Housing Discrimination and Pollution Exposures in the United States

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Abstract

Local pollution exposures disproportionately impact minority households, but the root causes remain unclear. This study conducts a correspondence experiment on a major online housing platform to test whether housing discrimination constrains minority access to housing options in markets with significant sources of airborne chemical toxics. We find that renters with African American or Hispanic/LatinX names are 41% less likely than renters with White names to receive responses for properties in low exposure locations. We find no evidence of discriminatory constraints in high exposure locations, indicating that discrimination increases relative access to housing choices at elevated exposure risk.

Key words: Housing Discrimination, Correspondence Experiment, Air Toxics
JEL Classification: Q51, Q53, R310

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1 Introduction

Over the past three decades, a range of studies have demonstrated that minority households in the United States are disproportionately exposed to harmful pollutants (Rosofsky et al., 2018, Clark et al., 2017, Ard, 2015, Shapiro, 2005, Ash and Fetter, 2004). This 'race gap' in pollution exposures is found both in cross-sectional data and also in neighborhood demographic changes following shifts in pollution concentrations (Mohai and Saha, 2015, Cushing et al., 2015, Mohai et al., 2009). Other work has revealed relationships between pollution exposures and persistent inequity in lifetime cancer risk (Collins et al., 2015, Morello-Frosch and Jesdale, 2006, Morello-Frosch et al., 2001) and chronic respiratory conditions such as asthma (Alexander and Currie, 2017, Currie, 2009). Studies of long-run impacts on in utero populations demonstrate that emissions exposures from nearby toxic plants or traffic congestion in close proximity to a home residence have critical effects on infant health and birth-weight (Currie et al., 2015, Currie and Walker, 2011, Currie and Schmieder, 2009, Currie and Neidell, 2005). This body of research elevates concern that differential location choices in US housing markets result in a persistent racial gap in a range of pollution-related health outcomes.

While evidence of an exposure gap is clear, it has been challenging to identify root causes. A key question involves whether housing market discrimination actively constrains choices available to minority households in low exposure neighborhoods. For over two decades, researchers have hypothesized that housing discrimination may be an important factor in explaining the exposure gap in the US (Crowder and Downey, 2010, Logan and Alba, 1993). However, no prior study has provided an empirical test of the *racial discrimination hypothesis*. This is challenging in observational data, as it requires disentangling discriminatory constraints from disparities in income (Banzhaf et al., 2019, Aliprantis et al., 2019, Logan, 2011), differences in information about exposure risk (Hausman and Stolper, 2019, Currie, 2011) and housing/neighborhood preferences that also affect residential sorting behavior (Depro et al., 2015, Banzhaf and Walsh, 2013). The discrimination mechanism differs fundamentally from the other factors in that it involves illegal behavior that imposes ex ante constraints on the choices of minority renters, potentially distorting sorting behavior even when households are perfectly informed about the risk of exposures. Examining the effect of housing discrimination on ex ante choice constraints is important for analyzing the race-gap in pollution exposures and for studying the channels through which housing discrimination may create barriers to human capital accumulation that contribute to racial inequality in the United States (Akbar et al., 2019, Graham, 2018, Chetty et al., 2018, Christensen and Timmins, 2018).

This paper uses a correspondence study conducted on a major online rental housing search platform to provide the first experimental evidence on the effect of discriminatory constraints on access to housing choices in markets with major pollution sources.[1] We define a representative sample of local rental housing markets using the set of US zip codes that contain major sources of toxic emissions (using the Toxic Release Inventory). In this sample of markets, the shares of African American and Hispanic/LatinX renters living in high versus low exposure locations are more than 50% higher than the White renter population. We then use the within-property randomization to test whether discrimination constrains the housing choices available to minority households at high exposure locations relative to comparable listings at low exposure locations that are available at the same time within the same market. We find that discriminatory behavior reduces the likelihood of response to minority renters with racially perceptible names by 41% in low-exposure locations, though we find no evidence of discriminatory constraints operating in the high exposure zones of the same markets. Our tests reveal that constraints in low exposure neighborhoods are considerably stronger for African American renters, especially for African American men.

We then examine how the discrimination-exposure relationship varies by neighborhood racial composition, rental price, and among properties that are matched using the housing/neighborhood characteristics that are visible to prospective renters on the search platform. We find that the relationship holds across neighborhoods with high/low shares of minority households, across segments of the rental price distribution, and within sets

[1]While online housing markets do not reflect all options available in the markets that we study, online housing platforms have increasingly become the locus of housing search and constitute an important channel for discriminatory behavior Apartments.com (2015).The referenced survey reports that 72% of housing searches were initiated on online platforms in 2015.

of highly comparable properties. By constraining the housing choices of minority renters in low exposure neighborhoods, discriminatory constraints in markets with major toxic facilities result in a ceteris paribus welfare effect for minority households that value clean air. Among renters that are informed about pollution exposures and are willing to pay to avoid them during a search, these constraints will increase the cost of that avoidance behavior. Among minority renters who may not be informed or who may not structure their search to specifically avoid high exposure neighborhoods, discriminatory constraints reduce the probability of sorting into low exposure locations relative to high exposure locations, thereby contributing to the race gap in exposures and related health outcomes.

Beyond the exposure gap, this paper contributes to a growing literature that uses correspondence and other experimental methods to study discriminatory behavior in labor and housing markets (Bertrand and Duflo, 2017). While recent literature has mainly focused on detecting discrimination or examining the mechanisms that underlie discriminatory behavior, the current study responds to recent calls for increased focus on the adverse impacts of discriminatory constraints (Kline and Walters, 2019, Guryan and Charles, 2013). New work by Kline and Walters (2019) illustrates the importance of heterogeneity in discriminatory behavior in the labor market. In the housing market, relatively little is known about the characteristics of neighborhoods where minority households face systematically stronger constraints (Phillips, 2017, Ewens et al., 2014, Hanson and Hawley, 2011). This study demonstrates that estimates of average effects can mask heterogeneity along dimensions that drive search and sorting processes and are therefore important for determining the adverse impacts of discriminatory behavior.

This paper proceeds as follows. The following section provides background on the experimental design and sample. Section 3 discusses experimental discusses results on the discrimination-exposure relationship by toxic concentration and by distance to TRI facility. Section 4 discusses heterogeneity in the discrimination-exposure relationship by price and housing/neighborhood characteristics. Section 5 concludes.

2 Study Area and Correspondence Design

We define a sampling frame that includes all zip codes surrounding major point sources of airborne chemical toxics, which are defined using facilities reporting emissions through the EPA's Toxic Release Inventory (TRI). This design yields a sample that is representative of localized housing markets that are characterized by substantial within-market variation in pollution exposures. Panel A of Figure 1 maps the set of US zip codes that contain a nearby high emitting facility.[2] The final study area uses a sample of 2,918 listings from 19 zip codes drawn at random from the set of high emissions markets.

Within each of the zip codes that we sample, we compile the full set of property listings on the day of data collection to simulate the choices available in a search. The sampling design ensures that estimates reflect differences across the full set of housing options advertised to prospective renters at the time of an experimental trial, simulating the set of options available to a prospective renter that is searching on the platform at that time. Immediately following compilation of the relevant listings in a given market, a name is randomly drawn and assigned from each of three racial groups.

Using prior literature on racialized perceptions in US populations, we select 18 first-last name pairs that are shown to have a high probability of cognitive association with each of 3 racial categories – African American, Hispanic/LatinX, White (Gaddis, 2017a,b). A question that has emerged in prior correspondence studies using racialized names is the possibility that any given name may signal race as well as other unobserved characteristics such as income (Guryan and Charles, 2013, Fryer Jr and Levitt, 2004). To test this empirically, we construct groups with each consisting of 3 male and 3 female names and stratify the sample of first names using statistical distribution of mother's educational attainment (low, medium, and high) from hospital birth records. The first name labels for this study are constructed using recent experimental work that tested the racialized perceptions of first and last names for African American, Hispanic/LatinX, and White social groups (Gaddis, 2017a,b). Last name labels were also taken from this work and

[2] A nearby facility is defined as a facility within one mile of the zip code boundary. High emitting facilities are defined as those with annual emissions ('stack and fugitive air releases') that fall above the 80th percentile of annual emissions.

tested for any geographic variability using related research (Crabtree and Chykina, 2018). Each of the resulting name groups consists of three male and three female names, one drawn from each of three levels of maternal educational attainment (high/medium/low).

Each rental apartment receives a sequence of three separate inquiries in the course of an experimental trial. The sequence of inquiries from the different race groups is randomized and inquiries for the same listing are never sent from two different identities on the same day.[3] Responses to inquiries are coded using two criteria that determine whether or not a housing choice is made available: (1) a response is received within 7 days of the associated inquiry and (2) the response indicates that the property is available for rent.[4] Discriminatory constraints are expressed in terms of *relative response rates*, which measure within-property differences in access to a given listing relative to an inquiry sent from a White name (the comparison group). We use the terms relative response rates, response rates, and likelihood of response interchangeably to refer to this measure throughout the paper.

Within each zip code, the concentration of airborne toxics is measured using the level of ambient concentrations in 810 square meter grid cells in the US Environmental Protection Agency's Risk-Screening Environmental Indicators (RSEI) Model. We use the RSEI measure of toxic concentration to define the level of exposure at each of the properties in the sample of available listings – the terms concentration and exposure are used interchangeably to refer to the RSEI measure at residential locations. Panel B of Figure 1 maps the locations of emissions sources, RSEI concentrations, and the approximate locations of properties using 2 of the zip codes in the sample.[5]

Figure 2 provides a descriptive analysis of the race gap in exposures in the sample using data on the renter populations data from the 2016 American Community Survey (ACS). The top panel summarizes the within-zip share of renters living in the highest quartile (and interquartile range) of exposures, relative to the lowest quartile. Dotted

[3]Balance tests are reported in Table A3.

[4]52% of responses are received within the first 8 hours of an inquiry, 74% are received within 24 hours and 98% are received within 5 days. The 7-day cutoff is used to restrict responses that may be received weeks or months after an inquiry and are not counted as choices in the study. We refer interested readers to Figure A6 for the distribution of inquiry response time in the sample.

[5]Maps of all zip codes provided in Figure A3.

lines illustrate the differences for the African American and Hispanic/LatinX groups relative to White renters. The bottom panel plots the fraction of the population shares for each group living in each quantile of the RSEI distribution for each zip code. Two facts emerge from the ACS data: (1) the relative shares of minority households living in the highest quartile of exposures is 60% higher for African Americans and 58% higher for Hispanix/LatinX residents than for the population of White renters and (2) households in all race groups sort across the full support of the exposure distribution in their zip code.

3 Housing Discrimination and Toxics Exposures

We estimate relative response rates using a within-property conditional logit estimator that measures the likelihood of access to listing j for a minority identity i (treatment), relative to an inquiry made to the same listing (j) from a White identity (comparison):

$$P(response_{ij}) = \sum_{\substack{Race\in\{Af.\,Am.,\\ LatinX\}}} \sum_{j} (\beta_{j,race} 1[i \in b_j] \times Race) + \theta X_i + \alpha_j + \epsilon_{ij} \qquad (1)$$

where b denotes a bin of within-zip toxic concentration. *Race* indicates the race group associated with the identity from which an inquiry is sent. X_i is a vector of individual control variables: gender, education level and the order in which the inquiry was sent. Point estimates are not sensitive to the inclusion of controls though precision increases slightly.[6] α_j is a listing fixed effect.

The primary set of tests defines exposures using ambient concentrations from the RSEI model and concentrations are divided into 3 bins: 0-25%, 25-75%, 75-100%. A second set of tests defines exposures according to distance from active TRI facilities, which have been shown to directly affect the health outcomes of the in utero population.[7]

[6]See Table A5 for comparison across specifications.
[7]RSEI concentrations are strongly but not perfectly correlated with ambient concentrations studied in the tests reported in Figure 3. Figure A5 plots the distribution of properties in each RSEI percentile by distance to TRI plants for the full sample. Figure A3 maps the relationship for each individual zip code.

Discrimination by RSEI Concentration

Figure 3 plots estimates of within-property response rates at different levels of pollution exposure, where exposures are defined using the RSEI measure of toxic concentrations, with properties divided into the lowest quartile, the interquartile range, and in the highest quartile of ambient emissions concentrations within a zip code. The plots measure differential constraints within the full set of properties simultaneously listed for rent in markets containing a major emissions source. Panel A plots estimates of discriminatory constraints facing minority identities as a whole. We estimate a 59% relative response rate to inquiries for properties located in the lowest quartile of the within-zip toxics concentration, indicating that inquiries from minority identities are 41% less likely to yield choices for minority renters at low levels of exposure. The strength of choice constraints declines as toxic exposure increases within a zip code. The relative response rate is 71% in the interquartile range of exposures. Among properties located in the *highest* quartile of toxics exposures, we find no statistical difference in the rate of response to minority identities. Taken together, these findings imply that minority households face ex ante constraints that increase access to housing choices in high exposure locations relative to low exposure locations.

Panel B plots estimates independently for African American and Hispanic/LatinX identities. While both groups face discriminatory constraints at low exposure locations, the relative response rates are substantially lower for African American identities (45%) than for Hispanic/LatinX identities (78%). Discriminatory constraints are smaller for both groups in the interquartile range of exposure risk. At the highest levels of exposure risk within a zip code, response rates to African American identities are equivalent to the White names. At high exposure locations, Hispanic/LatinX identities are 34% *more likely* than a White identity to receive a response.

Panel C provides evidence of stronger discriminatory constraints facing male minority identities, especially among properties at low exposure risk. We estimate relative response rates of 46% for minority male identities versus 79% among minority female identities.

We conduct additional tests to further decompose and explore these effects.[8] We find that the strongest discriminatory constraints in inquiries sent from African American male identities, where relative response rates are 28% in low exposure locations. We test for heterogeneity in within-group differences in response rates using first names associated with high/medium/low levels of maternal educational attainment. These tests provide suggestive evidence of somewhat stronger constraints facing minorities with names that signal a low SES background, though we do not detect statistical differences in the strength of constraints facing low/medium/high minority identities in low exposure zones. When facing discriminatory constraints, renters may also make multiple inquiries about a property to increase the likelihood of gaining access. We simulate this process by running two rounds using the same names. All tests indicate a *stronger* discriminatory response in follow-up inquiries. Whereas response rates for first inquiries are 58% from minority identities, 41% from African American identities, and 86% from Hispanic/LatinX identities, response rates to second inquiries are 38% from minority, 51% from Hispanic, and 27% from African American identities.[9]

Discrimination by Distance to Emissions Source

Prior work provides direct evidence that in utero exposures resulting from residential location choices surrounding TRI facilities have important effects on gestation and birthweight and that ambient pollution decays rapidly as a function of distance to the nearest plant, such that damages are concentrated within 1 mile (Currie et al., 2015, Currie and Schmieder, 2009).

Figure 5 reports evidence on discriminatory constraints using distance to the nearest TRI facility. The results mirror the findings on concentrations. We find no statistical difference in relative response rates among properties located within the 1 mile radius, indicating that minority renters do not face discriminatory barriers to access at locations that are linked to a 3-5% increase in the probability of low birth-weight (Currie et al., 2015). Among properties located beyond 1 mile from a TRI facility, we find a 66%

[8]We refer interested readers to Tables A9, and A10

[9]Results provided in Table A7.

response rate to inquiries made from minority identities. The tests again reveal substantially stronger constraints facing African American identities (52%) when compared to Hispanic/LatinX identities (83%). In high exposure zones, we detect no evidence of statistical differences facing African American identities and a 15% *higher* relative response rates for inquiries made from Hispanic/LatinX identities. These estimates provide evidence that discriminatory constraints reduce housing choices at safe distances from TRI facilities and, through that mechanism, may contribute to adverse gestational outcomes in minority households.

4 Heterogeneity in Discriminatory Constraints

Given the within-property randomization, the estimates in the prior section provide evidence on the discrimination-exposure relationship among all available properties in our sample of markets and indicates that discriminatory constraints limit the access of minority renters to housing in low exposure zones. In this section, we dig deeper into this relationship by examining how it varies with other housing and neighborhood attributes. Not surprisingly, properties in low/high exposure locations vary along several dimensions. The average price of a rental property in the highest quartile of within-zip toxics exposure is $278 lower than those in the lowest quartile. High exposure properties are more likely to be apartments in multi-family buildings and located in census block groups with higher shares of African American households, lower shares of Hispanic/White households, higher poverty rates, and higher rates of college educated households.[10] Results reported in Figure 4 examine heterogeneity in discriminatory constraints by: A) neighborhood racial composition, (B) rental price, and (C) the full set of matched housing and neighborhood characteristics available on the rental search platform.

Prior work demonstrates that discriminatory constraints tend to be stronger in neighborhoods with a higher share of non-minority (White) households (Hanson and Hawley, 2011, Ewens et al., 2014, Christensen and Timmins, 2018). This is illustrated in Panel A,

[10] See Table A2 for descriptive statistics of complete set of characteristics for properties in the sample and tests of differences by quartile of concentration.

which plots relative response rates for listings in census block groups with shares of minority households that fall above or below the median share in a zip code. The strongest constraints facing minorities are observed in low exposure zones with low shares of minority households. Relative response rates in the lowest quartile of concentrations are 40% in census block groups with below-median minority shares and 72% among census block groups with above-median minority shares. In the interquartile range of exposures, relative response rates are 71% among census block groups with below-median minority shares and 70% among census block groups with above-median minority shares. In the upper quartile of exposures, relative response rates are 150% among census block groups with above-median minority shares and 95% (not statistically significant) among census block groups with below-median minority shares.

Plots in Panel B examine discriminatory constraints among listings that fall above or below the median rental price within a zip code. These results indicate that minority identities face the strongest constraints when requesting properties listed at high prices in low exposure zones. Minority response rates are 55% for high priced properties in low exposure locations in the sample. Relative response rates are highest among low priced properties in high exposure zones. In both quantiles of the price distribution, constraints are stronger in low exposure than in high exposure locations. In an alternate test, we restrict the sample to listings that fall within 25% of the median rent in each zip code and find consistent results.[11]

Estimates in Panel C compare response rates among properties that are matched on price as well as housing/neighborhood characteristics that are visible to renters on the search platform.[12] These tests examine relative response rates among comparable properties that are simultaneously listed for rent and therefore reflect exact differences in comparable choices available to prospective renters in these markets at the time of the experiment. Response rates at each level of toxics exposure (quartile) are estimated

[11]We refer interested readers to Figure A8, which provides tests using a restricted sample of listings that fall within 25% of the median rent in each zip code.

[12]Housing characteristics include: rental price, bedrooms, bathrooms, square footage, and building type. Neighborhood characteristics include: crime, nearby grocery stores, demographic composition of census block group (share White, Black, Hispanic), poverty rate, unemployment rate, and share college educated.

relative to the most comparable properties at the other levels. 966 unmatched properties are dropped from this test, reducing the sample size to 1,275. Response rates in the matched test (62%) are highly similar to those in the full sample test (59%) in the lowest quartile of exposures, indicating that the relationship between choice constraints and toxic concentrations is present when accounting for differences in other housing and neighborhood characteristics. Estimates of response rates for the interquartile range of concentrations are less precise, likely resulting from the sampling restriction. Differences at the highest level of concentrations are somewhat smaller than, though not statistically different from, the full sample test.

5 Conclusion

For over two decades, researchers have advanced a *racial discrimination hypothesis* to explain the factors underlying the disparity in exposures to chemical toxics and other harmful pollutants in the United States. However, no prior study has provided an empirical test. This paper presents experimental evidence that racial discrimination constrains the housing choices of minority households with respect to major polluting facilities in the United States. We find that Hispanic/LatinX and African American renters face strong discriminatory constraints when searching for housing that would limit their exposure to emissions from major sources of chemical toxics in the US.

When initiating a search in a market containing a major pollution source, discriminatory behavior reduces the likelihood of response to minority renters with racially perceptible names by 41% in low exposure locations. Among African American renters, discriminatory behavior reduces the likelihood of response by 55% and by 72% for African American men. We find no evidence of discriminatory constraints operating in the high exposure zones of the same markets. The pattern holds in tests between properties that are matched on comparable characteristics, in different segments of the rental price distribution, and in neighborhoods with different shares of minority households. By reducing the set of choices available in less polluted neighborhoods relative to more polluted ones, choice constraints resulting from discriminatory behavior increase the cost of averting prolonged exposures to chemical toxics and directly affect the welfare of households that value clean air.

We emphasize the need for further study of the effects of discriminatory constraints on the location choices of minority households and highlight four limitations of the correspondence design to be addressed in future research. First, the present experimental results are limited to listings that appear on a single rental housing platform. There is evidence that digital platforms are used to initiate the majority of rental housing search processes in the US, but the study does not account for sub-markets that are advertised separately. Second, our estimates reflect the signal produced by a sample of names that is designed to elicit racialized perceptions and allows for analysis of heterogeneity in the effects by gender and maternal educational attainment. It is not representative of the total population of renters in the United States. Third, correspondence research designs do not capture discrimination in subsequent interactions that could further affect the probability of a viable lease.

Finally, the effects of constraints found in this study ultimately depend upon the extent to which they bind on the decisions of minority households. While correspondence designs provide important information on ex ante constraints, they do not alone provide information on the market outcomes of individuals that face discrimination. In ongoing research, we further examine interactions between discriminatory constraints and incomes, neighborhood preferences, and additional factors that also contribute to differential sorting behavior (Christensen and Timmins, 2020). In some settings, renters may not search in neighborhoods where discriminatory constraints bind or may invest in additional search to avoid adverse outcomes such as local pollution exposures. Data on renter population distributions from the ACS provides evidence that minority households sort across the full support of the distribution of pollution exposures in our study area and tend to sort into neighborhoods with elevated exposures. This indicates that while some minority households may structure their search or invest in additional search to avoid high exposure locations, others do not. These findings suggest that discriminatory behavior increases the cost of avoiding harmful exposures and suggest that reducing illegal discriminatory behavior could be important for reducing the racial gap in pollution exposures in the US.

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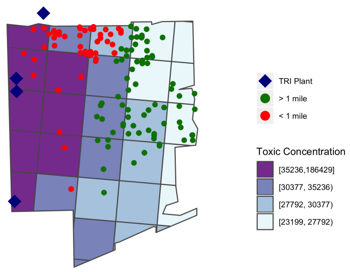
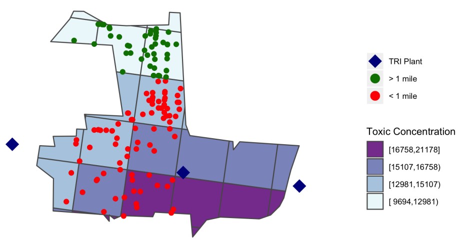
Tables and Figures

Figure 1. Zip Codes Within One Mile of a TRI Facility and Two Sample Zip Code Maps

Zip Codes Within One Mile of a TRI Facility



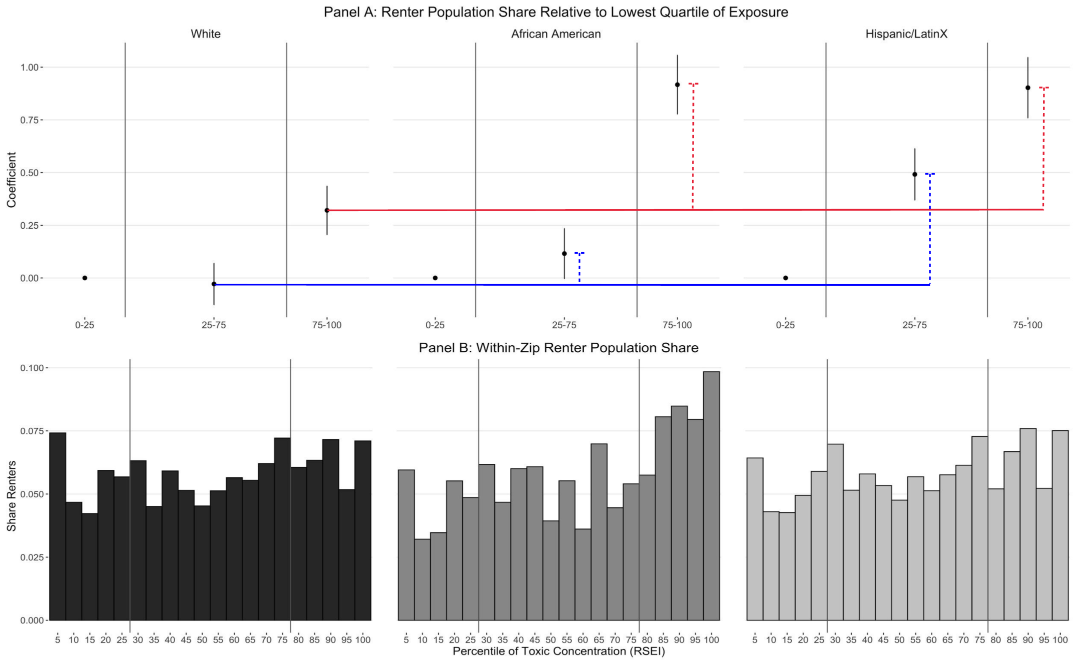
Sample Zip A



Sample Zip B

Note: Figure maps the 111 zip codes that are above the 80th percentile of TRI stack air releases, which are listed by name in Table A1. The lower panel maps two sample zip codes that are included in the experimental sample. Grid cells are shaded according to quartiles of RSEI toxic concentration. The blue rhomboids denote the location of TRI facilities. Circular markers illustrate property listings where the experiment was conducted, with red markers illustrating the sample of listings within one mile of a toxic plant and green markers denoting listings outside 1 mile. Refer to Figure A3 for full set of maps of zip codes in the experimental sample.

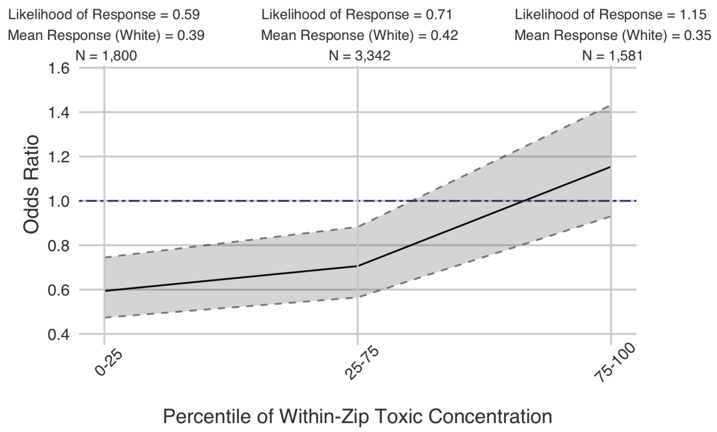
Figure 2. Observed Exposure Gap and Renter Population Distribution



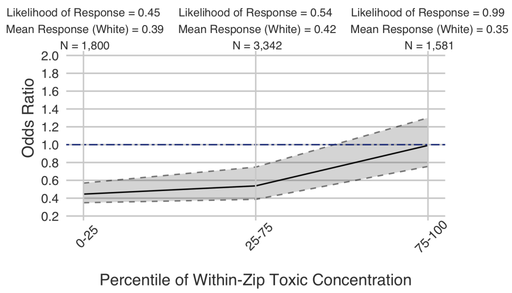
Note: Panel A panel plots differences in renter population shares in the highest quartile and interquartile range of toxic concentration exposures relative to lowest quartile (omitted category) for each racial group. Points represent coefficients with lines show 90% CI from the following regression: $y_{ij} = \beta_0 + \beta_{25-75} RSEI_{25-75} + \beta_{75-100} RSEI_{75-100} + \alpha_j + \epsilon_{ij}$, where y_{ij} is the inverse hyperbolic sine of renter population in block i from zip j. $RSEI_{25-75}$ is an indicator that takes the value one if the block is in the interquartile range and $RSEI_{75-100}$ if in the highest quartile of exposures. α_j is a zip code specific fixed effect. Vertical red dotted lines illustrate the size of the exposure gap in terms of differences in renter shares living at high versus low exposures for each minority group, relative to White renters. Vertical blue dotted lines illustrate the size of the exposure gap in terms of differences in renter shares living at interquartile versus low exposures for each minority group, relative to White renters. Panel B illustrates raw renter population shares by within-zip toxic concentration exposure percentile. Vertical lines delineate bin definitions used in both panels. Data for renters in block group comes from the 2016 ACS.

Figure 3. Relative Response Rates by Within-Zip Toxic Concentration

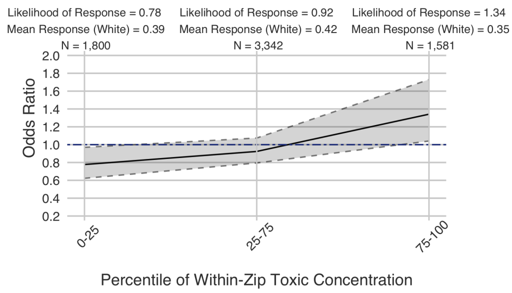
Panel A: Minority



Panel B: African American vs Hispanic/LatinX

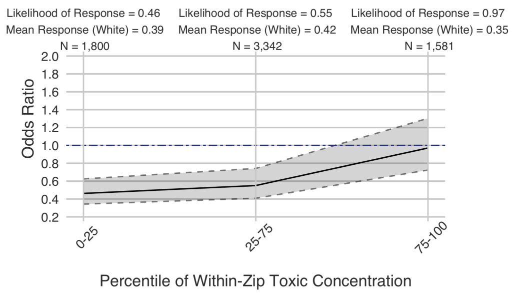


(a) African American

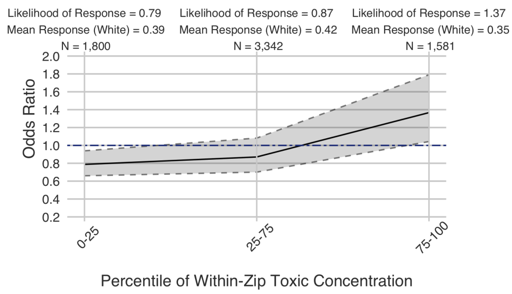


(b) Hispanic/LatinX

Panel C: Male vs Female



(c) Male

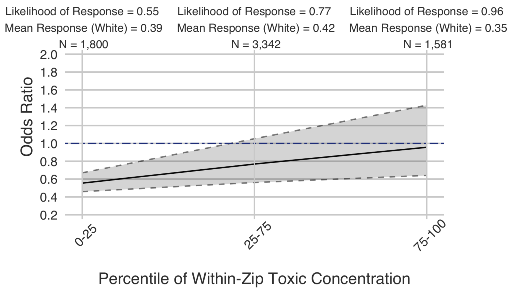


(d) Female

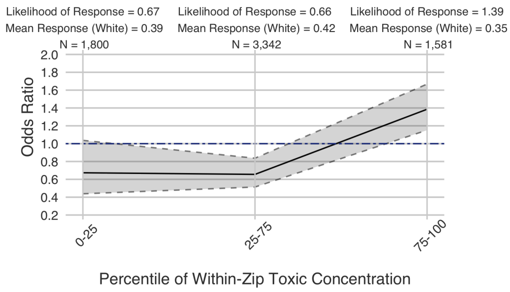
Note: Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the White identity. Standard errors clustered at the census tract level. 90% confidence intervals are plotted in grey. Refer to Table A5 for full set of point estimates and significance tests at 10%, 5% and 1% levels, for different sets of controls. All estimates are robust to inclusion/omission of controls.

Figure 4. Relative Response Rates by Within-Zip Toxic Concentration

Panel A: Above vs Below Median Rent

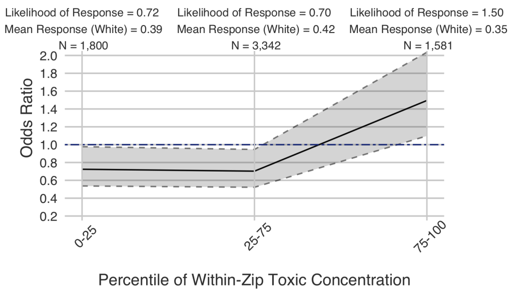


(A.1) Above Median Rent

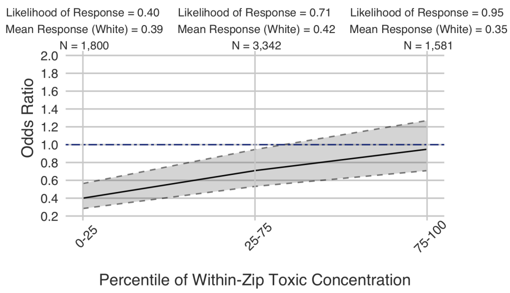


(A.2) Below Median Rent

Panel B: Demographic Composition, Above vs Below Minority Shares

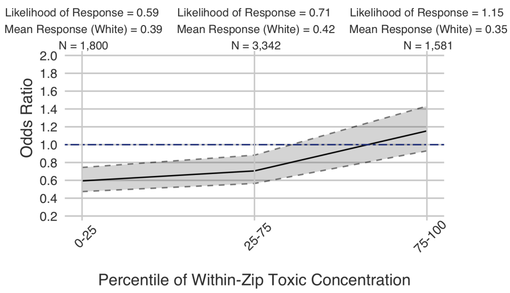


(B.1) Above Median Minority Share

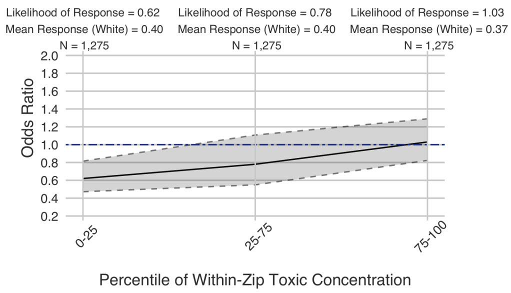


(B.2) Below Median Minority Share

Panel C: Full vs Matched Sample



(C.1) Full Sample

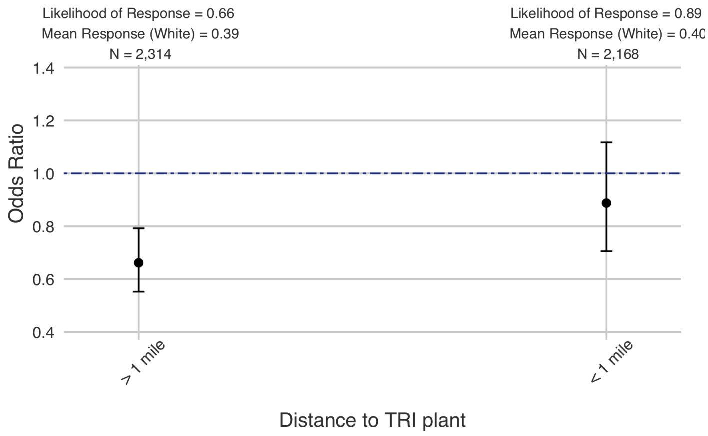


(C.2) Matched Sample

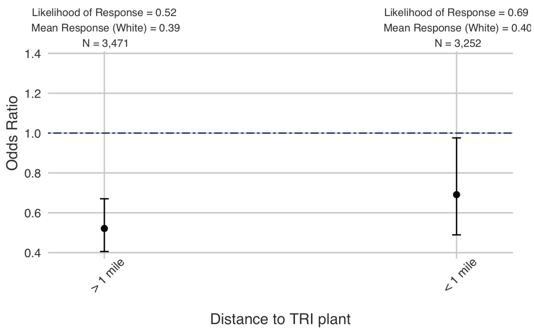
Note: Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the white identity. Standard errors clustered at the census tract level. Whiskers denote 90% confidence intervals.

Figure 5. Relative Response Rates by Proximity to Closest TRI Plant

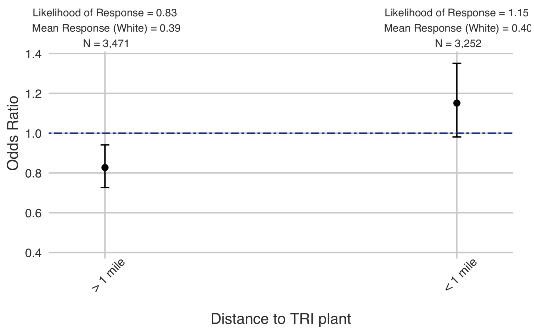
Panel A: Minority



Panel B: African American vs Hispanic/LatinX



(a) African American



(b) Hispanic/LatinX

Note: Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the White identity. Standard errors clustered at the census tract level. Whiskers denote 90% confidence intervals. Refer to Table A5 for full set of point estimates and significance tests at 10%, 5% and 1% levels.

Appendix

Experimental Design: Sample of Housing Markets and Rental Properties

The study focuses on exposures to toxic emissions reported in the Toxic Release Inventory (TRI), which identifies the exact location of major point sources in housing markets throughout the United States. Based on prior research reported in Currie et al. (2015), we define a potential study area that consists of all zip codes that contain at least one high-emitting TRI facility, defined using stack air emissions above the 80th percentile, located within one mile of a residential neighborhood. Table A1 lists the 111 zip codes that contain a high-emitting facility and at least 150 rental housing listings at the time of sample construction in September 2018.

Table A1. Zip Codes within One Mile of a Toxic Plant

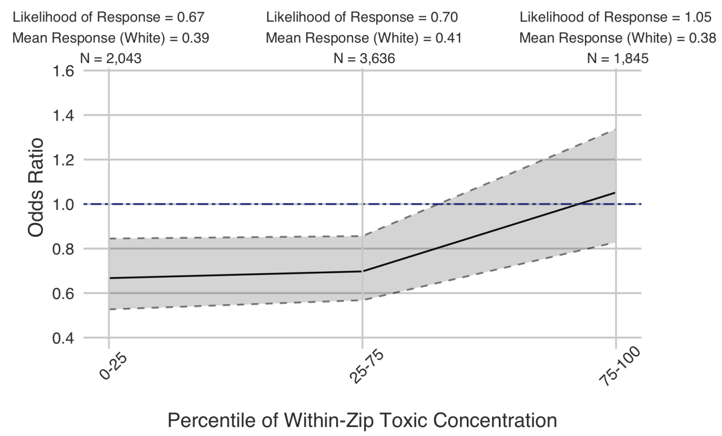
Zip code	City	State	Zip code	City	State	Zip code	City	State
35215	Birmingham	AL	60641	Chicago	IL	12866	Saratoga Springs	NY
85281	Tempe	AZ	60617	Chicago	IL	10012	New York	NY
85705	Tucson	AZ	60657	Chicago	IL	10009	New York	NY
92118	Coronado	CA	60617	Chicago	IL	10028	New York	NY
92672	San Clemente	CA	60616	Chicago	IL	10010	New York	NY
92101	San Diego	CA	60623	Chicago	IL	10016	New York	NY
92037	La Jolla	CA	61820	Champaign	IL	11206	Brooklyn	NY
90802	Long Beach	CA	60618	Chicago	IL	10021	New York	NY
80210	Denver	CO	60615	Chicago	IL	11238	Brooklyn	NY
80211	Denver	CO	60613	Chicago	IL	43201	Columbus	OH
20002	Washington	DC	60624	Chicago	IL	44107	Lakewood	OH
20001	Washington	DC	60647	Chicago	IL	73505	Lawton	OK
20009	Washington	DC	60651	Chicago	IL	19146	Philadelphia	PA
33021	Hollywood	FL	60619	Chicago	IL	19147	Philadelphia	PA
33025	Hollywood	FL	47906	West Lafayette	IN	19128	Philadelphia	PA
33312	Fort Lauderdale	FL	70118	New Orleans	LA	19148	Philadelphia	PA
33404	West Palm Beach	FL	70115	New Orleans	LA	19145	Philadelphia	PA
33410	West Palm Beach	FL	21224	Baltimore	MD	29403	Charleston	SC
32169	New Smyrna Beach	FL	21201	Baltimore	MD	37040	Clarksville	TN
33418	West Palm Beach	FL	21230	Baltimore	MD	37042	Clarksville	TN
33602	Tampa	FL	21229	Baltimore	MD	37042	Clarksville	TN
33178	Miami	FL	49503	Grand Rapids	MI	76549	Killeen	TX
33179	Miami	FL	63118	Saint Louis	MO	78666	San Marcos	TX
34243	Sarasota	FL	63118	Saint Louis	MO	79938	El Paso	TX
33019	Hollywood	FL	58103	Fargo	ND	79936	El Paso	TX
33018	Hialeah	FL	88101	Clovis	NM	77007	Houston	TX
33301	Fort Lauderdale	FL	10002	New York	NY	76543	Killeen	TX
33480	Palm Beach	FL	11211	Brooklyn	NY	78130	New Braunfels	TX
33033	Homestead	FL	11101	Long Island City	NY	77479	Sugar Land	TX
33407	West Palm Beach	FL	11217	Brooklyn	NY	77450	Katy	TX
33316	Fort Lauderdale	FL	11222	Brooklyn	NY	77054	Houston	TX
33020	Hollywood	FL	10022	New York	NY	77479	Sugar Land	TX
30906	Augusta	GA	11201	Brooklyn	NY	54751	Menomonie	WI
30309	Atlanta	GA	11205	Brooklyn	NY	54901	Oshkosh	WI
52240	Iowa City	IA	10065	New York	NY	53202	Milwaukee	WI
60614	Chicago	IL	10003	New York	NY	53212	Milwaukee	WI
60608	Chicago	IL	10314	Staten Island	NY	26505	Morgantown	WV

Note: Sample of zip codes with reported emissions that fall above the 80th percentile of the TRI, which constitute potential zip codes in the study.

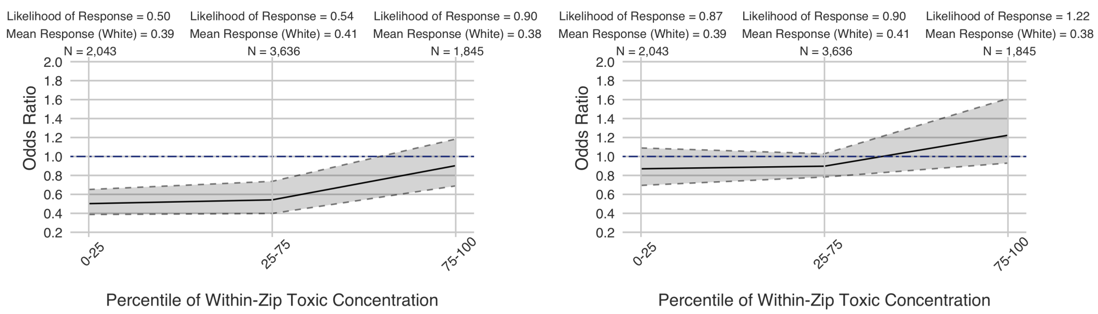
Figure 1 maps the zip codes with high emitting facilities. We select a random sample of zip codes from this set and compile the full set of property listings in each zip. We exclude zip codes that do not have at least 30% of listings within and at least 30% of listings beyond 1 mile of a facility, which is necessary to ensure the statistical power of tests for discriminatory response by exposure zone/level. Zip codes were sampled at random until the total sample of listings matched the number that was suggested by ex ante power calculations (2400-2700 listings). The full experimental sample includes 2,918 listings distributed across 19 zip codes. Of the total sample, 3 zip code trials were dropped as a result of small samples of listings when the trial was run (less than 30 listings) and 2 were dropped as a result of concern about rate limiting practices on the online platform during the associated trials. Rate limiting can affect experimental results by reducing the likelihood that property managers receive an inquiry and artificially lowering average response rates. We report estimates from the full sample of listings in Figures A1 and A2. Point estimates are consistent with the primary results, although the estimates are somewhat less precise. After removing the rate-limited trials from the dataset, the resulting sample includes 2,241 listings distributed across 14 zip codes.

Figure A1. Relative Response Rates by Within-Zip Toxic Concentration
Full Set of Experimental Zip Codes

Panel A: Minority



Panel B: African American vs Hispanic/LatinX

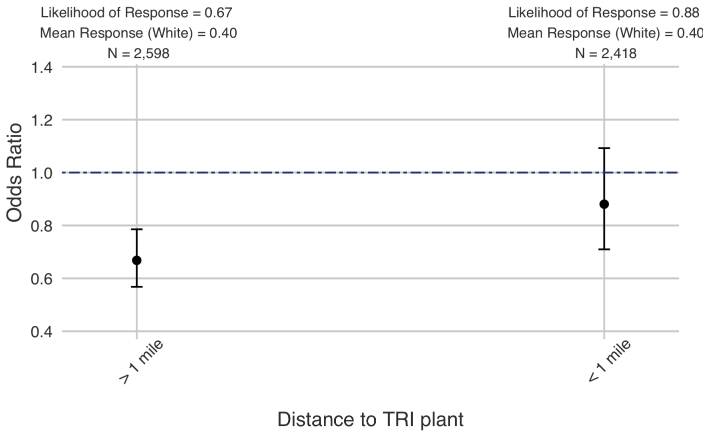


(a) African American (b) Hispanic/LatinX

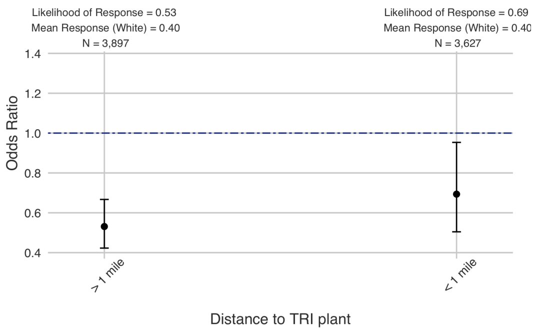
Note: The sample is restricted to properties within 25% of the median rent, reducing the sample to 1,164 listings (3,492 observations). Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the White identity. Standard errors clustered at the census tract level. 90% confidence intervals are plotted in grey.

Figure A2. Relative Response Rates by Proximity to Closest TRI Plant
Full Set of Experimental Zip Codes

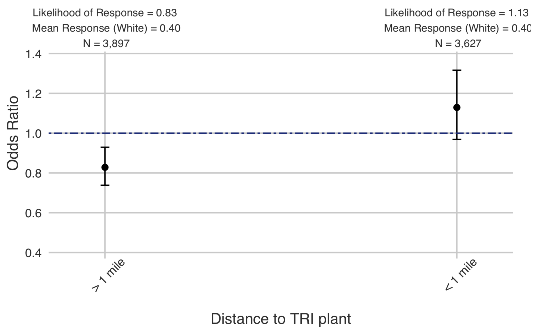
Panel A: Minority



Panel B: African American vs Hispanic/LatinX



(a) African American

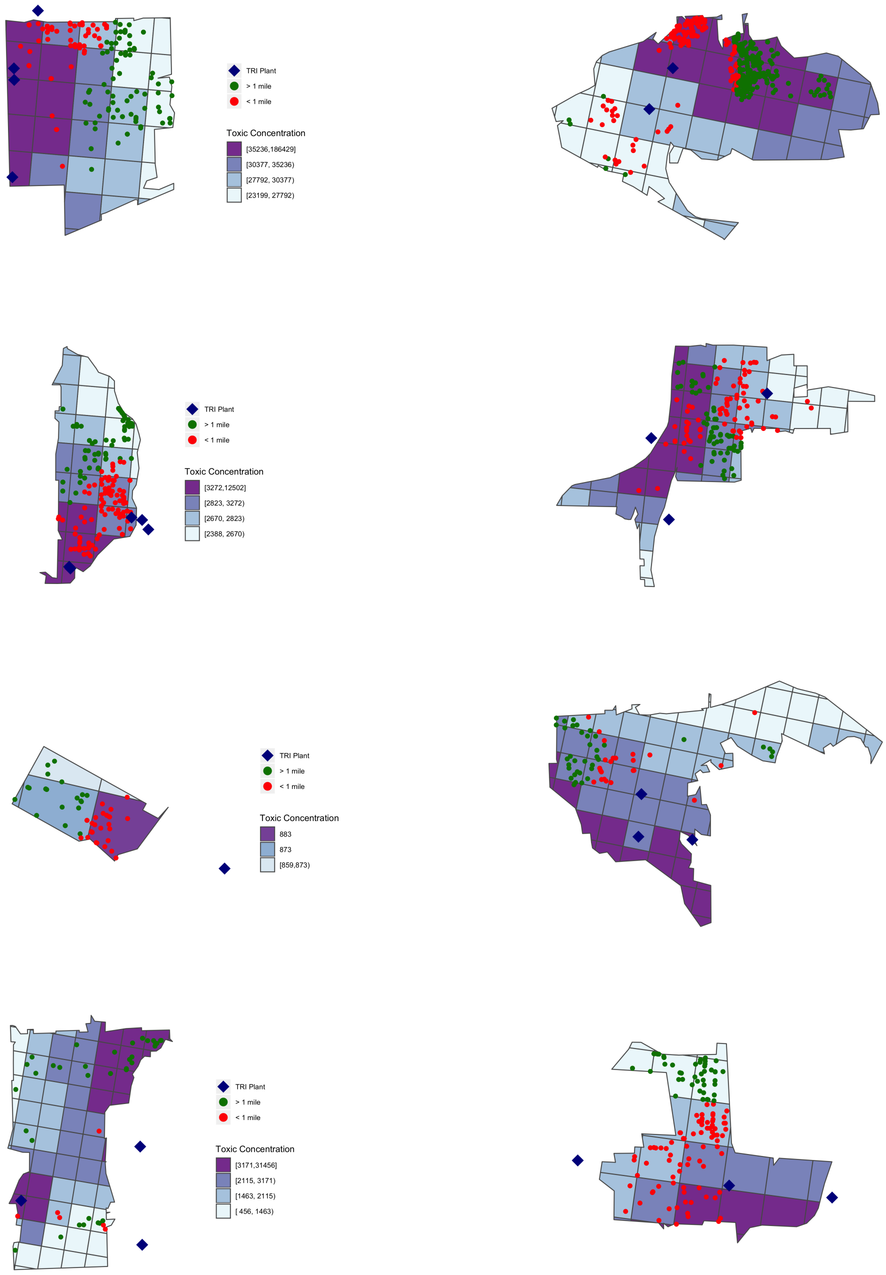


(b) Hispanic/LatinX

Note: The sample is restricted to zip codes where the withing-zip RSEI toxic concentration is congruent with the distance to the TRI facility. Two zip codes are dropped from the sample. Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the White identity. Standard errors clustered at the census tract level. Whiskers denote 90% confidence intervals.

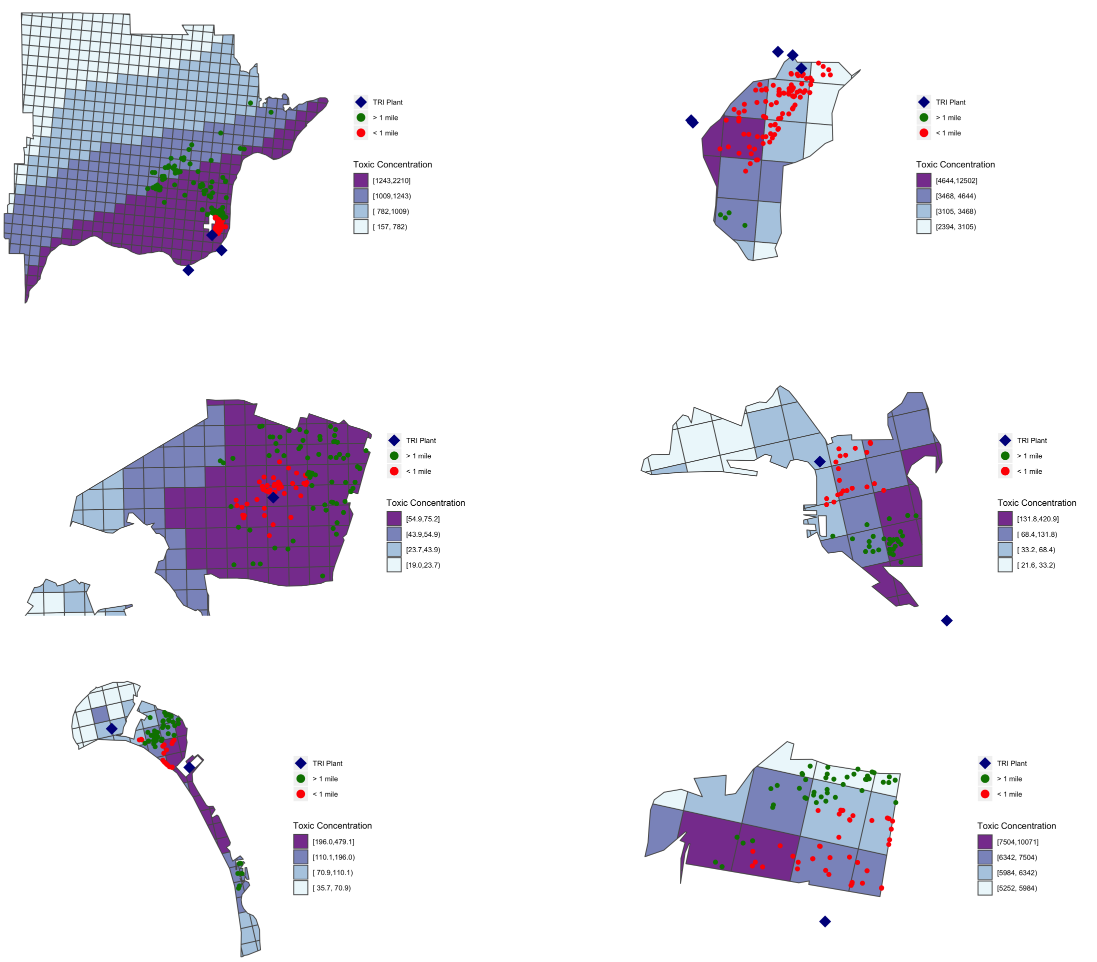
We define the level of exposure for each of the properties within the resulting sample based on their ambient concentrations of toxic pollutants using the Risk Screening Environmental Indicators (RSEI) measure developed by the US Environmental Protection Agency. Facilities report stack and fugitive air releases, direct water releases, and transfers to publicly-owned treatment works to the TRI in pounds per year. Aggregate concentrations in the RSEI model include the fate and transport of all chemical releases in the TRI and apply an inhalation toxicity weight. Direct water releases and transfers to publicly-owned treatment works (POTWs) use the higher of the oral slope factor toxicity weight or the reference dose toxicity weight for the chemical. Air releases and off-site transfers to incineration use the higher of the inhalation unit risk toxicity weight or the reference concentration toxicity weight. Figure A3 maps the locations of properties with respect to high-emitting facilities and gridded measures of concentrations from the RSEI model.

Figure A3. Zip Codes in Experiment



Note: Figure shows zip codes where the experiment was conducted. Shades of purple denote the quartiles of RSEI toxic concentration. The blue rhomboids denote the location of TRI plants. Circular markers illustrate property listings where the experiment was conducted, with red markers illustrating the sample of listings within one mile of a toxic plant and green markers denoting listings outside 1 mile.

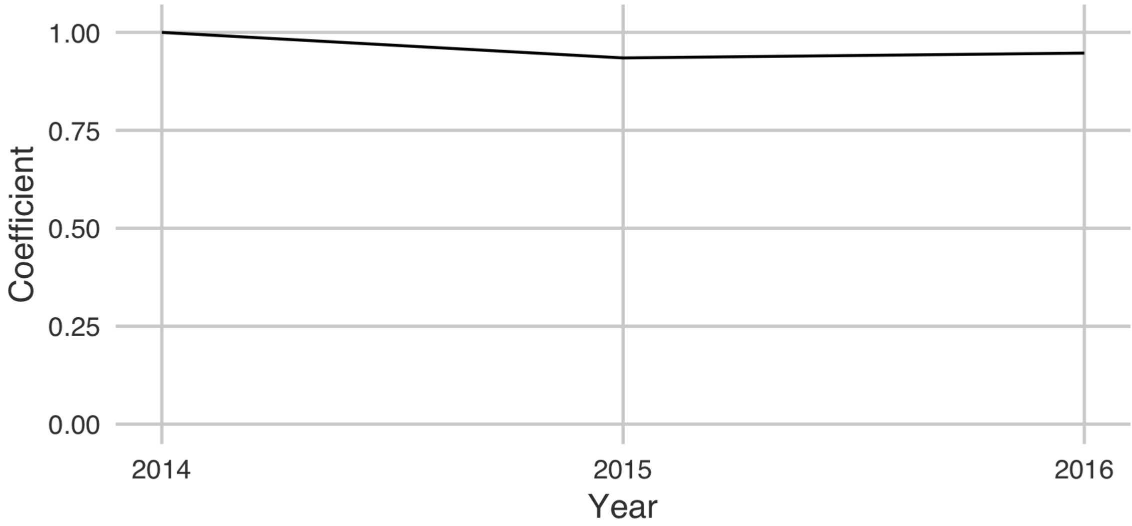
Figure A3.(cont.) Zip Codes in Experiment



Note: Figure shows zip codes where the experiment was conducted. Shades of purple denote the quartiles of RSEI toxic concentration. The blue rhomboids denote the location of TRI plants. Circular markers illustrate property listings where the experiment was conducted, with red markers illustrating the sample of listings within one mile of a toxic plant and green markers denoting listings outside 1 mile.

We use a measure of concentrations from the RSEI model that correspond to TRI emissions in 2016, which is the most recent available data. The experimental was conducted during 2018-2019. In order to evaluate the time-consistency of RSEI estimates, Figure A4 plots the correlation between observations in the percentile of exposure in our study area using the RSEI measure of concentrations during the 3-year period from 2014 to 2016. The figure indicates a correlation of over 90% across the 3-year period.

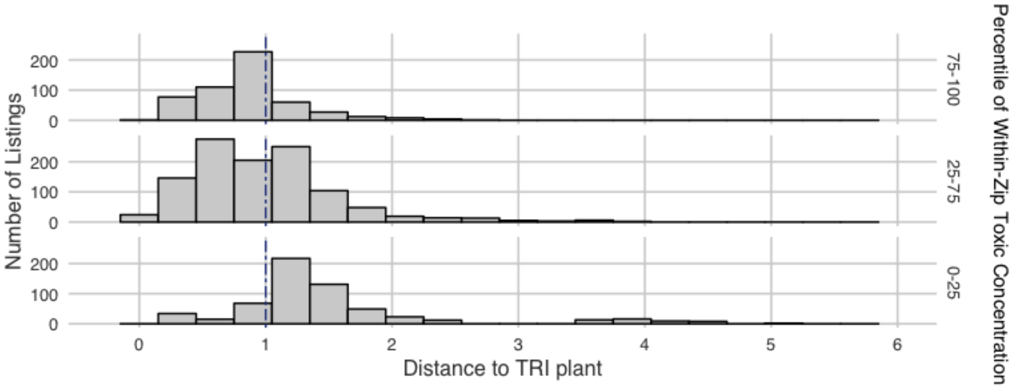
Figure A4. Persistence in Percentiles of Within-Zip Toxic Concentration



Note: Figure shows correlation of percentiles of RSEI measure of toxic concentration during the 3-year period (2014-2016).

We study the relationship between housing discrimination in high/low exposure zones using the definition of a high exposure area (within a mile of the toxic plant) that is consistent with prior evidence of gestational and birth-weight effects resulting from in utero exposures (Currie et al., 2015). Figure A5 plots the distribution of properties that are located within vs. outside 1 mile of a TRI facility for each quantile of within-zip toxics concentrations (RSEI). It is clear that the majority of properties in the upper quartile of concentrations are located within 1 mile of a facility and the majority of properties in the lowest quartile are located beyond 1 mile. The distribution of properties in the interquartile range of RSEI concentrations are relatively evenly located within/beyond 1 mile. The figure also illustrates that proximity is not a perfect measure of exposure in the sample, as there are some properties located within 1 mile that have low levels of exposure and vice versa.

Figure A5. Listings Within-Zip RSEI Toxic Concentration and Proximity to closest TRI



Note: Figure plots the number of listings by distance to TRI plant and percentiles of within-zip toxic concentrations in the sample. Dotted vertical line denotes the one mile threshold used to estimate differences.

Table A2 details the characteristics of properties at different levels of concentrations as well as reporting tests for within-zip differences in property/neighborhood characteristics. On average, toxic concentrations for properties in the highest quartile are 2,786 points higher than those in the lowest quartile. The RSEI cancer scores for these properties are 2.7 points higher and the non-cancer scores are 4.2 points higher. We also find significant differences in the rental prices and housing/neighborhood characteristics of properties in the different quartiles. Properties in the highest quartile are 10% less likely to be a single-family residence and more likely to be an apartment in a multi-family building. The rental prices of properties at higher concentrations are $278/month lower than properties at lower exposures. On average, they tend to have 0.13 fewer bedrooms. They also tend to be located in neighborhoods with fewer grocery stores, lower shares of Hispanic and White residents, but higher shares of African American residents. On average, they have higher poverty rates and higher shares of college educated residents.

Table A2. Property and Neighborhood Descriptive Statistics

	Percentiles of Within-Zip Toxic Concentration				
	0th-25th	25th-75th	75th-100th	Within-Zip Differences	
	(1)	(2)	(3)	(2)-(1)	(3)-(1)
Toxic Concentration	11,903	19,730.42	30,604.08	2,786.9153***	15,908.901***
	(11,986.91)	(23,090.97)	(46,262.32)	(494.7659)	(568.8277)
Cancer Score	5.76	7.87	10.36	1.2118***	2.7121***
	(9.59)	(11.31)	(15.16)	(0.2266)	(0.2605)
Non Cancer Score	3.23	5.79	6.27	3.5886***	4.198***
	(10.37)	(13.04)	(12.17)	(0.2633)	(0.3027)
Rent	2,234.58	1,703.08	1,839.93	-312.8947***	-278.8914***
	(2,435.61)	(1,335.09)	(1,549.37)	(38.309)	(43.9744)
Single Family Home	0.21	0.17	0.11	-0.0486***	-0.1018***
	(0.41)	(0.38)	(0.32)	(0.0106)	(0.0122)
Apartment	0.13	0.13	0.15	-0.0081	0.0282**
	(0.33)	(0.34)	(0.36)	(0.0099)	(0.0114)
Multi Family	0.49	0.52	0.58	0.0241*	0.0588***
	(0.5)	(0.5)	(0.49)	(0.0133)	(0.0153)
Other Bldg. Type	0.17	0.18	0.16	0.0326	0.0149
	(0.37)	(0.38)	(0.36)	(0.009)	(0.0104)
Bedrooms	2.43	2.27	2.33	-0.1332***	-0.1303***
	(1.13)	(0.98)	(0.93)	(0.029)	(0.0333)
Bathrooms	1.54	1.43	1.48	-0.0975***	-0.0259
	(0.76)	(0.63)	(0.64)	(0.0182)	(0.021)
Sqft.	716.33	749.19	694.33	-16.9457	5.2839
	(730.21)	(759.09)	(756.27)	(21.8172)	(25.0831)
Assault	220.55	183.76	253.29	-15.2645***	4.6102
	(319.98)	(272.19)	(387.81)	(4.1403)	(4.7565)
Groceries	31.93	25.14	28.44	-0.8493**	-2.9999***
	(44.01)	(22.79)	(35.54)	(0.3659)	(0.4203)
Share of Hispanics	0.1	0.13	0.09	0.0218***	-0.0309***
	(0.16)	(0.21)	(0.13)	(0.0047)	(0.0054)
Share of African American	0.21	0.23	0.3	0.0263***	0.0659***
	(0.27)	(0.29)	(0.34)	(0.0068)	(0.0079)
Share of Whites	0.69	0.64	0.61	-0.0386***	-0.0461***
	(0.27)	(0.27)	(0.32)	(0.006)	(0.0069)
Poverty Rate	0.24	0.29	0.27	0.0475***	0.026***
	(0.21)	(0.22)	(0.23)	(0.0046)	(0.0053)
Unemployment Rate	0.08	0.09	0.09	0.0023	0.0015
	(0.08)	(0.08)	(0.1)	(0.0021)	(0.0024)
Share of College Educated	0.29	0.26	0.28	-0.0106***	0.0131***
	(0.15)	(0.15)	(0.18)	(0.0036)	(0.0041)
Observations	1,800	3,342	1,581		
Listings	600	1,114	527		

Notes: Table shows mean and standard deviation (in parentheses) of property and neighborhood characteristics for the experimental data for listings by percentile of within-zip toxic concentration. Share of Hispanic, African American, White, poverty rate, unemployment rate, and share of college educated are measured at the block group level and come from the ACS 2015.

Correspondence Research Design

In a correspondence experiment, a researcher elicits racialized perceptions in a trial by constructing fictitious identities and experimentally varying a single trait (Bertrand and Duflo, 2017). The majority of correspondence research has focused on the use of racially distinct names as the trait used to elicit discriminatory behavior. While there are limitations associated with the use of any one particular trait, the consistent use of this design has enabled researchers to learn about racial perceptions of names across studies as well as in the general population. Correspondence studies select names that are likely to elicit behavior, such that the resulting actions can be clearly attributed to racialized perceptions. These names that are not necessarily representative of names in the population at large. Multiple randomized experiments have focused exclusively on the alignment between perceived associations with an ethnic/racial group and self-identified racial identity (Crabtree and Chykina, 2018, Gaddis, 2017a,b). Recent advances in this literature yield three important insights: (1) racialized perceptions of first names in the general population are, on average, 73-75% congruent with the observed racial/ethnic identity of names drawn from samples of birth record data when mothers from a given racial/ethnic group constitute the majority (ex. names for which more than 50% of children are born to Black/White/Hispanic mothers), (2) congruence between perceived and observed race/ethnicity increases (to 82% for African American and 92% White) with the addition of a last name that is consistent with the racial/ethnic population in birth records (congruence falls sharply when the last name is selected from a different group), (3) congruence is somewhat higher for White names drawn from mothers with high educational attainment and higher for black names when associated with a mother with low educational attainment (Gaddis, 2017a,b).[13]

Consistent with prior correspondence research, we assign a racial/ethnic identity using a set of 18 names that are shown to have a high probability of association with each of 3 racial categories throughout the United States: African American, Hispanic/LatinX, White. A question that has emerged in prior correspondence studies using racialized names is the possibility that any given name may signal race as well as other unobserved characteristics such as income (Guryan and Charles, 2013, Fryer Jr and Levitt, 2004). To test this empirically, we construct groups with each consisting of 3 male and 3 female names and stratify the sample of first names using statistical distribution of mother's educational attainment (low, medium, and high) from hospital birth records. The first name labels for this study are constructed using recent experimental work that tested the racialized perceptions of first and last names for African American, Hispanic/LatinX, and White social groups (Gaddis, 2017a,b). Last name labels were also taken from this work and tested for any geographic variability using related research (Crabtree and Chykina, 2018).

Randomization Protocol and Response Coding

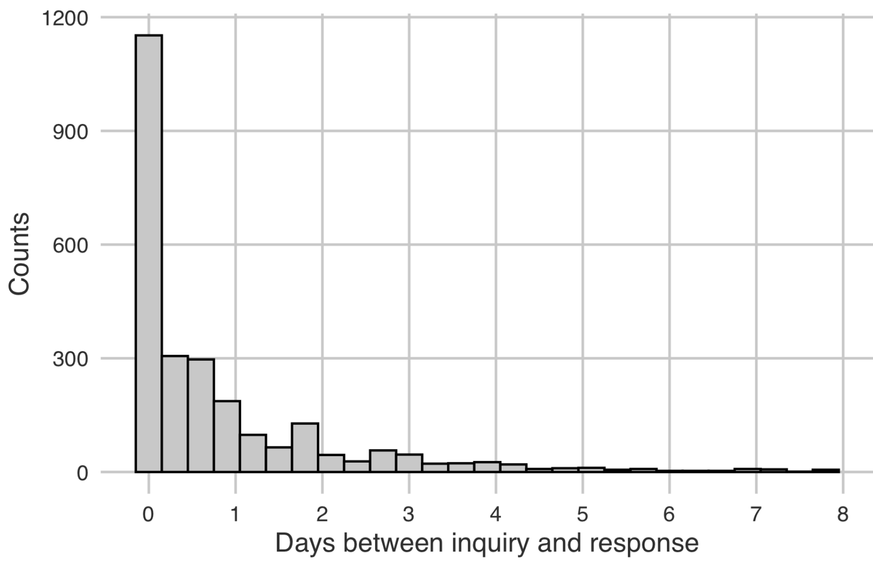
The research design simulates a housing search using all available listings in a zip code at a given time and is therefore reflective of the true set of options available in the given online market. By generating within-property estimates of response for each racial group,

[13]These studies use name distributions from New York state birth record data for all births from 1994 to 2012 obtained from the New York State Department of Health. Congruence experiments are implemented on Amazon Mechanical Turk and reflect the perceptions of users on that platform across the United States.

we can more directly examine the effect of discriminatory constraints on each choice set in the sample.

Immediately following the compilation of the relevant listings in a given market, a name is randomly drawn and assigned from each of three racial groups. Each rental apartment therefore receives a sequence of three separate inquiries in the course of an experimental trial (one from each group). The sequence of inquiries from the different race groups is randomized and inquiries for the same listing are never sent from two race groups on the same day. Responses from property managers are transmitted via email (gmail address associated with each name), phone messages (individual phone numbers associated with each name), and text messages. The content of phone, text, and email responses from property managers are recorded by a team of human coders to ensure the quality of the data. They are coded using two criteria that determine whether or not a response indicates that a housing choice is made available to a prospective renter: (1) a response is received within 7 days of the associated inquiry and (2) the response indicates that the property is available for rent.[14] Figure A6 plots the distribution of inquiry response time in the sample: 52% of responses are received within the first 8 hours of an inquiry, 74% are received within 24 hours and 98% are received within 5 days. The 7-day cutoff is used to restrict responses that may be received weeks or months after an inquiry and are not counted as choices in the study. Discriminatory constraints are expressed in terms of relative response rates, which measure the within-property difference in access to a housing choice. Relative response rates are estimated relative to an inquiry made to the same property from a White identity.

Figure A6. Days between Inquiry and Response



Note: Figure plots times elapsed between inquiries and responses in the sample using the timestamp given at the moment that an inquiry is sent and the timestamp given on the phone, email, or text response.

[14]Further details on inquiry response time are provided in Figure A6. 52% of responses are received within the first 8 hours of an inquiry, 74% are received within 24 hours and 98% are received within 5 days.

Table A3 reports the average response rate for inquiries made from a Hispanic or African American identity. Column 1 reports a relative response rate of 77% for the full set of minority identities in the sample, indicating that an inquiry made for the average listed property is 23% less likely to yield a housing choice when sent from a minority identity. The estimates in column 2 show that discriminatory constraints for the average home vary substantially between African American and Hispanic/LatinX renter identities. While inquiries made from African American identities are 60% less likely to yield a choice, there is no statistical difference in response to Hispanic/LatinX identities on average.

Table A3. Overall Discrimination Rates

	Dependent variable: *Response*	
	(1)	(2)
Minority	0.7673**	
	(0.6466 - 0.9104)	
African American		0.6016***
		(0.4708 - 0.7687)
Hispanic/LatinX		0.9748
		(0.8511 - 1.1165)
Mean Response (White)	0.39	0.39
Gender	Yes	Yes
Education Level	Yes	Yes
Inquiry Order	Yes	Yes
Observations	6,723	6,723
Listings	2,241	2,241
% w. diff. response	0.40	0.40

Notes: Table reports odds ratios from a within-property conditional logit with controls for gender, education and inquiry order. 90% Confidence Intervals reported in parentheses.*P < 10% level; **P < 5% level; ***P < 1% level.

Table A4 reports balance statistics for our experimental dataset. We note that some differences in name pairs or timing can occur if a listing is taken offline during a trial. We do not find any evidence of differences in the sequence of inquiries or the day of week, or the frequency of names associated with a given race-gender pair. We detect a small difference in the frequency of inquiries associated with different levels of maternal education – African American names associated with higher maternal education are slightly more common in our trials and Hispanic/LatinX names with high levels of maternal education are slightly less common in our trials. These variables are used as controls in our tests. Columns 1-4 of Table A5 report results with successive sets of controls, which indicate that there is no difference in estimates that include or omit the maternal education or other controls.

Table A4. Balance Statistics

	(1)	(2)	(3)	(4)	(5)
	Panel A: Inquiry Order				
	First	Second	Third		
African American	−0.0683	0.0343	0.0340		
	(0.0518)	(0.0513)	(0.0522)		
Hispanic/LatinX	−0.0316	−0.0313	0.0630		
	(0.0513)	(0.0522)	(0.0518)		
Panel B: Evidence of Differential Choices by Weekday					
	Mon	Tue	Wed	Thurs	Fri
African American	−0.0583	0.0222	0.0316	−0.0801	0.0561
	(0.0805)	(0.0861)	(0.0839)	(0.0895)	(0.0714)
Hispanic/LatinX	−0.0550	0.0149	−0.0071	−0.0677	0.0734
	(0.0804)	(0.0862)	(0.0845)	(0.0893)	(0.0712)
Panel C: Gender and Mother's Education Level					
	Gender		Mother's Education		
	Male	Female	Low	Medium	High
African American	−0.0448	0.0448	−0.0753	−0.0973	0.1529**
	(0.0599)	(0.0599)	(0.0709)	(0.0630)	(0.0623)
Hispanic/LatinX	−0.0896	0.0896	0.0518	0.0605	−0.1046*
	(0.0599)	(0.0599)	(0.0702)	(0.0625)	(0.0635)
Observations	6,723	6,723	6,723	6,723	6,723
Listings	2,241	2,241	2,241	2,241	2,241
% w. diff. response	0.40	0.40	0.40	0.40	0.40

Notes: Table reports balance statistics for the experimental data set. It shows the coefficients of logistic regression on different outcomes. In Panel A, the dependent variable takes 1 or 0 depending the order in which the inquiry was sent out, i.e. in Column (1) takes 1 if the inquiry was sent first and 0 otherwise. In Panel B, takes 1 or 0 depending the weekday the inquiry was sent. Panel C, does the same for male and females, and levels of maternal education. Standard errors clustered at the census tract level reported in parentheses.*$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.

Table A5. Estimates of Discriminatory Constraint on Housing Choice: Varying Controls

	Dependent variable: Response			
	(1)	(2)	(3)	(4)
Panel A: Percentile of Within-Zip RSEI Toxic Concentration				
Panel A.1.: Minority				
Minority 0-25th perc. Toxic Concentration	0.5830***	0.5860***	0.5804***	0.5939***
	(0.4819 - 0.7055)	(0.4836 - 0.7100)	(0.4714 - 0.7146)	(0.4736 - 0.7447)
Minority 25-75th perc. Toxic Concentration	0.7033**	0.7124**	0.7114**	0.7059**
	(0.5569 - 0.8881)	(0.5701 - 0.8901)	(0.5704 - 0.8873)	(0.5645 - 0.8827)
Minority 75-100th perc. Toxic Concentration	1.1857	1.1850	1.1872	1.1542
	(0.9497 - 1.4803)	(0.9624 - 1.4592)	(0.9712 - 1.4512)	(0.9302 - 1.4323)
Panel A.2.: By Race				
Af. American 0-25th perc. Toxic Concentration	0.4560***	0.4519***	0.4419***	0.4456***
	(0.3657 - 0.5684)	(0.3629 - 0.5628)	(0.3507 - 0.5568)	(0.3486 - 0.5696)
Af. American 25-75th perc. Toxic Concentration	0.5299***	0.5411***	0.5386***	0.5380***
	(0.3710 - 0.7569)	(0.3831 - 0.7643)	(0.3833 - 0.7568)	(0.3864 - 0.7492)
Af. American 75-100th perc. Toxic Concentration	1.0265	1.0273	1.0230	0.9912
	(0.7621 - 1.3826)	(0.7726 - 1.3660)	(0.7762 - 1.3484)	(0.7554 - 1.3007)
Hispanic/LatinX 0-25th perc. Toxic Concentration	0.7399***	0.7515**	0.7487**	0.7771*
	(0.6104 - 0.8968)	(0.6196 - 0.9116)	(0.6060 - 0.9251)	(0.6224 - 0.9704)
Hispanic/LatinX 25-75th perc. Toxic Concentration	0.9228	0.9252	0.9251	0.9240
	(0.8064 - 1.0560)	(0.8129 - 1.0531)	(0.8088 - 1.0581)	(0.7946 - 1.0746)
Hispanic/LatinX 75-100th perc. Toxic Concentration	1.3728**	1.3694**	1.3792**	1.3416*
	(1.0744 - 1.7540)	(1.0820 - 1.7331)	(1.0949 - 1.7373)	(1.0407 - 1.7295)
Panel B: Proximity to TRI facility				
Panel B.1.: Minority				
Toxic Plant less than 1 mile × Minority	0.8940	0.9056	0.9053	0.8877
	(0.7137 - 1.1199)	(0.7308 - 1.1221)	(0.7305 - 1.1219)	(0.7055 - 1.1170)
Toxic Plant more than 1 mile × Minority	0.6576***	0.6581***	0.6554***	0.6618***
	(0.5446 - 0.7939)	(0.5513 - 0.7854)	(0.5460 - 0.7867)	(0.5529 - 0.7922)
Panel B.2.: By Race				
TRI Plant less than 1 mile × African American	0.6999*	0.7140*	0.7099*	0.6910*
	(0.4990 - 0.9816)	(0.5122 - 0.9951)	(0.5097 - 0.9887)	(0.4894 - 0.9758)
TRI Plant more than 1 mile × African American	0.5236***	0.5213***	0.5159***	0.5215***
	(0.3949 - 0.6944)	(0.3973 - 0.6840)	(0.3940 - 0.6756)	(0.4057 - 0.6704)
TRI Plant less than 1 mile × Hispanic/LatinX	1.1435	1.1477	1.1515	1.1512
	(0.9818 - 1.3319)	(0.9923 - 1.3273)	(0.9904 - 1.3389)	(0.9809 - 1.3510)
TRI Plant more than 1 mile × Hispanic/LatinX	0.8184***	0.8214***	0.8208***	0.8271**
	(0.7243 - 0.9248)	(0.7369 - 0.9157)	(0.7269 - 0.9269)	(0.7270 - 0.9410)
Gender		Yes	Yes	Yes
Education Level			Yes	Yes
Inquiry Order				Yes
Observations	6,723	6,723	6,723	6,723
Listings	2,241	2,241	2,241	2,241
% w. diff. response	0.40	0.40	0.40	0.40

Notes: Table reports odd ratios from a within-property conditional logit model with successive inclusion of controls. Panel A reports results based on the percentile of within-zip toxic concentration. Panel A.1. shows odd ratio of minority names relative to white names. Panel A.2. separates minority names into African American and Hispanic/LatinX names. Panel B report results based on distance to closest TRI plant. Panel B.1 reports odd ratio of minority names relative to White. Panel B.2. separates minority into African American and Hispanic/LatinX names. Standard errors clustered at Zip Code level. 90% Confidence Intervals reported in parentheses.*$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.

Prior correspondence studies have found evidence of a within-trial impact when multiple inquiries are sent in matched correspondence designs in competitive labor markets (Phillips, 2016). Table A6 compares results using data from 1st inquiries, 2nd inquiries, or 3rd inquiries, rather than matched inquiries. While the power of these tests is limited, these estimates indicate that the average within-trial effect may be smaller on minority renters that make first inquiries.

Table A6. Estimates of Discriminatory Constraint on Housing Choice: Inquiry Order

	Dependent variable: Response		
	(1)	(2)	(3)
	1st Inquiry	2nd Inquiry	3rd Inquiry
Panel A: Quartiles of RSEI Toxic Concentration			
Panel A.1.: Minority			
Minority 0-25th perc. Toxic Concentration	0.7406***	0.7178***	0.7822**
	(0.6144 - 0.8926)	(0.6058 - 0.8505)	(0.6462 - 0.9468)
Minority 25-75th perc. Toxic Concentration	0.8877	0.9238	0.8666
	(0.7608 - 1.0357)	(0.8025 - 1.0633)	(0.7491 - 1.0026)
Minority 75-100th perc. Toxic Concentration	1.1431	0.8287	0.8459
	(0.9140 - 1.4296)	(0.6830 - 1.0054)	(0.6644 - 1.0770)
Panel A.2.: By Race			
African American 0-25th perc. Toxic Concentration	0.5799***	0.6795***	0.6551**
	(0.4466 - 0.7530)	(0.5677 - 0.8134)	(0.4994 - 0.8595)
African American 25-75th perc. Toxic Concentration	0.7688*	0.7789***	0.7360***
	(0.5920 - 0.9983)	(0.6673 - 0.9093)	(0.6140 - 0.8822)
African American 75-100th perc. Toxic Concentration	1.0022	0.6976**	0.8477
	(0.7800 - 1.2878)	(0.5338 - 0.9117)	(0.6009 - 1.1957)
Hispanic/LatinX 0-25th perc. Toxic Concentration	0.9364	0.7651*	0.8963
	(0.7463 - 1.1749)	(0.6033 - 0.9704)	(0.7319 - 1.0976)
Hispanic/LatinX 25-75th perc. Toxic Concentration	1.0086	1.1000	1.0150
	(0.8451 - 1.2038)	(0.9029 - 1.3401)	(0.8634 - 1.1932)
Hispanic/LatinX 75-100th perc. Toxic Concentration	1.3047	0.9690	0.8436
	(0.9640 - 1.7658)	(0.7507 - 1.2507)	(0.6091 - 1.1684)
Panel B: Proximity to TRI Plant			
Panel B.1.: Minority			
TRI Plant less than 1 mile × Minority	1.0135	0.8882	0.9274
	(0.8562 - 1.1997)	(0.7771 - 1.0153)	(0.8016 - 1.0729)
TRI Plant more than 1 mile × Minority	0.8067**	0.7999**	0.7603***
	(0.7018 - 0.9273)	(0.6931 - 0.9233)	(0.6407 - 0.9022)
Panel B.2.: By Race			
TRI Plant less than 1 mile × African American	0.8779	0.7435***	0.8217
	(0.7281 - 1.0587)	(0.6236 - 0.8865)	(0.6690 - 1.0092)
TRI Plant more than 1 mile × African American	0.6715***	0.7207***	0.6622***
	(0.5371 - 0.8396)	(0.5996 - 0.8663)	(0.5393 - 0.8130)
TRI Plant less than 1 mile × Hispanic/LatinX	1.1583	1.0515	1.0499
	(0.9110 - 1.4726)	(0.8777 - 1.2598)	(0.8953 - 1.2312)
TRI Plant more than 1 mile × Hispanic/LatinX	0.9587	0.8982	0.8541
	(0.8476 - 1.0843)	(0.7603 - 1.0611)	(0.7042 - 1.0360)
Gender	Yes	Yes	Yes
Education Level	Yes	Yes	Yes
Observations	2,241	2,241	2,241

Notes: Table reports odd ratios from a logistic regressions with columns referring to the order in which inquiries were sent out. Panel A reports results based on the percentile of within-zip toxic concentration. Panel A.1. reports odd ratios of minority names relative to White names. Panel A.2. separates minority names into African American and Hispanic/LatinX names. Panel B reports results based on distance to closest TRI plant. Panel B.1 reports odd ratio of minority names relative to White, and Panel B.2. separates minority into African American and Hispanic/LatinX names. Standard errors clustered at Zip Code level. 90% Confidence Intervals reported in parentheses.*$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.

When facing discriminatory constraints, renters may make multiple inquiries on a property to increase the likelihood of gaining access. It is not clear whether a renter who sends additional inquiries will face different constraints in subsequent rounds. We test this in a sub-sample of the markets in the study, where we simulate this process by running two rounds using the same names. Table A7 reports relative response rates from tests using the first and second round of inquiries on the same properties. All tests indicate a *stronger* discriminatory response in follow-up inquiries. Whereas relative response rates for first inquiries are 58% from minority identities, 41% from African American identities, and 86% from Hispanic/LatinX identities, relative response rates to second inquiries are 38% from minority, 51% from Hispanic, and 27% from African American identities.

Table A7. Overall Discrimination Rates
Properties with Two Inquiries

	Dependent variable: *Response* (1)	(2)
Minority First Inquiry	0.5805**	
	(0.3752 - 0.8981)	
Minority Second Inquiry	0.3804***	
	(0.3099 - 0.4671)	
African American First Inquiry		0.4052***
		(0.2369 - 0.6929)
African American Second Inquiry		0.2723***
		(0.2048 - 0.3621)
Hispanic/LatinX First Inquiry		0.8587
		(0.5071 - 1.4540)
Hispanic/LatinX Second Inquiry		0.5129***
		(0.4173 - 0.6304)
Observations	1,572	1,572
Listings	524	524
% w. diff. response	0.38	0.38

Notes: Table reports odd ratios from a within-property conditional logit model including controls for gender, education and order the inquiry was sent. *$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.

Table A8 plots relative response rates within the subset of listings after removing responses from computer-generated response systems (16% of the sample). Computer-generated responses are unlikely to exhibit discriminatory behavior in this market, though we note that later interactions with property managers for the same homes may present discriminatory constraints. Baseline estimates in the paper include both human- and computer-generated responses, which together characterize the level of discriminatory constraint facing prospective renters. The estimates in Table A8 estimates indicate that relative response rates from human-generated responses are somewhat lower than estimate from the full sample – 50% in the lowest quartile, 60% in the interquartile range, and not different from the response to White identities in the highest quartile of concentrations.

Table A8. Estimates of Discriminatory Constraint on Housing Choice Heterogeneity by Response Origin: Human or Computer

	Dependent variable: Response	
	Full Sample	Human-Generated Responses
	(1)	(2)
Panel A.1.: Minority		
Minority 0-25th perc. Toxic Concentration	0.5939***	0.5005***
	(0.4736 - 0.7447)	(0.3896 - 0.6430)
Minority 25-75th perc. Toxic Concentration	0.7059**	0.6036***
	(0.5645 - 0.8827)	(0.4643 - 0.7847)
Minority 75-100th perc. Toxic Concentration	1.1542	1.0513
	(0.9302 - 1.4323)	(0.7866 - 1.4050)
Panel A.2.: By Race		
African American 0-25th perc. Toxic Concentration	0.4456***	0.3898***
	(0.3486 - 0.5696)	(0.2863 - 0.5307)
African American 25-75th perc. Toxic Concentration	0.5380***	0.4804***
	(0.3864 - 0.7492)	(0.3229 - 0.7147)
African American 75-100th perc. Toxic Concentration	0.9912	0.8205
	(0.7554 - 1.3007)	(0.5772 - 1.1663)
Hispanic/LatinX 0-25th perc. Toxic Concentration	0.7771*	0.6274***
	(0.6224 - 0.9704)	(0.4986 - 0.7894)
Hispanic/LatinX 25-75th perc. Toxic Concentration	0.9240	0.7505***
	(0.7946 - 1.0746)	(0.6311 - 0.8926)
Hispanic/LatinX 75-100th perc. Toxic Concentration	1.3416*	1.3388
	(1.0407 - 1.7295)	(0.9924 - 1.8060)
Gender	Yes	Yes
Education Level	Yes	Yes
Inquiry Order	Yes	Yes
Observations	6,723	5,637
Listings	2,241	1,879
% w. diff. response	0.40	0.38

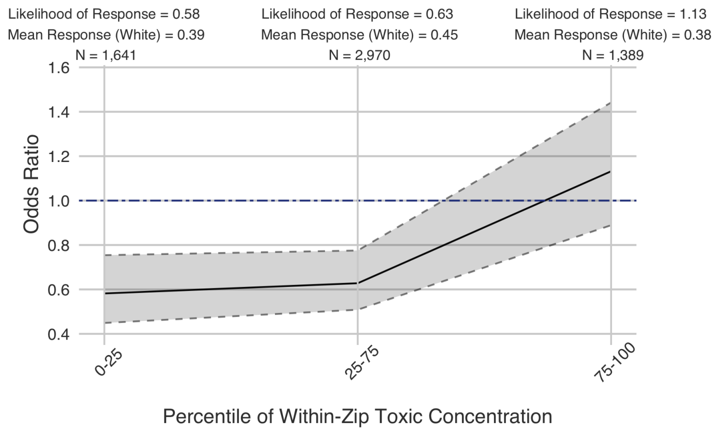
Notes: Table reports odds ratios from a within-property conditional logit regression for the full sample and excluding computer-generated responses. Column (1) reports results for the full sample. Column (2) excludes 362 listings that responded with computer-automated responses. Panel A.1. shows odds ratios of minority names relative to White names. Panel A.2. separates minority names into African American and Hispanic/LatinX names. Standard errors clustered at Zip Code level. 90% Confidence Intervals reported in parentheses.*$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.

Robustness of Results to Sampling Restrictions

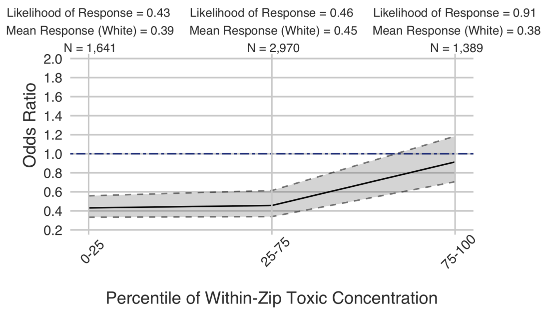
This section evaluates the robustness of main experimental estimates to various sample restrictions. Figure A7 provides tests that exclude zip codes that are located within 1 mile of a high-emitting TRI facility but where properties in the zip are located at concentrations measured below 1,000 by RSEI. The relative likelihood of response to a renter with a name associated with minority groups is 58% at locations in the lowest quartile of the within-zip concentration, which is very similar to the 59% response rate when using the full data. The response rate for African American identities in the restricted sample (43%) and for Hispanic/LatinX (78%) are very similar to the main experimental full-sample estimate, 45% and 78% respectively.

Figure A7. Relative Response Rates by Within-Zip Toxic Concentration
RSEI Toxic Concentrations above 1,000

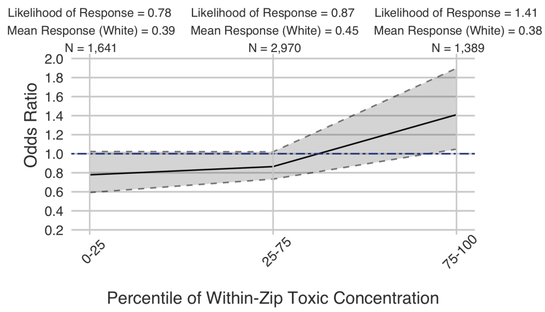
Panel A: Minority



Panel B: African American vs Hispanic/LatinX



(a) African American



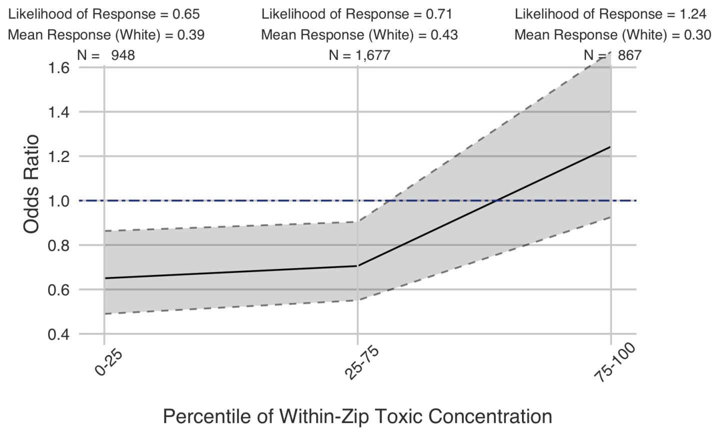
(b) Hispanic/LatinX

Note: Sample drops 3 Zip codes with RSEI toxic concentrations below 1,000. Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the White identity. Standard errors clustered at the census tract level. 90% confidence intervals are plotted in grey.

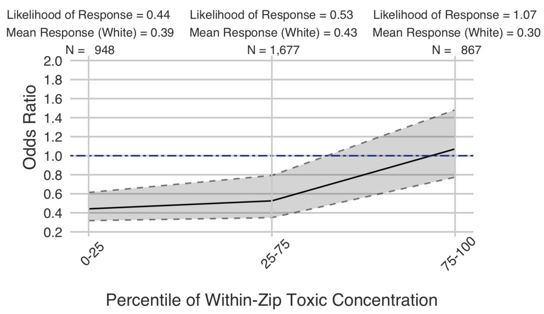
Figure A8 provides tests using a restricted sample of listings that fall within 25% of the median rent in each zip code. While the sample restriction reduces the precision of the estimates, the patterns in constraints are consistent with main results reported in the paper. The relative likelihood of response to a renter with a name associated with minority groups is 65% at locations in the lowest quartile of the within-zip concentration, which is very similar to the 59% response rate when using the full data. The response rate for African American identities in the restricted sample (44%) is very similar to the main experimental full-sample estimate (45%). The estimate for Hispanic/LatinX identities (90%) is somewhat higher than the full sample estimate (78%).

Figure A8. Relative Response Rates by Within-Zip Toxic Concentration
Restricted Sample (within 25% of the Zip-median rent)

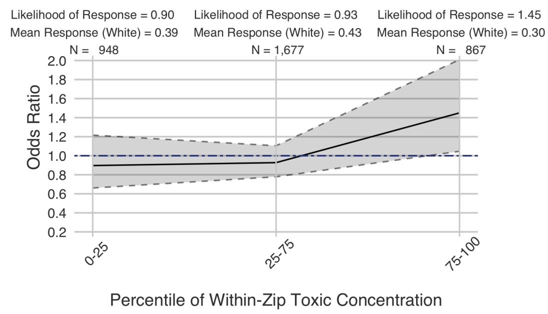
Panel A: Minority



Panel B: African American vs Hispanic/LatinX



(a) African American



(b) Hispanic/LatinX

Note: The sample is restricted to properties within 25% of the median rent, reducing it to 1,164 listings (3,492 observations). Figure plots estimates (odds ratios) from Eq. (1). The omitted category is the White identity. Standard errors clustered at the census tract level. 90% confidence intervals are plotted in grey.

Heterogeneity by Maternal Education

Table A9 reports estimates by maternal education using information on first names from hospital birth records. Point estimates from these tests provide suggestive evidence of stronger discriminatory constraints facing minority renters with names that are associated with low maternal educational attainment. For listings in the lowest quartile of concentrations, relative response rates to inquiries from African American names are 28% when associated with low maternal educational attainment, 47% when associated with medium maternal educational attainment, and 60% when associated with high maternal educational attainment. We find similar patterns for Hispanic/LatinX identities, although we do not detect statistical differences in relative response rates between the groups.

Table A9. Estimates of Discriminatory Constraint on Housing Choice Heterogeneity by Maternal Education

	Dependent variable: Response	
	(1)	(2)
Minority 0-25th perc. Toxic Concentration × Low	0.5196*** (0.3846 - 0.7019)	
Minority 25-75th perc. Toxic Concentration × Low	0.6011*** (0.4558 - 0.7928)	
Minority 75-100th perc. Toxic Concentration × Low	1.3016 (0.9537 - 1.7763)	
Minority 0-25th perc. Toxic Concentration × Medium	0.5478*** (0.3784 - 0.7929)	
Minority 25-75th perc. Toxic Concentration × Medium	0.6208** (0.4238 - 0.9094)	
Minority 75-100th perc. Toxic Concentration × Medium	0.9094 (0.5827 - 1.4193)	
Minority 0-25th perc. Toxic Concentration × High	0.7466* (0.5601 - 0.9951)	
Minority 25-75th perc. Toxic Concentration × High	0.9276 (0.7377 - 1.1664)	
Minority 75-100th perc. Toxic Concentration × High	1.3728* (1.0466 - 1.8006)	
African American 0-25th perc. Toxic Concentration × Low		0.2818*** (0.1710 - 0.4644)
African American 25-75th perc. Toxic Concentration × Low		0.3334*** (0.1875 - 0.5927)
African American 75-100th perc. Toxic Concentration × Low		1.2190 (0.6782 - 2.1910)
African American 0-25th perc. Toxic Concentration × Medium		0.4671*** (0.3018 - 0.7228)
African American 25-75th perc. Toxic Concentration × Medium		0.5001* (0.2761 - 0.9058)
African American 75-100th perc. Toxic Concentration × Medium		0.6933 (0.4331 - 1.1099)
African American 0-25th perc. Toxic Concentration × High		0.6013* (0.3741 - 0.9664)
African American 25-75th perc. Toxic Concentration × High		0.7938 (0.4981 - 1.2650)
African American 75-100th perc. Toxic Concentration × High		1.2719 (0.7211 - 2.2434)
Hispanic/LatinX 0-25th perc. Toxic Concentration × Low		0.6686 (0.3505 - 1.2755)
Hispanic/LatinX 25-75th perc. Toxic Concentration × Low		0.7364** (0.5821 - 0.9315)
Hispanic/LatinX 75-100th perc. Toxic Concentration × Low		1.0769 (0.7519 - 1.5426)
Hispanic/LatinX 0-25th perc. Toxic Concentration × Medium		0.7404 (0.5380 - 1.0189)
Hispanic/LatinX 25-75th perc. Toxic Concentration × Medium		0.9758 (0.6683 - 1.4248)
Hispanic/LatinX 75-100th perc. Toxic Concentration × Medium		1.4244* (1.0301 - 1.9695)
Hispanic/LatinX 0-25th perc. Toxic Concentration × High		0.8646 (0.5162 - 1.4482)
Hispanic/LatinX 25-75th perc. Toxic Concentration × High		1.0697 (0.7130 - 1.6047)
Hispanic/LatinX 75-100th perc. Toxic Concentration × High		1.5282** (1.1410 - 2.0468)
Gender	Yes	Yes
Inquiry Order	Yes	Yes
Observations	6,723	6,723
Listings	2,241	2,241
% w. diff. response	0.40	0.40

Notes: Table reports odds ratios from a within-property conditional logit by percentile of within-zip toxic concentration and for different levels of maternal education. Column (1) reports the odd ratio for minority names relative to white names. Column (2) separates minority names into African American and Hispanic/LatinX names. Standard errors clustered at Zip Code level. 90% Confidence Intervals reported in parentheses.*$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.

Table A10. Estimates of Discriminatory Constraint on Housing Choice Heterogeneity by Gender

	Dependent variable: Response	
	(1)	(2)
Minority 0-25th perc. Toxic Concentration × Female	0.7873**	
	(0.6598 - 0.9396)	
Minority 25-75th perc. Toxic Concentration × Female	0.8707	
	(0.7007 - 1.0821)	
Minority 75-100th perc. Toxic Concentration × Female	1.3668*	
	(1.0431 - 1.7909)	
Minority 0-25th perc. Toxic Concentration × Male	0.4628***	
	(0.3424 - 0.6254)	
Minority 25-75th perc. Toxic Concentration × Male	0.5508***	
	(0.4085 - 0.7426)	
Minority 75-100th perc. Toxic Concentration × Male	0.9711	
	(0.7237 - 1.3032)	
African American 0-25th perc. Toxic Concentration × Female		0.7005***
		(0.5768 - 0.8506)
African American 25-75th perc. Toxic Concentration × Female		0.8366
		(0.6156 - 1.1369)
African American 75-100th perc. Toxic Concentration × Female		1.3792
		(0.9527 - 1.9967)
African American 0-25th perc. Toxic Concentration × Male		0.2788***
		(0.1880 - 0.4135)
African American 25-75th perc. Toxic Concentration × Male		0.3448***
		(0.2423 - 0.4908)
African American 75-100th perc. Toxic Concentration × Male		0.7095
Hispanic/LatinX 0-25th perc. Toxic Concentration × Female		0.9143
		(0.7115 - 1.1750)
Hispanic/LatinX 25-75th perc. Toxic Concentration × Female		0.9047
		(0.7317 - 1.1187)
Hispanic/LatinX 75-100th perc. Toxic Concentration × Female		1.3565
		(0.9470 - 1.9432)
Hispanic/LatinX 0-25th perc. Toxic Concentration × Male		0.6756**
		(0.4949 - 0.9222)
Hispanic/LatinX 25-75th perc. Toxic Concentration × Male		0.9525
		(0.7015 - 1.2933)
Hispanic/LatinX 75-100th perc. Toxic Concentration × Male		1.3581
		(0.9392 - 1.9639)
Education Level	Yes	Yes
Inquiry Order	Yes	Yes
Observations	6,723	6,723
Listings	2,241	2,241
% w. diff. response	0.40	0.40

Notes: Table reports odds ratios from a within-property conditional logit by percentile of within-zip toxic concentration and applicant gender. Column (1) reports odds ratios for minority names relative to White names. Column (2) separates minority names into African American and Hispanic/LatinX names. Standard errors clustered at Zip Code level. 90% Confidence Intervals reported in parentheses.*$P < 10\%$ level; **$P < 5\%$ level; ***$P < 1\%$ level.