiment did not assess whether door hangers and incentives increased self-inspections in other municipalities in the water system's service area, where there is a higher concentration of single-family, owner-occupied, and higher valued homes. These municipalities are also expected to have a lower concentration of lead service lines because the housing stock is newer. However, there are many lead and unknown service lines in these municipalities that will have to be replaced, so it could still be useful to test whether print outreach and incentives are effective in this other population.

This field experiment was unable to assess whether alternative forms of outreach besides door hangers could have caught the attention of the target population. In-person visits, text messages, and emails are alternative approaches to print outreach that could be considered in future work. Print materials could also be distributed by alternative messengers that are trusted in the community, such as schools or medical professionals. Text and emails hold promise as a very low-cost form of outreach with easy potential for reminders. However, it could be difficult for water utilities to target renter-occupied properties with these modes if they only have electronic contact information for the bill payer, who is not necessarily the property resident.

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Appendix

Power analysis

Prior to randomization of treatment and control groups, we used Stata to estimate the minimum detectable effect (MDE) of treatment on the proportion of households that complete service line inspection, with 80% power and alpha 0.05. MDE for each planned comparison is shown in Table 1, with primary analyses in bold. Assuming an approximate sample size of 9,000, randomization at the address level, and three equal groups (one control and two treatment), we anticipated a sample size of 3,000 per treatment arm. We were thus powered to detect a 2.3 percentage point change in inspection up-take for each treatment, assuming a baseline take-up rate of up to 10%.[9] Benchmarks for an expected effect size in this context are extremely limited. We used intuition and results from the previous informational postcard and grant studies (Klemick et al. 2024) to estimate sample size requirements.[10] Though we expected a higher effect for Treatment 2, we retained 3,000 households in this group to ensure power to detect at least a 5 percentage-point difference between pooled low ($10 and $25) and high ($50 and $100) incentive groups. Given budget considerations and higher expected uptake rates in the higher incentive groups, we allocated Treatment 2 households unequally: 875 each in $10 and $25 groups, 750 in $50, and 500 in the $100 group.

Table 1. Minimum Detectable Effect for Each Comparison

Comparison*	**MDE (percentage points)**	**Comparison group uptake****	**n1 (comparison)**	**n2 (treatment)**
Treatment 1 vs. Control	2.28	10%	3,000	3,000
Treatment 2 (pooled) vs. Control	2.28	10%	3,000	3,000
Treatment 2 (pooled) vs. Treatment 1	2.47	20%	3,000	3,000
Treatment 2 high (pooled $50, $100) vs. low (pooled $10, $25) incentive	5.07	30%	1,750	1,250
Treatment 2 $25 vs $10	5.62	20%	875	875
Treatment 2 $50 vs $25	6.90	40%	875	750
Treatment 2 $100 vs $50	7.75	60%	500	750

*Items in bold are the study's main comparisons. All calculations assume 80% power, 5% alpha. **Uptake assumptions in the comparison group are conservative, to ensure statistical power in worst-case scenarios.

In addition, we used power simulations to confirm that these power calculations would hold under the stratification used for randomization. These simulations used the following procedure:

1. Generate 100 potential treatment assignments, using random assignment stratified on block group and owner occupancy, starting with a new seed each time.

[9] The baseline rate for registration in the LSL replacement program observed among Trenton households at the time of this analysis was 18%. We used program registration as a proxy uptake of LSL self-inspections since both require an active response from the resident. We assumed a baseline take-up rate of 10% in this analysis because we expected a lower baseline rate for this group that had resisted outreach to date.

[10] We observed no effect from the simple informational postcard but expected the more visible door hanger and reminder for Treatment 1 would have a modest, higher effect. Following the local community organization grant program, there was a 14 percentage-point increase in participation in contractor-led inspections; however, comparability is unclear, given the different inspection method and promise of a full subsidy for replacement following inspection.

2. For each potential treatment assignment, simulate binary outcomes for each household (whether the address participated in the self-inspection) using the following average uptakes for each treatment group.

a. Control: 10%

b. Treatment 1 - $0: 12.3%

i. Note that we set the difference between the average uptake for Control and Treatment 1 at the MDE calculated previously.

c. Treatment 2a - $10: 20%

d. Treatment 2b - $25: 40%

e. Treatment 2c - $50: 60%

f. Treatment 2d - $100: 75%

3. Estimate treatment effects for each potential treatment assignment using equations (1) and (2) and store p-values obtained from the regressions.

4. Across the 100 simulations, count the following:

a. Any Power 1: how many times either Treatment 1 or Treatment 2 was estimated to have a statistically significant effect ($\alpha = 0.05$) using equation (1).

b. All Power 1: how many times both Treatment 1 or Treatment 2 was estimated to have a statistically significant effect using equation (1).

c. Any Power 2: how many times at least one of Treatment 1, Treatment 2 – Low Incentive, or Treatment 2 – High Incentive was estimated to have a statistically significant effect using equation (2).

d. All Power 2: how many times all of Treatment 1, Treatment 2 – Low Incentive, and Treatment 2 – High Incentive were estimated to have a statistically significant effect using equation (2).

We found that in 100% of simulations, Treatment 2 estimates were significant. The Treatment 1 effect (set at our MDE of 2.3 percentage points) was estimated with significance in 79% of simulations. This is consistent with our power calculations determining that a 2.3 percentage point difference was the minimum we could detect with 80% power.

Undeliverable addresses

The study team was unable to deliver door hangers to 163 of the 6,113 addresses assigned to receive door hangers (3%) for the following reasons (in order of frequency):

1. The property was vacant/abandoned.
2. The property was not accessible due to gate, dog, or owner requesting to not be contacted.
3. The property could not be found.

In addition, two addresses were neither delivered nor marked undeliverable. It seems likely these were mistakenly excluded from delivery when we switched to a new system to track door hanger deliveries.

Figure 5 shows the distribution of undeliverable addresses by treatment group. The $10 incentive hangers had fewer addresses that could not be delivered relative to other treatment groups, despite being the largest treatment group. This could be coincidence, or it could reflect inconsistencies in delivery implementation, such as certain staff members being more likely to successfully identify an address, or to inaccurately record an address as delivered.

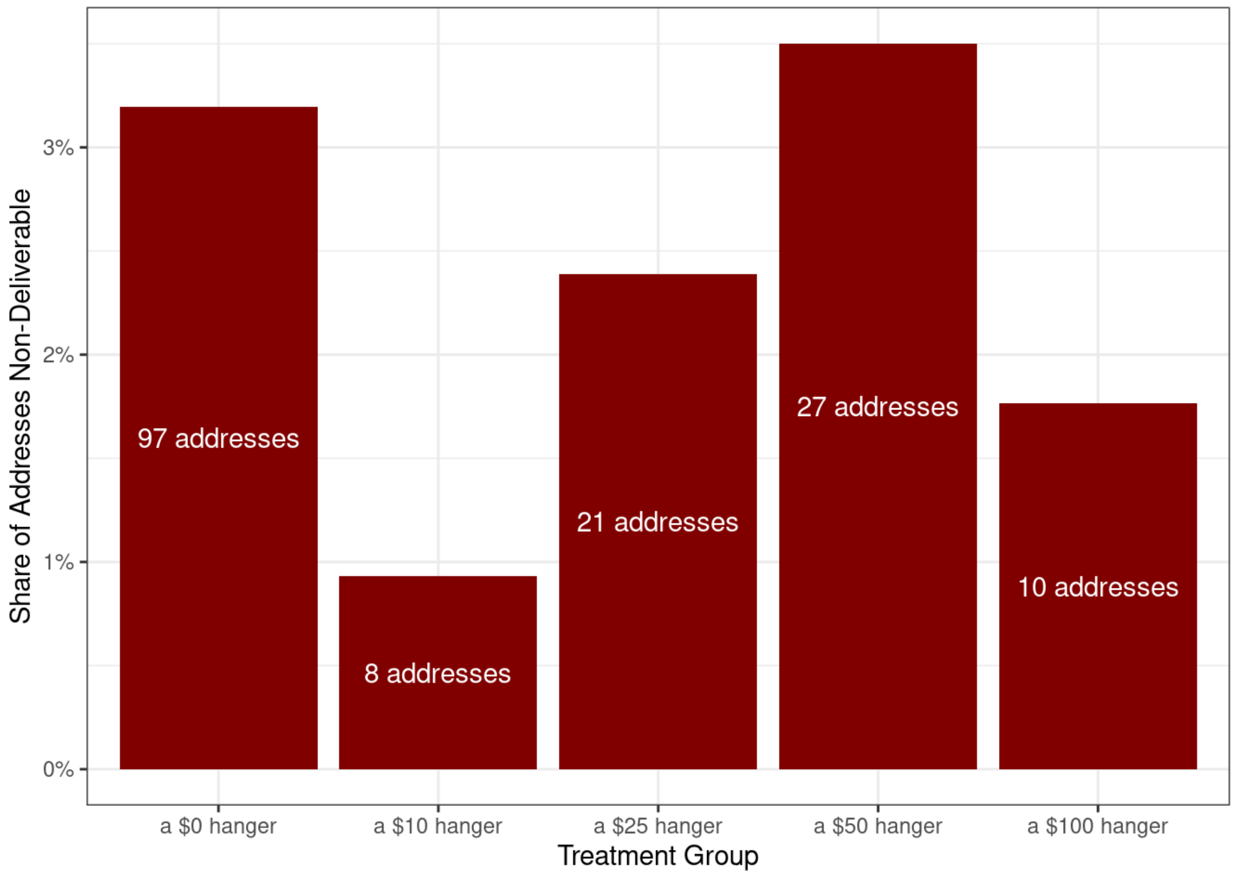

Figure 6. Undeliverable addresses by treatment group