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The Effects of Air Pollution on Individual Psychological Distress

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Abstract

This study is the first of its kind to utilize longitudinal, nationally representative panel data from the United States to assess the relationship between exposure to air pollution and reports of psychological distress. Using annual-average measures of air pollution in respondents' census blocks of residence we find that over the period 1999 to 2011 particulate matter 2.5 is significantly associated with increased psychological distress; this association remains even after controlling for a robust set of demographic, socioeconomic, and health-related covariates. This study suggests that public health efforts to reduce the personal and societal costs of mental illness should consider addressing not only individual characteristics and factors in the social environment, but also underexplored facets of the physical environment such as air pollution.

Keywords

air pollution; mental health; particulate matter; psychological distress

INTRODUCTION

It is widely established in the public and environmental health literatures that exposure to air pollution is hazardous to human health[1]. Past research has largely focused on physical health effects: the association of air pollution with various adverse respiratory and cardiovascular disease outcomes has been particularly well documented[2,3]. However, recent epidemiological and animal toxicology studies also suggest a plausible connection between air pollution and psychological health.

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This is an important avenue of investigation since mental illnesses are common in the United States (US) and account for a sizable share of the burden of disease[4]. According to findings from the 2014 National Survey on Drug Use and Health (NSDUH), nearly one in five Americans ages 18 and older (18.1% or 43.6 million adults) had a mental illness in the past year and 4.1% (9.8 million adults) had a serious mental illness. This has profound implications for individual and population health[5], mental health care systems, and the economy[6]. Nevertheless, the environmental determinants of mental illness remain only partially understood.

New evidence has emerged regarding the impact of air pollution on the brain and in the pathogenesis of mental illness. Of interest are animal (e.g., rodent and feral dog) and human studies suggesting that air pollution exposure may lead to neuroinflammation, oxidative stress, cerebrovascular damage, and neurodegenerative pathology via several cellular and molecular pathways[7]. A separate but related line of research has further implicated neuroinflammation and cerebrovascular damage in the risk and/or exacerbation of certain mental illnesses (e.g., depression)[8,9,10,11].

Air pollution has also been associated with the more proximal behavioral determinants of psychological health. In particular, in areas with higher levels of air pollution, people tend to reduce the amount of time they spend outdoors[12]. Such averting behavior introduces a number of indirect pathways through which air pollution may further induce or worsen psychological distress, including limited exposure to sunlight and subsequent vitamin D deficiency[13,14], reduced physical activity and/or exercise[15,16,17], reduced contact with parks and other green space[18,19,20], and social isolation[21,22,23].

Despite growing empirical justification for investigating the effects of air pollution on psychological health, relatively few studies have done so explicitly. The small body of research in this area has examined the association of air pollution with depressive symptoms[24,25], anxiety[26], suicide risk[27], and associated emergency department visits[28,29,30]. Findings from this work are promising but not conclusive, as many of these studies tend to rely on small samples, utilize inconsistent measures and methodologies[31], or are limited in demographic[25,26,32], geographic[24,33,34], and/or temporal[27] scope. Of the few studies conducted in the US, one found no association between air pollution and depressive symptoms among older adults[24], while two others reported pollution effects on anxiety symptoms[26] and depression[32].

The present study is among the first to assess the impact of air pollution on psychological distress, a global rather than disorder-specific indicator of mental health problems which encompasses depression, anxiety, and other mood disorders, among US adults. Psychological distress can interfere with social functioning and activities of daily living,[35] and has been associated with increased risks of chronic disease and mortality[36,37,38]. We extend past research by utilizing over a decade of nationally-representative data on individual respondents merged with highly resolved temporal and spatial measures of fine particulate matter ($PM_{2.5}$), a mixture of solid particles and liquid droplets that are 2.5 micrometers in diameter and smaller, in respondents' neighborhoods. Given the ubiquitous but often modifiable nature of air pollution exposure, even associations with psychological distress that are of relatively small magnitude have the potential to greatly impact the personal and societal burdens of mental illness.

DATA AND METHODS

We use individual-level data from the 1999 to 2011 waves of the Panel Study of Income Dynamics (PSID), a longitudinal, replenishing survey of Americans which began in 1968 as a national probability sample of over 18,000 individuals in approximately 4,800 families. As of 2011, the PSID had expanded to include information on the demographic characteristics, socioeconomic position, and health of over 24,000 individuals in nearly 9,000 families.

Sample

The analytic sample for this study comprises 6,006 PSID respondents who were interviewed at least once and up to 6 times (mean=3) between 1999 and 2011, years that correspond with our data on psychological distress and air pollution exposure (psychological distress was not assessed in the PSID in 2005). We organize this information into a series of person-period observations, with each observation referring to the two-year period between PSID interviews. In total, respondents contributed 17,974 person-period observations.

Independent variable

To this dataset, we attach annual-average concentrations of $PM_{2.5}$ in respondents' neighborhoods using the PSID's supplemental Geospatial Match File. $PM_{2.5}$ is defined by particulate size and is derived primarily from combustion: fireplaces or wood stoves, car engines, and coal- or natural gas-fired power plants are all major sources. Between 1999 and 2011, respondents resided in blocks in which the concentration of $PM_{2.5}$ was, on average, 11.34 micrograms per cubic meter (μg/m^3), with a range of 2.16 to 24.23 μg/m^3. For reference, the Environmental Protection Agency's (EPA) annual national safety standard for $PM_{2.5}$ is 12 μg/m^3. Consistent with nationwide trends, $PM_{2.5}$ in respondents' neighborhoods declined from an average of 13.23 μg/m^3 to 9.46 μg/m^3 during our observation window (Figure 1).

Our measures of neighborhood $PM_{2.5}$ exposure are derived from the EPA's Air Quality System, a database which contains ambient air pollution measurements collected from a nationwide network of monitoring stations. Because these monitoring stations are unevenly distributed across the US and vary across time, we used a combination of land-use regression (LUR) and universal kriging to spatially interpolate reliable air pollution estimates in respondents' neighborhoods. This strategy is described in detail elsewhere[39]. In brief, the LUR was based on a database of over 265 geographic covariates, including: population density, total emissions of criteria air pollutants, land use, the normalized difference vegetation index (NDVI), measures of impervious surfaces, distance to and length of major road ways, and distance to commercial zones, airports, railroads, and the like. These variables were measured using a variety of buffer sizes of various radii ranging from 50 meters to 30 kilometers. Given such a large number of multicollinear variables, partial least squares (PLS) techniques were used to select only a subset of relevant covariates. The nation was then divided into three regions – (1) East, (2) Mountain West, and (3) West Coast

- and $PM_{2.5}$ prediction models using universal kriging for spatial smoothing were run separately in each region for each year. These models showed high cross-validated R^2, with a national R^2 of 0.88, and well-calibrated predictive intervals. This approach has also been applied in several recent epidemiologic studies of air pollution and health[40,41,42,43,44]. In this work, for each interview year, predictions were made at the census block centroid of respondents' census blocks of residence, the smallest unit of geography available in the PSID.

Dependent Variable

Psychological distress is measured with the Kessler 6 (K6) Non-Specific Psychological Distress Scale[45], a composite instrument of 6 items assessing how often an individual felt sad, nervous, restless, hopeless, worthless, or "that everything was an effort" during the past 30 days. Each item is scored from 0 ("none of the time") to 4 ("all of the time"). Combined scores from the 6 items on this scale range from 0 to 24. According to past research, values of 5 to 12 may be indicative of moderate mental distress[46], while scores of 13 and higher have been shown in clinical calibration studies to be associated with serious mental illness[47]. Notably, however, no clear standards have yet emerged for optimal K6 scoring[45]. The mean K6 score was 3.71 across person-periods in our sample (range: 0 - 24), with no noticeable year-to-year variation over the study period. Moreover, t-tests of seasonal variation in mean K6 scores were not statistically significant. As such, we do not adjust for temporal trends in our analyses.

Covariates

We also considered a number of potentially confounding covariates. Sociodemographic covariates included: age, race (non-Hispanic white, non-Hispanic black, Latino), gender (male, female), marital/cohabitation status (unpartnered, married/cohabitating), years of education, homeownership (rent, own), employment status (unemployed, employed, student, retired), family size, and household income. Health-related covariates included: smoking status (never smoked, current smoker, past smoker), body mass index (BMI), physical activity, alcohol use, and chronic conditions. We measured physical activity level by adding together the number of times per week an individual participated in light and heavy activity. Tertiles were created based on the distribution of all person-period observations with low activity categorized as anything below 3.23 times per week, medium activity between 3.23 and 8 times per week, and high activity as anything over 8 times per week. Alcohol consumption categories were defined a priori, adhering as closely as possible to the National Institute on Alcohol Abuse and Alcoholism's definitions of drinking behavior. As such, low drinking was defined as less than 1 drink per day, moderate drinking as 1 to 4 drinks per day, and high drinking as five or more drinks per day (versus no drinking). Chronic disease status was assessed with respect to asthma, lung disease, hypertension, heart disease, heart attack, and diabetes using the question: "Has a doctor ever told you that you have or had [said condition]?" Lastly, we measured neighborhood poverty as the poverty rate of the census tracts in which respondents resided at each survey wave using U.S. Census data.

Analytical strategy

To estimate the effects of air pollution on psychological distress, we fit a series of linear regression models to our pooled dataset[1]. We calculated robust standard errors to account for the non-independence of person-period observations related to the same individual. Model 1 focused on bivariate associations between psychological distress and $PM_{2.5}$ measured in the previous period. We used a one-year lagged measure of pollution to reflect the temporal ordering of our focal relationship and because we expected the effects of air pollution to be lagged or cumulative rather than instantaneous. Moreover, given the lack of evidence to support a specific lag period, we conceptualized a one-year lag as a proxy for longer-term exposure, as previous studies have also done[48].

Our second model adjusted for age, race, gender, marital/cohabitation status, years of education, homeownership, employment status, family size, and household income. Model 3 adjusted for a number of health behavioral characteristics and chronic conditions, including physical activity, BMI, smoking status, drinking behavior, asthma, lung disease, diabetes, and various indicators of heart disease, in addition to the sociodemographic variables just listed. Model 4 added an additional control for neighborhood poverty. We also ran analogous logistic regression models for the dichotomous version of the K6 score (<13 vs. ≥13). These results are largely consistent with those for the continuous measure and are available in the supplemental materials (Appendix A).

RESULTS

Table 1 presents summary statistics for our key independent and dependent variables, along with the demographic, socioeconomic, and health-related covariates. The variables in the top panel were measured continuously and are accompanied by ranges, grand means, and standard deviations. The variables in the bottom panel were coded dichotomously (1 if applicable, 0 otherwise) and are therefore presented as percentages of the sample. The total number of person-period observations and the corresponding number of individual respondents are presented with each variable.

$PM_{2.5}$ has a statistically significant association with psychological health before as well as after adjustment for relevant covariates (Table 2). In the bivariate analysis (**Model 1**), K6 scores were greater (worse) among respondents who resided in blocks with higher concentrations of $PM_{2.5}$ (b= 0.46; 95% CI= 0.35-0.56). Consistent with conventions in the environmental health literature, coefficient estimates are expressed throughout as change in respondents' K6 score per a 5 unit change in $PM_{2.5}$.

In multivariate analyses adjusted for demographic, socioeconomic, and health-related covariates, the relationship between $PM_{2.5}$ and psychological distress remained statistically significant, albeit attenuated by just over half in the fully-adjusted model (**Model 4**). The addition of demographic covariates accounted for the largest share of this reduction, with years of education, household income, marital/cohabitation status, and race playing the

[1]While the distribution of the K6 is not normal (there is clustering at or near zero), comparable negative binomial models produced substantively equivalent results to the pooled linear regressions reported. Given the ease of interpreting OLS coefficients, the linear models were selected over the negative binomial models for final presentation.

largest explanatory roles. The addition of health behavioral and chronic disease covariates (**Model 3**), however, increased the magnitude of the $PM_{2.5}$ coefficient, likely due to their potential moderating effects on psychological distress.

Given well-documented differences in psychological distress by gender[49] and racial-ethnic group[50], we also performed a combined gender- and race-stratified analysis using the final, fully-adjusted model (Table 3). In these stratified models, white women were the only gender-race group in which a statistically significant relationship between $PM_{2.5}$ and psychological distress remained. Additionally, the magnitude of this relationship was twice that observed in the pooled analysis. It should be noted, however, that in a race- and gender-stratified analysis using the dichotomous version of the K6 (Appendix B), a sizable and significant positive association for black men was found, while the significance for white women was only marginal ($p<0.1$).

DISCUSSION

Most past research on the health repercussions of air pollution has focused on adverse respiratory. and cardiovascular disease outcomes. Only a handful of studies have examined the association of air pollution with psychological health, despite growing evidence elucidating possible mechanisms to support such a relationship. Those studies that have considered the air pollution-psychological health link tend to rely on demographically[25,26,32]-and geographically-limited[24,33,34] samples at a single cross-section in time, and often utilize relatively crude measures of air pollution exposure[24] or mental health[28,29,30].

This study extends the emerging research in this area. Specifically, using longitudinal data for a nationally-representative sample of individuals, merged with robust annual-average measures of air pollution in respondents' census blocks of residence, we show that even after adjustment for various demographic, socioeconomic, and health-related covariates, higher concentrations of $PM_{2.5}$ are associated with an increased risk of psychological distress.

In addition, when stratified by race and gender, we find differential impacts of $PM_{2.5}$ on psychological distress. Specifically, the overall association between $PM_{2.5}$ and distress (measured as a continuous K6 score) appears to be driven by the effect among white women. However, the positive and significant finding for black men in supplementary analyses using the dichotomous version of the K6 suggests that further investigation into the intersecting roles of race and gender in the relationship between $PM_{2.5}$ and psychological distress is warranted.

Notably, however, additional analyses (Appendices C & D) examining other indicators of air pollution, including nitrogen dioxide (NO_2) and coarse particulate matter (PM_{10}), did not show statistically significant effects on psychological distress beyond the simple bivariate associations. These null findings point to the need for future research assessing variations in the effects of the physical environment across different pollutants and health outcomes.

Study Limitations

These findings should be interpreted in the context of several study limitations. First, although our observation window spans over a decade from 1999 to 2011, we examine psychological health as a function of air pollution measured solely in the prior time period (versus a cumulative measure better able to capture chronic exposure). However, past research on human health generally. and at least one animal toxicologic study of depressive symptoms more specifically[51] suggest that longer-term exposure to air pollution may be more detrimental than single point in time measurements. Future research examining both the physical and psychological health effects of longer durations of air pollution exposure will be valuable.

Second, we relied on self-reports of psychological distress. Although the K6 is a validated instrument for use in community-based samples[52,53], the items that make up the scale were specifically selected to minimize variation in reports across gender and racial-ethnic groups. Given potential asymmetries in social experiences, including air pollution exposure, by gender and race (e.g., the social context of disadvantage is not the same experience for whites as it is for African Americans due to racial residential segregation), the K6 may mask variation in reports of psychological distress, perhaps especially among women and/or people of color[54,55]. The use of gender- and race-stratified models in our study addresses, in part, such concerns; however, additional research examining the validity of mental health scales such as the K6 across gender and race, as well as their intersection, is critical.

Finally, although our models include a number of demographic, socioeconomic, and health-related covariates to control for possible confounding, the potential for residual and unmeasured confounding is always a limitation in observational studies. Furthermore, theory and past research suggest that many of the covariates we consider confounders may in fact be on the causal pathway between air pollution exposure and psychological distress (e.g., physical activity level). A fuller examination of the direct and indirect mechanisms through which air pollution operates on psychological health, however, was beyond the scope of the present study. Future research in this area would benefit from explicit assessments of the more proximal determinants linking air pollution and psychological distress, including various physiological and (mal)adaptive behavioral responses to environmental hazards, especially among racial/ethnic minority groups and other vulnerable populations who are disproportionately exposed to air pollution[56,57].

Public Health Implications

Nonetheless, this study suggests that public health efforts to reduce the personal and societal costs of mental illness should consider addressing not only individual characteristics and factors in the social environment, but also underexplored facets of the physical environment such as air pollution. Although nationwide levels of air pollution have declined over the last several decades[58], past research indicates that even exposure to relatively low levels of air pollution, including at levels below EPA safety standards, may be associated with adverse health effects[59].

Moreover, given the ubiquitous nature of air pollution across the US, even the relatively modest adverse association we observed may be related to considerable population attributable psychological health risks. Fortunately, air pollution is also readily modifiable through local, state, and national policies and practices directed at curbing vehicle and industrial sources of pollution. The political context and environmental regulations associated with the more recent declines in pollution, however, may shift with electoral changes in political administration, making ongoing research and action on the environmental determinants of psychological health even more critical.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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HIGHLIGHTS

- Exposure to $PM_{2.5}$ is positively associated with increased psychological distress
- This finding holds when adjusting for demographic, socioeconomic, and health controls
- There are differential impacts by race and gender on this association
- Supplementary analyses did not find significant associations for NO_2 or PM_{10}

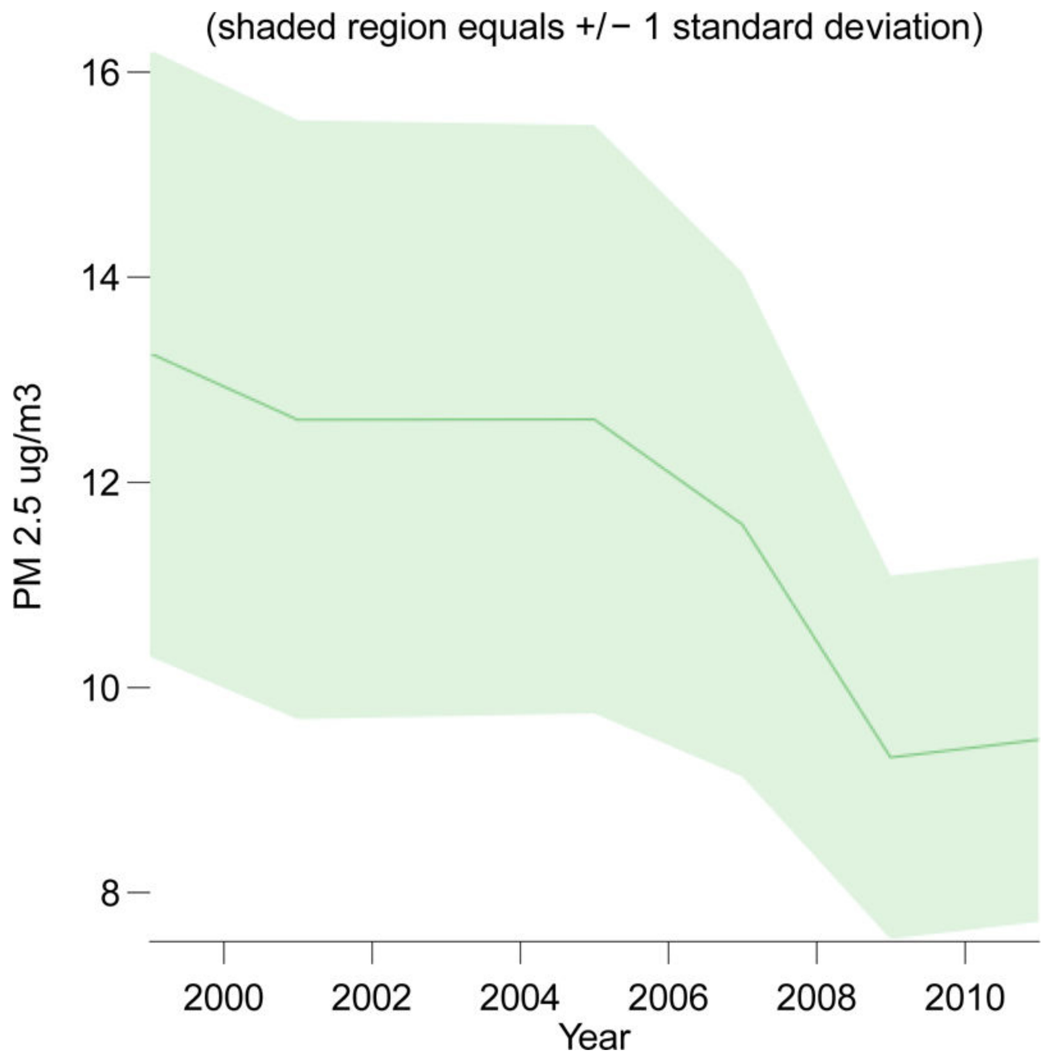

Figure 1.
Mean PM 2.5 decline over time in data sample

Table 1

Data sample descriptives

	Median	Range	Mean ± SD
K6	2	0 – 24	3.71 ± 4.13
PM 2.5 ug/m3	11.234	2.16 – 24.23	11.35 ± 2.93
Age	42	15 – 97	43.72 ± 15.57
Years of Education	12	0 – 14	13.03 ± 2.37
Family Income ($1,000s)	$40.00	-$73.50 – $1,657.51	$55.59 ± $66.15
Family Size	2	1 – 14	2.7 ± 1.5
BMI	26.75	12.8 – 69.00	28.08 ± 6.4
Neighborhood Poverty Rate	0.15	0.00 – 0.86	0.18 ± 0.12
	N (Observations)	N (Unique Individuals)	Percentage
Married/Cohabitating	9,422	3,425	52.42%
Homeowner	10,205	3,381	56.78%
White	11,468	3,753	63.80%
Black	5,801	1,999	32.27%
Latino/a	705	254	3.92%
Male	6,049	2,176	33.65%
Female	11,925	3,830	66.35%
Unemployed	3,872	2,116	21.54%
Employed	12,118	4,669	67.42%
Student	287	248	1.60%
Retired	1,697	757	9.44%
Active (Low)	6,140	3,252	34.16%
Active (Moderate)	6,628	3,816	36.88%
Active (High)	5,206	3,043	28.96%
Never Smoked	8,504	3,026	47.31%
Quit Smoking	4,936	1,896	27.46%
Smoker	4,534	1,899	25.23%
Never Drink	7,652	3,208	42.57%
Drinker (Low)	4,765	2,600	26.51%
Drinker (Moderate)	4,760	2,535	26.48%
Drinker (High)	797	568	4.43%
Asthma	2,354	927	13.10%
Lung Disease	1,621	654	9.02%
Hypertension	5,774	2,083	32.12%
Heart Disease	1,595	576	8.87%
Heart Attack	700	273	3.89%
Diabetes	1,869	713	10.40%

Note: 17,974 observations for 6,006 unique individuals

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Table 2

Linear regression of PM 2.5 on K6 Psychological Distress

	Dependent variable: Psychological Distress - Continuous (0 – 24)			
	Bivariate (1)	**Demographics (2)**	**Health Behaviors/Diagnoses (3)**	**Neighborhood Poverty (4)**
PM 2.5 (5ug/m3)	0.457*** (0.351, 0.564)	0.180*** (0.073, 0.288)	0.192*** (0.087, 0.298)	0.185*** (0.079, 0.290)
Age		0.019 (−0.005, 0.043)	−0.015 (−0.039, 0.009)	−0.015 (−0.038, 0.009)
Age Squared		−0.0004*** (−0.001, −0.0002)	0.0002* (−0.0005, 0.00004)	0.0002* (−0.0005, 0.00004)
Coupled		−0.451*** (−0.613, −0.289)	−0.356*** (−0.517, −0.196)	−0.356*** (−0.517, −0.196)
Years of Education		−0.171*** (−0.201, −0.140)	−0.125*** (−0.156, −0.094)	−0.124*** (−0.155, −0.093)
Homeowner		−0.518*** (−0.675, −0.361)	−0.376*** (−0.530, −0.222)	−0.365*** (−0.521, −0.210)
Black		−0.216** (−0.383, −0.049)	−0.287*** (−0.456, −0.118)	−0.325*** (−0.508, −0.143)
Latino/a		−0.571*** (−0.926, −0.216)	−0.447** (−0.796, −0.099)	−0.471*** (−0.821, −0.121)
Female		0.355*** (0.230, 0.481)	0.415*** (0.287, 0.543)	0.410*** (0.282, 0.538)
Employed		−1.685*** (−1.875, −1.495)	−1.435*** (−1.638, −1.268)	−1.448*** (−1.632, −1.263)
Student		−0.563* (−1.174, 0.047)	−0.448 (−1.051, −0.155)	−0.449 (−1.051, 0.153)
Retired		−1.010*** (−1.315, −0.706)	−1.056*** (−1.353, −0.758)	−1.051*** (−1.348, −0.753)
Family Size		−0.013 (−0.065, 0.039)	−0.012 (−0.063, 0.040)	−0.013 (−0.064, 0.038)
Family income ($1,000s)		−0.002*** (−0.003, −0.001)	−0.002*** (−0.003, −0.001)	−0.002*** (−0.002, −0.001)
Active (Moderate)			−0.207*** (−0.355, −0.060)	−0.207*** (−0.355, −0.060)
Active (High)			−0.161** (−0.319, −0.004)	−0.163** (−0.320, −0.005)
Quit Smoking			0.181** (0.040, 0.321)	0.180** (0.039, 0.320)
Smoker			0.914*** (0.745, 1.083)	0.909*** (0.740, 1.078)
Drinker (Low)			0.111 (−0.040, 0.262)	0.119 (−0.033, 0.271)
Drinker (Moderate)			0.070 (−0.090, 0.229)	0.075 (−0.085, 0.234)
Drinker (High)			0.367** (0.032, 0.703)	0.367** (0.032, 0.702)
BMI			0.020*** (0.009, 0.031)	0.020*** (0.009, 0.031)

	Dependent variable: Psychological Distress - Continuous (0 – 24)			
	Bivariate (1)	**Demographics (2)**	**Health Behaviors/Diagnoses (3)**	**Neighborhood Poverty (4)**
Asthma			0.535*** (0.329, 0.740)	0.535*** (0.329, 0.740)
Heart Attack			0.300 (−0.107, 0.707)	0.296 (−0.111, 0.703)
Heart Disease			0.748*** (0.467, 1.029)	0.749*** (0.468, 1.029)
Hypertension			0.573*** (0.417, 0.730)	0.570*** (0.414, 0.726)
Lung Disease			0.769*** (0.509, 1.029)	0.768*** (0.508, 1.028)
Diabetes			0.619*** (0.378, 0.859)	0.617*** (0.377, 0.858)
Neighborhood Poverty Rate	2.512*** (2.270, 2.755)			0.402 (−0.204, 1.009)
Constant		7.268*** (6.567, 7.970)	6.045*** (5.293, 6.797)	5.980*** (5.221, 6.739)
Observations	17,974	17,974	17,974	17,974
R^2	0.004	0.081	0.113	0.113
Adjusted R^2	0.004	0.08	0.112	0.112
Residual Std. Error	4.119	3.958	3.89	3.89
F Statistic	76.042***	113.037***	81.565***	78.824***

Note:

* p<0.1;

** p<0.05;

*** p<0.01

Table 3

Race and gender stratified linear regressions of PM 2.5 on K6

	Dependent variable: Psychological Distress - Continuous (0 – 24)					
	White Males (1)	**White Females (2)**	**Black Males (3)**	**Black Females (4)**	**Latino Males (5)**	**Latina Females (6)**
PM 2.5 (5ug/m3)	0.001 (−0.007, 0.008)	0.009** (0.001, 0.018)	0.017* (−0.002, 0.036)	0.002 (−0.013, 0.017)	0.002 (−0.019, 0.023)	−0.009 (−0.045, 0.028)
Age	0.001 (−0.002, 0.003)	0.004*** (0.003, 0.006)	0.003 (−0.001, 0.007)	0.00004 (−0.003, 0.003)	−0.002 (−0.015, 0.011)	0.009** (0.001, 0.018)
Age Squared	−0.00001 (−0.00003, 0.00002)	−0.0001*** (−0.0001, 0.00004)	−0.00004 (−0.0001, 0.00001)	−0.00001 (−0.00004, 0.00003)	0.00002 (−0.0001, 0.0002)	−0.0001*** (−0.0002, −0.00004)
Coupled	0.006 (−0.009, 0.022)	−0.018*** (−0.031, −0.005)	0.014 (−0.015, 0.043)	−0.016 (−0.036, 0.003)	−0.023 (−0.082, 0.036)	0.006 (−0.060, 0.071)
Years of Education	−0.003** (−0.006, −0.001)	−0.005*** (−0.008, −0.002)	−0.004* (−0.009, 0.001)	−0.002 (−0.007, 0.002)	−0.003 (−0.012, 0.005)	−0.005 (−0.017, 0.008)
Homeowner	0.006 (−0.022, 0.009)	−0.010 (−0.023, 0.003)	−0.001 (−0.024, 0.022)	−0.021** (−0.039, −0.004)	0.027 (−0.026, 0.080)	0.070* (−0.007, 0.147)
Employed	−0.076*** (−0.108, −0.044)	−0.052*** (−0.068, −0.037)	−0.060*** (−0.089, −0.030)	−0.069*** (−0.089, −0.050)	0.0001 (−0.034, 0.034)	−0.056 (−0.132, 0.019)
Student	−0.039 (−0.129, 0.051)	−0.031 (−0.076, 0.015)	−0.027 (−0.127, 0.073)	0.017 (−0.054, 0.089)	0.031 (−0.029, 0.091)	−0.075* (−0.156, 0.006)
Retired	−0.074*** (−0.111, −0.038)	−0.031*** (−0.053, −0.009)	0.004 (−0.063, 0.071)	−0.056** (−0.102, −0.010)	0.129 (−0.050, 0.308)	−0.025 (−0.133, 0.082)
Family Size	−0.002 (−0.007, 0.003)	−0.003 (−0.008, 0.001)	0.001 (−0.008, 0.010)	0.003 (−0.003, 0.009)	−0.006 (−0.014, 0.003)	−0.008 (−0.024, 0.008)
Family income ($1,000s)	−0.00003* (−0.0001, 0.00000)	−0.00004 (−0.0001, 0.00002)	−0.0002 (−0.0005, 0.0001)	−0.0001 (−0.0004, 0.0003)	0.001 (−0.0003, 0.002)	−0.001 (−0.002, 0.0004)
Active (Moderate)	−0.012* (−0.024, 0.001)	−0.010* (−0.022, 0.001)	−0.005 (−0.031, 0.020)	−0.019** (−0.037, −0.001)	−0.009 (−0.062, 0.044)	−0.014 (−0.073, 0.045)
Active (High)	−0.014** (−0.027, −0.0004)	−0.004 (−0.016, 0.009)	−0.019 (−0.043, 0.004)	−0.019 (−0.039, 0.001)	−0.020 (−0.077, 0.036)	0.007 (−0.069, 0.084)
Quit Smoking	−0.010** (−0.019, −0.0003)	0.00003 (−0.010, 0.010)	−0.006 (−0.030, 0.018)	0.017 (−0.004, 0.038)	−0.006 (−0.046, 0.034)	0.051 (−0.028, 0.129)
Smoker	0.027*** (0.012, 0.043)	0.019** (0.004, 0.034)	0.010 (−0.013, 0.034)	0.033*** (0.012, 0.054)	0.015 (−0.030, 0.060)	−0.047 (−0.111, 0.017)

	Dependent variable: Psychological Distress - Continuous (0 – 24)					
	White Males (1)	**White Females (2)**	**Black Males (3)**	**Black Females (4)**	**Latino Males (5)**	**Latina Females (6)**
Drinker (Low)	−0.002 (−0.016, 0.012)	−0.008 (−0.020, 0.003)	0.007 (−0.021, 0.034)	0.008 (−0.012, 0.028)	−0.049* (−0.104, 0.007)	0.063 (−0.031, 0.157)
Drinker (Moderate)	−0.009 (−0.022, 0.003)	−0.009 (−0.022, 0.004)	0.017 (−0.007, 0.040)	0.003 (−0.018, 0.024)	−0.026 (−0.077, 0.024)	−0.003 (−0.077, 0.071)
Drinker (High)	0.008 (−0.020, 0.035)	−0.002 (−0.038, 0.034)	0.041 (−0.008, 0.090)	−0.004 (−0.070, 0.062)	−0.043* (−0.090, 0.005)	−0.106* (−0.216, 0.004)
BMI	−0.001 (−0.002, 0.001)	0.0001 (−0.001, 0.001)	−0.0001 (−0.002, 0.002)	0.001* (−0.00002, 0.002)	−0.003 (−0.007, 0.001)	0.001 (−0.005, 0.006)
Asthma	0.014 (−0.008, 0.035)	0.023** (0.005, 0.041)	0.003 (−0.032, 0.038)	0.007 (−0.018, 0.033)	0.010 (−0.054, 0.073)	0.023 (−0.094, 0.141)
Heart Attack	0.036** (0.005, 0.067)	0.011 (−0.032, 0.054)	−0.023 (−0.085, 0.039)	−0.003 (−0.065, 0.059)	0.352 (−0.177, 0.880)	0.028 (−0.171, 0.227)
Heart Disease	0.002 (−0.018, 0.022)	0.028** (0.004, 0.052)	0.025 (−0.037, 0.087)	0.040* (−0.001, 0.081)	−0.085 (−0.243, 0.073)	0.131 (−0.061, 0.324)
Hypertension	0.013* (−0.00004, 0.026)	0.019*** (0.006, 0.032)	0.012 (−0.014, 0.039)	0.021** (0.001, 0.040)	0.034 (−0.037, 0.104)	0.054 (−0.024, 0.132)
Lung Disease	−0.011 (−0.034, 0.011)	0.039*** (0.015, 0.063)	0.011 (−0.042, 0.064)	0.044*** (0.011, 0.077)	−0.026 (−0.063, 0.011)	0.002 (−0.154, 0.158)
Diabetes	0.023* (−0.004, 0.050)	0.037*** (0.013, 0.061)	0.030 (−0.010, 0.070)	0.006 (−0.021, 0.033)	0.001 (−0.089, 0.091)	0.002 (−0.085, 0.089)
Neighborhood Poverty Rate	0.055 (−0.011, 0.120)	0.059** (0.002, 0.116)	−0.100*** (−0.174, −0.025)	−0.081*** (−0.142, −0.020)	−0.090 (−0.238, 0.058)	0.159 (−0.083, 0.401)
Constant	0.147*** (0.074, 0.220)	0.068** (0.006, 0.129)	0.060 (−0.056, 0.175)	0.110** (0.017, 0.203)	0.222 (−0.084, 0.528)	−0.040 (−0.292, 0.211)
Observations	4,002	7,466	1,732	4,069	315	390
R^2	0.061	0.061	0.042	0.05	0.17	0.109
Adjusted R^2	0.055	0.058	0.028	0.044	0.095	0.046
Residual Std. Error	0.148	0.195	0.194	0.237	0.159	0.248
F Statistic	9.934***	18.706***	2.888***	8.219***	2.274***	1.715**

Note:

*p<0.1;

** p<0.05;

*** p<0.01