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Single-Mother Families and Air Pollution: A National Study*

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Abstract

Objective—This study uses tract-level demographic data and toxicity-weighted air pollutant concentration estimates for the continental United States to determine whether (1) single-mother families are overrepresented in environmentally hazardous Census tracts and (2) the percentage of single-mother families in a Census tract is a significant predictor of tract-level toxic concentration estimates.

Methods—After calculating tract-level toxic concentration estimates for the average female-headed family, male-headed family, and married-couple family with and without children, we use fixed-effects regression models to determine whether the percentage of single-mother families in a tract is a significant predictor of tract-level toxic concentration estimates.

Results—Single-mother families are overrepresented in environmentally hazardous Census tracts, and the percentage of single-mother families in a tract remains a significant predictor of estimated toxic concentration levels even after controlling for many of the most commonly used variables in the literature.

Conclusion—Environmental inequality researchers need to broaden their focus beyond race and income to include groups such as single-mother families in their research.

In a recent study of 14 U.S. metropolitan areas, Downey (2005a) found that the presence of single-mother families in a Census tract was a relatively strong predictor of tract proximity to industrial activity. The statistically significant associations Downey found between the percentage of single-mother families in a tract and tract proximity to industrial activity persisted after controlling for tract income levels and tract racial composition. Moreover, *percent single-mother families* was one of the strongest predictors included in the study.

Like Downey (2005a), this study asks whether single-mother families are overrepresented in environmentally hazardous Census tracts and whether the percentage of single-mother families in a Census tract is a statistically significant predictor of environmental hazard presence levels even after controlling for other important predictors of environmental hazard presence. This study also asks whether the representation of single-mother families in environmentally hazardous Census tracts is similar to that of single-father families and married-parent families. Determining whether this is the case is important because if single-mother families are overrepresented in environmentally hazardous Census tracts this may simply be due to the fact that all families with children are overrepresented in such tracts.

Despite their similarities, this study extends Downey (2005a) in four important ways. First, it includes complete Census tract coverage of the continental United States (the 48 contiguous states and Washington, DC). Second, it uses toxicity-weighted air pollutant concentration

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estimates, rather than industrial facility proximity data, to indicate environmental risk. Third, it includes several control variables that have been associated with environmental hazard presence in previous studies but were not included in Downey (2005a). Fourth, in addition to asking whether all families with children are overrepresented in environmentally hazardous Census tracts, this study also asks whether families with children less than six years old are overrepresented in environmentally hazardous Census tracts.

These differences are important because (1) Downey's findings cannot be generalized to other metropolitan areas or to the United States as a whole, (2) several researchers have raised concerns about the quality of hazard proximity data (Bowen, 2002), (3) young children are particularly susceptible to the negative health effects of toxic pollution (Pastor, Sadd, and Morello-Frosch, 2004), and (4) including additional control variables in the analysis increases our confidence in the validity of our results.

Literature Review

Environmental inequality researchers have studied the distribution of social groups around a variety of environmental hazards, including hazardous waste sites, manufacturing facilities, superfund sites, chemical accidents, and air pollutants (Ash and Fetter, 2004; Bowen, 2002; Derezinski, Lacy, and Stretesky, 2003; Downey, 2005b; Morello-Frosch, Pastor, and Sadd, 2001; Ringquist, 2005). Although most researchers have focused their attention on income- and race-based environmental inequality (Downey, 2005a), some researchers have studied environmental inequality as it relates to other social groups, including children (Environmental Health Perspectives, 2002; Evans and Marcynyszyn, 2004; Legg, 2002; Pastor, Sadd, and Morello-Frosch, 2004), women (Environmental Health Perspectives, 2002; Smith et al., 2006), populations with special needs (Chakraborty and Armstrong, 2001), immigrants (Hunter, 2000; Pellow and Park, 2002), and farm workers (Arcury, Quandt, and Russell, 2002). Nevertheless, with the exception of Downey (2005a), no researcher has asked whether families with children are overrepresented in environmentally hazardous neighborhoods.

This is an important oversight because research suggests that children, especially young children, are more susceptible than adults to the negative health effects of toxic pollution. Children's greater susceptibility is due to physiological, behavioral, and metabolic differences between children and adults that affect their exposure and physical reaction to environmental pollutants (Bearer, 1995; Cline et al., 1989; Crom, 1994; Guzelian, Henry, and Olin, 1992; Landrigan et al., 2004; Pastor, Sadd, and Morello-Frosch, 2004; Rogge and Combs-Orme, 2003). Moreover, because single parents tend to have relatively low incomes (Christopher, 2005), they are less likely than married parents or adults without children to possess the resources necessary to provide themselves and their children with adequate medical care (Williams and Collins, 1995). Thus, determining whether families with children are disproportionately burdened by environmental hazards represents an important challenge for environmental inequality and public health researchers.

Data and Methods

The pollution data used in this study were derived from the Environmental Protection Agency's (EPA) Risk-Screening Environmental Indicators (RSEI) project. The RSEI model from which the data were derived models the toxicity-weighted concentration of air pollutants released from every facility listed in the EPA's Year 2000 Toxics Release Inventory (TRI) (see Ash and Fetter (2004) for a discussion of how these data differ from those found in the public RSEI release). The TRI records the number of pounds of specified toxic chemicals released into the environment each year by industrial facilities that fall into one of seven industrial categories, employ the equivalent of 10 or more full-time workers, and manufacture, process, or otherwise

use the specified chemicals in specified quantities. For each TRI data year, the RSEI provides a toxicity-weighted plume model estimate of the concentration of local TRI air releases for every one-kilometer square grid cell in a grid covering the entire United States. We apportion these grid cell estimates to each Census tract in the continental United States using an algorithm described in Downey (2007; this article also describes the strengths and weaknesses of the RSEI). Thus, we use the RSEI to calculate a toxicity-weighted air pollutant concentration estimate (a *toxic concentration* estimate) for each Census tract in the United States.

The demographic data used in this study were obtained from the 2000 U.S. Census. The family-structure variables include the percentage of families in a tract that are single-mother families with children less than 18 years old and children less than six years old (two separate variables), the percentage of families in a tract that are single-father families with children less than 18 years old and children less than six years old, and the percentage of families in a tract that are married-parent families with children less than 18 years old and children less than six years old. Other demographic variables were selected based on their importance in prior research. These variables include percent Hispanic, percent non-Hispanic black, percent non-Hispanic Asian, per-capita income, the percentage of residents living below the federal poverty line, the percentage of residents 25 years old and older who have completed at least one year of college (percent some college), median property value, median housing unit age, the percentage of tract housing units that are vacant (percent vacant), and the percentage of employed tract residents 16 years old and older who are engaged in manufacturing occupations (percent engaged in manufacturing). Because these variables and the hazard variable are highly skewed, we calculate their natural log values before inserting them into the regression equations presented below.

We log all the independent variables rather than just the skewed independent variables because (1) so many of the independent variables are skewed and (2) logging the dependent variable and all the independent variables simplifies regression model interpretation (model coefficients now indicate the percentage change in the dependent variable for a 1 percent increase in the independent variable). We also run separate regression models for families with children less than 18 years old and families with children less than six years old because young children are particularly susceptible to the negative health effects of toxic pollutants (see our earlier discussion). Finally, fixed-effects regression models are employed in order to control for unobserved heterogeneity. These models provide identical results to those that would have been obtained had we run OLS models that included a dummy variable for each metropolitan area in the United States, with nonmetropolitan area tracts as the reference category.

Results

In order to determine whether single-mother families live in neighborhoods with higher toxic concentration values than do other types of families, Table 1 calculates the neighborhood toxic concentration values of the average female-headed family, male-headed family, and married-couple family with children, without children, and with and without children combined. The top portion of Table 1 shows that in the continental United States, the average female-headed family lives in a Census tract that has a toxic concentration value of 637.65. This value is significantly different from and 1.13 times as great as the neighborhood toxic concentration value of the average male-headed family and significantly different from and 1.36 times as great as the neighborhood toxic concentration value of the average married-couple family.

Table 1 also shows that in the continental United States, the average single-mother family with children less than six years old lives in a Census tract with a toxic concentration value of 733.77. This value is significantly different from the average toxic concentration value of each of the other family types listed in the bottom portion of Table 1, ranging from 1.18 times as great as

the value for single-mother families with children 6–17 years old to 1.62 times as great as the value for married-parent families with children 6–17 years old. Single-mother families with children ages 6–17 have the second highest average toxic concentration value, followed closely by single-father families with children less than six years old and female-headed families without children. The three married family groups have by far the lowest average toxic concentration values found in Table 1.

Thus, in the continental United States, female-headed families are overrepresented in neighborhoods with high toxic concentration values, as are single-father families with children less than six years old. One possible explanation for this is that single-parent families are more likely than other families to live in low-income and minority neighborhoods (Franklin, Smith, and McMiller, 1995; Wilson, 1987) which, in turn, are disproportionately likely to house environmental hazards (Brulle and Pellow, 2006). To test this explanation, Tables 2 and 3 regress *toxic concentration logged* on percent single-mother families logged, percent single-father families logged, and *percent married-parent families logged*, controlling for tract racial composition, tract income levels, and other tract characteristics commonly associated with environmental hazard presence. Table 2 presents results for families with children less than 18 years old and Table 3 presents results for families with children less than six years old.

The first model in Table 2 includes the family structure variables only. In this model, the dependent variable, *toxic concentration logged*, is positively associated with percent single-mother families logged (children < 18), negatively associated with percent married-parent families logged (children < 18), and insignificantly associated with percent single-father families logged (children < 18). Including the race, income, and poverty variables in the analysis (Model 2) makes the positive association between *percent single-father families logged* and the dependent variable statistically significant, but weakens the significant associations that exist between the other two family structure variables and the dependent variable. Finally, inserting the remaining control variables into the regression equation (Model 3) has little effect on the coefficient for *percent single-mother families logged*. However, *percent single-father families logged* is now negatively associated with the dependent variable.

Thus, in the continental United States, *percent single-mother families logged* continues to be significantly and positively associated with *toxic concentration logged* even after controlling for race, income, and other neighborhood characteristics commonly associated with environmental hazard presence. Moreover, *percent single-father families logged* and *percent married-parent families logged* are both negatively associated with *toxic concentration logged* once other factors are controlled for, suggesting that single-mother families, single-father families, and married-parent families are not similarly distributed across environmentally hazardous neighborhoods.

It is possible, of course, that *percent single-mother families logged* is positively associated with the dependent variable in Models 1–3 because single-mother families are overrepresented in large urban areas or in highly polluted urban areas. Thus, Model 4 restricts the analysis to metropolitan areas with more than 1 million residents, Model 5 restricts the analysis to the 83 most “RSEI-polluted” metropolitan areas in the continental United States, and Model 6 restricts the analysis to the 33 most “RSEI-polluted” metropolitan areas in the continental United States. These highly polluted metropolitan areas were selected by ranking the 329 metropolitan areas in the continental United States according to the neighborhood toxic concentration value of the average person in each metropolitan area (regardless of race) and then selecting those metropolitan areas that make up the most RSEI-polluted 10 percent and 25 percent of metropolitan areas in the continental United States.

There are several important differences between the results found in Models 4–6 and the results found in Model 3. First, the coefficient for *percent single-father families logged* is no longer statistically significant in Model 6. Second, the association between *single-mother families logged* and the dependent variable appears to be much stronger in Model 6 than in Model 3, and stronger in Model 3 than in Models 4 and 5: a 1 percent increase in *percent single-mother families logged* results in a 0.38 percent increase in *toxic concentration logged* in the 33 most polluted U.S. metropolitan areas, but in only a 0.196 percent increase in *toxic concentration logged* in the continental United States, a 0.104 percent increase in *toxic concentration logged* in the largest U.S. metropolitan areas, and a 0.159 percent increase in *toxic concentration logged* in the 83 most polluted U.S. metropolitan areas. Third, the negative association between *married-parent families logged* and the dependent variable appears to be stronger in highly polluted metropolitan areas (Model 6) than in other metropolitan areas. Fourth, percent engaged in manufacturing logged and median property value logged are both strongly and positively associated with the dependent variable in the continental United States as a whole, but insignificantly or negatively associated with the dependent variable in large metropolitan areas and highly polluted metropolitan areas (Models 4–6). Fifth, *percent Hispanic logged* is negatively associated with the dependent variable in the continental United States, but positively associated with the dependent variable in large metropolitan areas and highly polluted metropolitan areas (Models 4–6).

In addition, pseudo- R^2 values are much larger when the analysis is restricted to highly polluted metropolitan areas: the pseudo- R^2 value equals 0.2515 in Model 5 and 0.2413 in Model 6, but only 0.1745 in Model 3 and 0.1738 in Model 4. Moreover, the pseudo- R^2 values for the reduced models (see the second and third-to-last rows in Table 2) indicate that when *percent single-mother families logged* is the only independent variable included in the regression model, it only explains 4 percent of the variance in the dependent variable in the continental United States and 6 percent of the variance in the dependent variable in large metropolitan areas, but 11 percent of the variance in the dependent variable in the 83 most polluted U.S. metropolitan areas and almost 13 percent of the variance in the dependent variable in the 33 most polluted U.S. metropolitan areas.

Thus, Table 2 shows that in large metropolitan areas, highly polluted metropolitan areas, and the continental United States as a whole, the association between *percent single-mother families logged* and *toxic concentration logged* is at least partially independent of neighborhood income levels, neighborhood racial composition, and other neighborhood characteristics commonly associated with environmental hazard presence. Table 2 also shows that *percent single-mother families logged* explains a sizeable proportion of the variance in the dependent variable in the 33 and 83 most highly polluted metropolitan areas in the United States. Moreover, unreported analyses show that when the other two family structure variables are inserted into the regression models by themselves, they explain relatively little of the variance in the dependent variable in the 33 and 83 most highly polluted metropolitan areas in the United States.

Turning our attention to Table 3, we see that all three family structure variables are positively associated with *toxic concentration logged* in Models 2 and 3 (the continental United States), but that only percent single-mother families with young children logged is positively associated with *toxic concentration logged* in large metropolitan areas (Model 4) and highly polluted metropolitan areas (Models 5–6). As in Table 2, percent engaged in manufacturing logged and median property value logged are both strongly and positively associated with the dependent variable in Model 3, but insignificantly or negatively associated with the dependent variable in Models 4–6. Conversely, *percent Hispanic logged* is negatively associated with the dependent variable in Model 3, but positively associated with the dependent variable in Models 4–6. Also consistent with Table 2, pseudo- R^2 values are larger in Models 5 and 6 than in Models

3 and 4, both for the full regression models and for regression models in which percent single-mother families with young children logged is the only independent variable included in the analysis.

Discussion

The findings presented in the previous section demonstrate that female-headed families and single-father families with young children are overrep-resented in neighborhoods with high toxic concentration levels and that single-mother families with young children are more highly overrepresented in toxic neighborhoods than are any other family group included in this study. These findings also demonstrate that the associations between the two single-mother family variables and *toxic concentration logged* persist after controlling for neighborhood income levels, neighborhood racial composition, and other neighborhood characteristics commonly associated with environmental hazard presence, and that this holds true in large metropolitan areas, highly polluted metropolitan areas, and the continental United States as a whole.

Moreover, when the two single-mother family variables are inserted into the regression models by themselves, they explain a relatively large proportion of the variance in the dependent variable in the 33 and 83 most RSEI-polluted metropolitan areas in the continental United States. This is not true of the other family-structure variables, which unreported analyses show explain relatively little of the variation in the dependent variable in the most highly polluted U.S. metropolitan areas.

It is also the case that the coefficients for the two single-mother family variables are highly stable across regression models. This is not the case for the coefficients for percent Hispanic logged, percent engaged in manufacturing logged, median property value logged, or the other family-structure variables, all of which change sign or move from significance to nonsignificance as we move from one regression model to another.

As with any study, caution must be taken in interpreting the findings reported here. For example, this study relies on a single environmental hazard indicator rather than multiple hazard indicators. As a result, we do not know whether the findings presented here hold for other environmental hazards, either singly or when considered as a group. In addition, this study does not test causal hypotheses. Thus, we do not know why female-headed families and single-father families with young children are overrepresented in neighborhoods with high toxic concentration values or why single-mother families with young children are so much more highly represented in hazardous neighborhoods than are other families. Finally, rather than investigating specific metropolitan areas or regions of the country, this study examines large metropolitan areas, highly polluted metropolitan areas, and the United States as a whole. Although this is one of the study's strengths, it is possible that the relationship between neighborhood family structure and neighborhood toxic concentration levels varies according to metropolitan area or region of the country.

These caveats notwithstanding, this study increases our understanding of environmental inequality in several ways. First, it confirms Downey's (2005a) finding that neighborhood family composition is an important predictor of neighborhood environmental hazard levels, and it does so using national, toxicity-weighted, air pollutant concentration data and a set of control variables not included in Downey's (2005a) study. This study also confirms Downey's finding that single-mother, single-father, and married-parent families are not similarly distributed across environmentally hazardous neighborhoods: single-mother families with young children are more highly represented in neighborhoods with high toxic concentration values than are any other family group investigated in the study, and the two single-mother

family variables are the only family-structure variables included in this study that are positively associated with the dependent variable in all the regression models presented above.

Second, by demonstrating that single-mother families are overrepresented in environmentally hazardous neighborhoods and that their presence in a neighborhood is a strong and independent predictor of environmental hazard presence levels, this study suggests that environmental inequality researchers need to broaden their research focus beyond race and income. As noted earlier, several researchers have already done so, but most have not. Third, the fact that the associations between the single-mother family variables and *toxic concentration logged* remain statistically significant in all of the full regression models suggests that environmental inequality cannot be explained simply by reference to racist siting decisions, labor or housing market racism, or the location of industrial activity in poor and low-income neighborhoods (Downey, 2005b). If these factors alone explained the existence of environmental inequality, then the associations between the single-mother family variables and the environmental hazard variables in this and the Downey (2005a) study would not have remained statistically significant after controlling for neighborhood race and income characteristics.

Fourth, in the fixed-effects regression models in Tables 2 and 3, percent non-Hispanic black and percent non-Hispanic Asian are both significantly and positively associated with *toxic concentration logged* in all four full regression models, and *percent Hispanic* is significantly and positively associated with *toxic concentration logged* in large and highly polluted metropolitan areas. In addition, unreported analyses show that in the continental United States, the average black person lives in a Census tract with a much higher toxic concentration value than does the average person of any other racial/ethnic group. Thus, in arguing that environmental inequality researchers need to broaden their focus to include the study of single-mother families and other subordinate groups, we are not trying to suggest that environmental racial inequality is unimportant.

Fifth, the fact that single-mother families and single-father families with young children are overrepresented in neighborhoods with high toxic concentration values should be of great concern to environmental inequality and public health researchers, not to mention to the members of these families. As noted earlier, children are particularly susceptible to the negative health effects of toxic pollutants. Single parents are also less likely than married parents and adults without children to possess the resources necessary to provide themselves and their children with adequate medical care. Moreover, research suggests that exposure to toxic pollutants may negatively affect school performance (Diette et al., 2000; Pastor, Sadd, and Morello-Frosch, 2004), which, in turn, is likely to impact future success in the job market.

Thus, the overrepresentation of single-mother families and single-father families with young children in environmentally hazardous neighborhoods has serious public health implications, and potentially serious educational and labor market implications. It is therefore incumbent upon researchers to determine (1) why these families are overrepresented in environmentally hazardous neighborhoods and (2) whether certain segments of these populations are more overrepresented than others. For example, are minority, poor, or working-class single-parent families more likely than other single-parent families to live in environmentally hazardous neighborhoods? Do lifecycle factors play a role in placing single-parent families with young children in more polluted neighborhoods than single-parent families without young children? What role does gender play in shaping environmental inequality? Do public housing and welfare policies shape the distribution of families across polluted and nonpolluted neighborhoods? These are not easy questions to answer, but answering them will improve our understanding of environmental inequality and may help activists, researchers, and governments reduce the environmental burden experienced by single-parent and female-headed families.

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TABLE 2
Fixed-Effects Regression Models for Families with Children Less than 18 Years Old

	Model 1 Entire U.S.	Model 2 Entire U.S.	Model 3 Entire U.S.	Model 4 Large Metro Areas	Model 5 83 Most Polluted Metro Areas	Model 6 33 Most Polluted Metro Areas
<i>Family Structure Variables</i>						
% Single-mother families logged (<18)	0.347***	0.203***	0.196***	0.104***	0.159***	0.380***
% Single-father families logged (<18)	0.009	0.035**	-0.020*	-0.067***	-0.062***	0.004
% Married-parent families logged (<18)	-0.205***	-0.136***	-0.282***	-0.235***	-0.301***	-0.324***
<i>Control Variables</i>						
% Hispanic logged		-0.008	-0.044***	0.167***	0.194***	0.177***
% Non-Hispanic black logged		0.188***	0.243***	0.112***	0.126***	0.185***
% Non-Hispanic Asian logged		0.102***	0.170***	0.161***	0.133***	0.195***
Per-capita income logged		-0.011	0.587***	0.444***	0.391***	0.484***
% Poverty logged		-0.060***	-0.021	0.045*	0.101***	-0.077
% Some college logged			-0.573***	-0.290***	-0.256***	-0.087
% Engaged in manufacturing logged			0.534***	0.017	-0.066**	-0.108*
% Vacant logged			0.371***	0.172***	0.151***	-0.245***
Median property value logged			0.444***	-0.107***	0.024	-0.097
Median house age logged			0.422***	0.355***	0.622***	0.487***
Constant	4.653***	4.574***	-5.803***	2.137***	1.608**	2.666*
R^2	0.0450	0.0670	0.1745	0.1738	0.2515	0.2413
R^2 (reduced 1) ^a			0.0408	0.0631	0.1100	0.1287
R^2 (reduced 2) ^b			0.0450	0.0802	0.1384	0.1460
<i>N</i>	64,433	64,433	63,601	18,640	12,982	3,921

^aThe R^2 value for the regression model that only includes the single-mother family variable as a predictor.

^bThe R^2 value for the regression model that only includes the three family structure variables as predictors.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$.

TABLE 3
Fixed-Effects Regression Models for Families with Children Less than 6 Years Old

	Model 1 Entire U.S.	Model 2 Entire U.S.	Model 3 Entire U.S.	Model 4 Large Metro Areas	Model 5 83 Most Polluted Metro Areas	Model 6 33 Most Polluted Metro Areas
<i>Family Structure Variables</i>						
% Single-mother families logged (<6)	0.332 ***	0.165 ***	0.174 ***	0.094 ***	0.126 ***	0.205 ***
% Single-father families logged (<6)	0.089 ***	0.080 ***	0.035 **	-0.051 ***	0.043 *	0.026
% Married-parent families logged (<6)	-0.037 ***	0.063 ***	0.075 ***	-0.020	-0.039 *	-0.044
<i>Control Variables</i>						
% Hispanic logged		-0.031	-0.082 ***	0.139 ***	0.164 ***	0.165 ***
% Non-Hispanic black logged		0.217 ***	0.281 ***	0.130 ***	0.157 ***	0.247 ***
% Non-Hispanic Asian logged		0.081 ***	0.154 ***	0.157 ***	0.128 ***	0.181 ***
Per-capita income logged		-0.031	0.597 ***	0.477 ***	0.374 ***	0.465 ***
% Poverty logged		-0.008	0.029 *	0.086 ***	0.157 ***	0.027
% Some college logged			-0.610 ***	-0.312 ***	-0.274 ***	-0.055
% Engaged in manufacturing logged			0.487 ***	-0.023	-0.116 ***	-0.141 **
% Vacant logged			-0.341 ***	-0.148 ***	-0.135 ***	-0.238 ***
Median property value logged			0.420 ***	-0.152 ***	0.000	-0.209 *
Median house age logged			0.477 ***	0.385 ***	0.664 ***	0.535 ***
Constant	4.454 ***	4.365 ***	-6.645 ***	1.617 ***	1.134 **	3.200 **
R^2	0.0345	0.0667	0.1714	0.1663	0.2434	0.2272
R^2 (reduced 1) ^a			0.0333	0.0506	0.0855	0.0921
R^2 (reduced 2) ^b			0.0345	0.0566	0.0983	0.0995
N	64,427	64,427	63,601	18,641	12,982	3,921

^aThe R^2 value for the regression model that only includes the single-mother family variable as a predictor.

^bThe R^2 value for the regression model that only includes the three family structure variables as predictors.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$.