Long-Term Exposure to Fine Particulate Matter, Residential Proximity to Major Roads and Measures of Brain Structure

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Background and Purpose—Long-term exposure to ambient air pollution is associated with cerebrovascular disease and cognitive impairment, but whether it is related to structural changes in the brain is not clear. We examined the associations between residential long-term exposure to ambient air pollution and markers of brain aging using magnetic resonance imaging.

Methods—Framingham Offspring Study participants who attended the seventh examination were at least 60 years old and free of dementia and stroke were included. We evaluated associations between exposures (fine particulate matter [PM$_{2.5}$] and residential proximity to major roadways) and measures of total cerebral brain volume, hippocampal volume, white matter hyperintensity volume (log-transformed and extensive white matter hyperintensity volume for age), and covert brain infarcts. Models were adjusted for age, clinical covariates, indicators of socioeconomic position, and temporal trends.

Results—A 2-µg/m$^3$ increase in PM$_{2.5}$ was associated with −0.32% (95% confidence interval, −0.59 to −0.05) smaller total cerebral brain volume and 1.46 (95% confidence interval, 1.10 to 1.94) higher odds of covert brain infarcts. Living further away from a major roadway was associated with 0.10 (95% confidence interval, 0.01 to 0.19) greater log-transformed white matter hyperintensity volume for an interquartile range difference in distance, but no clear pattern of association was observed for extensive white matter.

Conclusions—Exposure to elevated levels of PM$_{2.5}$ was associated with smaller total cerebral brain volume, a marker of age-associated brain atrophy, and with higher odds of covert brain infarcts. These findings suggest that air pollution is associated with insidious effects on structural brain aging even in dementia- and stroke-free persons. (Stroke. 2015;46:1161-1166. DOI: 10.1161/STROKEAHA.114.008348.)

Key Words: air pollution ■ brain infarcts ■ neuroimaging

Long-term exposure to particulate air pollution has been associated with higher incidence of stroke$^1$ and impaired cognitive function in older adults.$^2,3$ Long-term exposures have also been associated with changes in cerebral hemodynamics,$^4$ impaired microvascular reactivity,$^5$ and greater carotid atherosclerotic burden.$^6$ Air pollution has been hypothesized to affect the central nervous system through activation of systemic inflammatory pathways and vascular dysfunction.$^7$ Particulate air pollution is a pervasive component of urban and suburban ambient air pollution. Animal models have shown that particles can translocate from the nose via the olfactory nerve into the brain, and evidence of these particles has been found in the striatum, frontal cortex, and cerebellum.$^8$ However, it is not known whether long-term exposures to air pollution at urban background levels are related to measures of structural integrity and atrophy in the brains of older adults.

Magnetic resonance imaging (MRI) of the brain can detect early vascular impairment$^9$ that is associated with subsequent risk of dementia and stroke.$^{10}$ Therefore, we investigated the associations between exposure to fine particulate matter (PM$_{2.5}$) and residential proximity to major roadways with measures of total cerebral brain volume (TCBV), hippocampal volume (HV), white matter hyperintensity volume (WMHV), and covert brain infarcts (CBI) in the Framingham Offspring Study. We hypothesized that higher long-term exposure to ambient air pollution would be associated with...
subclinical damage as indicated by smaller TCBV and HV, larger WMHV, and higher odds of CBI.

Materials and Methods

Study Participants
The design of the Framingham Offspring Study has been detailed previously. Community-dwelling participants living in the New England Region with no history of dementia, stroke, or transient ischemic attack who attended the seventh examination (1998–2001) were aged ≥60 years at the time of MRI and were eligible for inclusion in this study (n=943). All participants provided written informed consent, and the Institutional Review Boards at Beth Israel Deaconess Medical Center and Boston Medical Center approved the protocol.

Exposure Assessment

PM2.5 Satellite Data
Participant primary addresses at the seventh examination were geocoded using ArcGIS 10 (ESRI, Redlands, CA), and census tract median household income was assigned (US Census 2000). Beginning in the year 2000, Moderate Resolution Imaging Spectroradiometer satellite-derived Aerosol Optical Density measurements were used to predict daily PM2.5 concentration across New England as previously described.11

Near Roadway Exposure
Residential proximity to the nearest A1, A2, or A3 roadway was determined by US Census Features Class in ArcGIS. We categorized proximity based on the following cut points: <50, 50 to <100, 100 to <200, 200 to <400, and 400 to <1000 m. We also evaluated the continuous association between the natural logarithm of proximity to a major roadway and neuroimaging outcomes because we have previously reported that this exposure and mortality were linearly associated. Participants living further than 1000 m from a major road in rural areas were excluded in primary analyses because the exposures of individuals living in exurb areas beyond 1000 m away from a major roadway are likely to be different from those of people living in urban and suburban areas.

Volumetric Brain MRI
TCBV, HV, and WMHV assessments and inter-rater reliability have been described previously. Total cranial volume was determined by manual delineation of the intracranial vault, and total brain parenchymal volume was determined by mathematical modeling. TCBV was then computed as a ratio of brain parenchymal volume:total cranial volume. The T2-weighted double spin-echo coronal sequences were acquired in 4-mm contiguous slices. Extensive WMHV (EXT-WMHV) was determined as a binary outcome by whether the log(WMHV/total cranial volume) was >1 SD above the age-adjusted mean in this cohort. The presence of CBI was determined manually on the basis of size (>3 mm), location, and characteristics of the lesions.

Additional Covariates
History of cardiovascular disease was determined as previously described. Prevalent diabetes mellitus was defined as a fasting glucose ≥126 mg/dL or oral hypoglycemic or insulin use at an examination or any previous history of diabetes mellitus (excluding gestational diabetes). Smoking status (never, current, and former), pack-years smoked (<10 years, ≥10 years, and missing), education (no high school, high school, some college, bachelors or higher), and alcohol intake (0, 1–7 drinks/wk, and 7–14, ≥15) were self-reported. Fasting homocysteine was measured in plasma. Systolic and diastolic seated blood pressures were calculated as the mean of 2 measurements taken during the clinical examination.

Table 1. Population Characteristics (n=943)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median [IQR] or n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at MRI, y</td>
<td>68 [9]</td>
</tr>
<tr>
<td>Systolic blood pressure, mmHg</td>
<td>129 [25]</td>
</tr>
<tr>
<td>Diastolic blood pressure, mmHg</td>
<td>72 [13]</td>
</tr>
<tr>
<td>Men</td>
<td>456 [48%]</td>
</tr>
<tr>
<td>Prevalent cardiovascular disease</td>
<td>130 [14%]</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>73 [8%]</td>
</tr>
<tr>
<td>Former</td>
<td>532 [56%]</td>
</tr>
<tr>
<td>Never</td>
<td>337 [36%]</td>
</tr>
<tr>
<td>Missing</td>
<td>1 (&lt;1%)</td>
</tr>
<tr>
<td>Prevalent heart failure</td>
<td>46 [5%]</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>134 [14%]</td>
</tr>
<tr>
<td>Hypertension medication use</td>
<td>366 [39%]</td>
</tr>
<tr>
<td>Homocysteine</td>
<td>8.3 [3.1]</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>51 [5%]</td>
</tr>
<tr>
<td>High school</td>
<td>311 [33%]</td>
</tr>
<tr>
<td>Some college/associate degree</td>
<td>275 [29%]</td>
</tr>
<tr>
<td>Bachelors or higher</td>
<td>298 [32%]</td>
</tr>
<tr>
<td>Missing education</td>
<td>8 (&lt;1%)</td>
</tr>
<tr>
<td>Median household income</td>
<td>63,479 [29,270]</td>
</tr>
<tr>
<td>Total cerebral brain volume</td>
<td>78.41 [4.39]</td>
</tr>
<tr>
<td>Hippocampal volume</td>
<td>0.33 [0.07]</td>
</tr>
<tr>
<td>Log white matter hyperintensity volume</td>
<td>-2.69 [1.30]</td>
</tr>
<tr>
<td>Extensive white matter hyperintensity</td>
<td>135 [14%]</td>
</tr>
<tr>
<td>Covert brain infarcts</td>
<td>133 [14%]</td>
</tr>
</tbody>
</table>

IQR indicates interquartile range; and MRI, magnetic resonance imaging.

Statistical Methods
Linear and logistic regression models were used to evaluate continuous outcomes (TCBV, HV, and WMHV) and dichotomous outcomes (EXT-WMHV and CBI), respectively. We first adjusted for age at MRI, [age at MRI], sex, time from examination 7 to MRI, median household income, date of MRI, smoking status, pack-years smoked, education, alcohol intake, and sine and cosine of MRI date to account for seasonal trends (model 1). We then added covariates thought to be potential confounders that could also be mediators of the associations.

Table 2. Exposure Characteristics

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Median [IQR] or n (%)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5, μg/m³</td>
<td>11.1 [1.7]</td>
<td>7.7—17.6</td>
</tr>
<tr>
<td>Distance to major road, m</td>
<td>173 [367]</td>
<td>0–993</td>
</tr>
</tbody>
</table>

IQR indicates interquartile range; and PM2.5, particulate matter. Estimates unavailable on 13 participants.

†Sixty-nine participants living ≥1000 m from a major road excluded.
between particulate air pollution and brain structure, including natural logarithm of homocysteine, systolic blood pressure, diabetes mellitus, cardiovascular disease, history of atrial fibrillation, hypertension medications, and obesity. Smoking, or median income below the 25th percentile. Participants lived a median distance (25th to 75th percentile) from a major road of 173 (48–415) m (Table 2). The Spearman rank correlation between the natural logarithm of residential distance from a major road and PM$_{2.5}$ was −0.15.

Higher PM$_{2.5}$ was associated with smaller TCBV and 1.46 times (95% confidence interval [CI], 1.10 to 1.94) higher odds of CBI (Tables 3 and 4). A 2-$\mu$g/m$^3$ increase in PM$_{2.5}$ was associated with a 0.32 U difference in TCBV (95% CI, −0.59 to −0.05). There was no clear pattern of association between PM$_{2.5}$ and HV, WMHV, or EXT-WMHV.

An interquartile range difference in residential proximity to a major road was associated with 0.10 (95% CI, 0.01 to 0.19) higher WMHV. A similar pattern was observed with categories of distance. However, there was no evidence of an association between proximity to a major road and EXT-WMHV, or was it associated with TCBV, HV, or CBI.

There was no evidence of effect modification for the observed associations by sex, diabetes mellitus diagnosis, obesity, smoking, or median income below the 25th percentile. Only the association between PM$_{2.5}$ and TCBV met criteria for significant deviation from linearity, suggesting a stronger association at lower exposure levels and wide CIs at high levels (Figure I in the online-only Data Supplement). We found

### Results

Table 1 shows population characteristics. The median (interquartile range) of PM$_{2.5}$ exposure was 11.1 (1.7) $\mu$g/m$^3$. Participants lived a median distance (25th to 75th percentile) from a major road of 173 (48–415) m (Table 2). The Spearman rank correlation between the natural logarithm of residential distance from a major road and PM$_{2.5}$ was −0.15.

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### Table 2. Associations Between Covariates and Continuous Volumetric Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Exposure</th>
<th>$\beta$</th>
<th>95% CI</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hippocampal volume</td>
<td>&lt;50</td>
<td>0.004</td>
<td>(−0.005 to 0.014)</td>
<td>865</td>
</tr>
<tr>
<td>50 to &lt;100</td>
<td>0.003</td>
<td>(−0.011 to 0.016)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>100 to &lt;200</td>
<td>0.005</td>
<td>(−0.006 to 0.016)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>200 to &lt;400</td>
<td>0.003</td>
<td>(−0.007 to 0.013)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>400 to &lt;1000</td>
<td>Ref</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Log(distance)‡</td>
<td>−0.002</td>
<td>(−0.007 to 0.003)</td>
<td>865</td>
<td></td>
</tr>
<tr>
<td>PM$_{2.5}$§</td>
<td>0.0001</td>
<td>(−0.005 to 0.005)</td>
<td>921</td>
<td></td>
</tr>
<tr>
<td>Log (white matter hyperintensities)</td>
<td>&lt;50</td>
<td>−0.17</td>
<td>(−0.35 to 0.01)</td>
<td>873</td>
</tr>
<tr>
<td>50 to &lt;100</td>
<td>−0.13</td>
<td>(−0.37 to 0.11)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>100 to &lt;200</td>
<td>−0.07</td>
<td>(−0.27 to 0.13)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>200 to &lt;400</td>
<td>0.02</td>
<td>(−0.16 to 0.21)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>400 to &lt;1000</td>
<td>Ref</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Log(distance)‡</td>
<td>0.10</td>
<td>(0.01 to 0.19)</td>
<td>873</td>
<td></td>
</tr>
<tr>
<td>PM$_{2.5}$§</td>
<td>−0.06</td>
<td>(−0.16 to 0.03)</td>
<td>929</td>
<td></td>
</tr>
<tr>
<td>Total cerebral brain volume</td>
<td>&lt;50</td>
<td>0.23</td>
<td>(−0.29 to 0.75)</td>
<td>873</td>
</tr>
<tr>
<td>50 to &lt;100</td>
<td>0.45</td>
<td>(−0.24 to 1.14)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>100 to &lt;200</td>
<td>−0.02</td>
<td>(−0.60 to 0.56)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>200 to &lt;400</td>
<td>−0.19</td>
<td>(−0.73 to 0.35)</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>400 to &lt;1000</td>
<td>Ref</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Log(distance)‡</td>
<td>−0.15</td>
<td>(−0.41 to 0.11)</td>
<td>873</td>
<td></td>
</tr>
<tr>
<td>PM$_{2.5}$§</td>
<td>−0.32</td>
<td>(−0.59 to −0.05)</td>
<td>929</td>
<td></td>
</tr>
</tbody>
</table>

CI indicates confidence interval; MRI, magnetic resonance imaging; and PM$_{2.5}$, particulate matter.

*Model 1 adjusted for age, age2, sex, time from examination 7 to MRI, median household income, date of MRI, smoking status, pack-years smoked, education (no high school, high school, some college, bachelors or higher), drinking categories and sine and cosine of MRI date to account for seasonal trends.

†Model 2 adjusted for model 1 covariates+log (homocysteine), systolic blood pressure, diabetes mellitus, cardiovascular disease, history of atrial fibrillation, hypertension medications, and obesity.

‡Scaled to difference between 25th and 75th percentile of distance (367 m).

§Scaled to 2 $\mu$g/m$^3$ difference in PM$_{2.5}$.
analyses to regions within 1000 m of a major road or cluster - in injury did not alter the association between PM2.5 and TCBV.ing by socioeconomic position. Adjustment for covert brain reflect small-vessel disease.26 Smaller TCBV has been associ-

ciety that we observed for a 2-

≈

μ
g/m 3 increase in PM 2.5 was

ciation that we observed for a 2-

−0.32 (95% CI, −0.59 to −0.05) TCBV and with 1.46 times
ground levels in New England was associated with smaller
the range of exposures observed at urban and suburban back-

cerebrovascular damage.22–24

ambient air pollution are associated with structural changes

(95% CI, 1.10 to 1.94) higher odds of CBI. These findings

In this study, we observed that an increase in PM 2.5 within

Discussion

In this study, we observed that an increase in PM 2.5 within

the range of exposures observed at urban and suburban back-

ground levels in New England was associated with smaller

−0.32 (95% CI, −0.59 to −0.05) TCBV and with 1.46 times

(95% CI, 1.10 to 1.94) higher odds of CBI. These findings

support the hypothesis that higher long-term exposures to
ambient air pollution are associated with structural changes
in the brain that could precede cognitive impairment and overt cerebrovascular damage.22-24

To our knowledge, there are no published studies of asso-
ciations between air pollution and brain volume or CBI in
older adults. Although CBI may appear asymptomatic, these small infarcts typically located in deep regions of the brain have been associated with neurological abnormalities, poorer cognitive function,25 onset of dementia,24 and are thought to reflect small-vessel disease.26 Smaller TCBV has been associ-
ated subsequent stroke among Framingham Offspring partici-
pants27 and also with poorer performance on tests of attention,
executive, and visuospatial function.16 The magnitude of asso-
ciation that we observed for a 2-μg/m3 increase in PM 2.5 was
similar to ≈1 year of brain aging computed as the ratio of the coefficients for PM 2.5 and age in the model. Adjustment for CBI did not alter this association, suggesting that atrophy was

independent of the presence of asymptomatic injury and not merely a direct result of the presence of cerebral infarction.

The mechanisms through which air pollution may affect brain aging remain unclear, but systemic inflammation resulting from deposition of fine particles in alveoli is likely important. Upregulation of a proinflammatory state has been associated both with elevated risk of stroke7,28 and cognitive decline.29 Circulating levels of biomarkers indicative of systemic inflammation have been associated with lower brain volume.30

Our findings are largely consistent with previous studies show-
ing that long-term exposure to ambient air pollution is associ-
ated with vascular impairment.4,5,12 Several previous studies have reported associations between long-term pollution exposure and living close to major roads with incident stroke4,11,31 and poorer cognitive function in older adults.2,3,33 Living in a high air pollution region in Mexico City was associated with greater accumu-
lation of 42-amino acid form of β-amyloid in the frontal cortex and hippocampus than living in a nonpolluted area.34

Although evidence on the associations between long-term air pollution exposures and white matter damage is limited, an ecological study in Mexico reported associations between higher levels of air pollution and white matter damage in chil-
dren and dogs.35 Our findings of a positive association between WMHV and living further from a major road but no associa-
tion with EXT-WMHV were unexpected. However, among Framingham Offspring Study participants, EXT-WMHV was associated with poorer cognitive function48 and elevated risk of stroke10 but WMHV was not, suggesting a threshold for these associations. Different findings may have distinct under-
lying pathophysiological mechanisms. To evaluate this, it will


Table 4. Associations Between Exposures and Binary Outcome

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Exposure</th>
<th>Model 1*</th>
<th>Model 2†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive white matter</td>
<td>&lt;50</td>
<td>0.88 (0.51–1.52)</td>
<td>0.94 (0.53–1.67)</td>
</tr>
<tr>
<td>hyperintensity volume</td>
<td>50 to &lt;100</td>
<td>0.56 (0.25–1.29)</td>
<td>0.59 (0.25–1.38)</td>
</tr>
<tr>
<td>for age</td>
<td>100 to &lt;200</td>
<td>0.86 (0.46–1.60)</td>
<td>0.96 (0.51–1.83)</td>
</tr>
<tr>
<td>Log(distance)‡</td>
<td>1.11 (0.84–1.48)</td>
<td>1.09 (0.81–1.47)</td>
<td>873</td>
</tr>
<tr>
<td>PM2.5§</td>
<td>1.00 (0.76–1.32)</td>
<td>0.94 (0.70–1.26)</td>
<td>929</td>
</tr>
<tr>
<td>Covert brain infarcts</td>
<td>&lt;50</td>
<td>1.21 (0.67–2.17)</td>
<td>1.29 (0.70–2.36)</td>
</tr>
<tr>
<td>50 to &lt;100</td>
<td>1.25 (0.58–2.67)</td>
<td>1.16 (0.53–2.56)</td>
<td>...</td>
</tr>
<tr>
<td>100 to &lt;200</td>
<td>1.17 (0.61–2.23)</td>
<td>1.10 (0.56–2.15)</td>
<td>...</td>
</tr>
<tr>
<td>200 to &lt;400</td>
<td>1.69 (0.95–3.00)</td>
<td>1.72 (0.95–3.11)</td>
<td>...</td>
</tr>
<tr>
<td>400 to &lt;1000</td>
<td>Ref</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Log(distance)‡</td>
<td>1.05 (0.79–1.40)</td>
<td>1.02 (0.75–1.37)</td>
<td>870</td>
</tr>
<tr>
<td>PM2.5§</td>
<td>1.46 (1.10–1.94)</td>
<td>1.37 (1.02–1.85)</td>
<td>926</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; MRI, magnetic resonance imaging; OR, odds ratio; and PM2.5, particulate matter.

*Model 1 adjusted for age, age2, sex, time from examination 7 to MRI, median household income, date of MRI, smoking status, pack-years smoked, education (no high school, high school, some college, bachelors or higher), drinking categories and sine and cosine of MRI date to account for seasonal trends.

†Model 2 adjusted for model 1 covariates + log (homocysteine), systolic blood pressure, diabetes mellitus, cardiovascular disease, history of atrial fibrillation, hypertension medications, and obesity.

‡Scaled to difference between 25th and 75th percentile of distance (367 m).

§Scaled to 2 μg/m3 difference in PM2.5.
require additional studies in experimental models designed to address these questions. There were some differences in associations we observed for PM$_{2.5}$ and residential proximity to a major roadway. Although both capture features of long-term exposure to ambient air pollution, proximity is an integrated measure of exposure to traffic, which includes vehicle emissions, noise, ultrafine particles, road dust, and gaseous pollutants such as nitrogen dioxide, carbon monoxide, and volatile organic compounds but does not specifically account for the intensity of traffic or meteorologic conditions at a given location. In contrast, modeled PM$_{10}$ incorporates both locally and regionally generated air pollution. Hence, they represent different aspects of ambient pollutant exposures.

Our study is not without limitations. Although we accounted for individual-level and area-level characteristics of socioeconomic position, there may be residual confounding. However, the results from our analysis taking spatial clustering into account were similar to our primary results, and previous literature using modeled PM$_{10}$ has also shown that correlations between socioeconomic position and PM$_{10}$ are low within urban areas. The Framingham Offspring population comprised mostly white participants. Therefore, these results may not be generalizable to other populations. Recent addresses were stable, with 91% of participants reporting the same address at the sixth and seventh examination cycles. Our PM$_{10}$ data are based on an average for the year 2001 similar to other large epidemiological studies. This approach limits the influence of secular trends in exposure, while capturing the spatial distribution of average PM$_{2.5}$. This study also has several strengths, including a relatively large, community-based sample, inclusion of both men and women, quantitative brain MRI, and individual-level estimates of exposures.

Conclusions
We observed evidence suggesting that long-term exposure to PM$_{2.5}$ is associated with lower TCBV and more CBI among older adults. Additional studies will be necessary to confirm or refute these findings, extend the work to include traffic-related air pollution and cognitive function in a cohort of older men. Environ Health Perspect. 2011;119:682–687. doi: 10.1289/ehp.1002767.


Au R, Massaro JM, Wolf PA, Young ME, Beiser A, Seshadri S, et al. Association of white matter hyperintensity volume with decreased

**Sources of Funding**
This work was supported by grants from the National Institutes of Health (NIH: ES022243, ES000002, AG008122, AG033193, AG016495, NS017950, and N01 HC052195) and the United States Environmental Protection Agency (USEPA; R834798). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the USEPA. No funding organization had any role in the design and conduct of the study; collection; management, analysis and interpretation of the data; and preparation of the article. Its contents are solely the responsibility of the grantee and do not necessarily represent the official views of the funders. Furthermore, USEPA does not endorse the purchase of any commercial products or services mentioned in the publication.

**Disclosures**
None.

**References**


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*Stroke*. 2015;46:1161-1166; originally published online April 23, 2015; doi: 10.1161/STROKEAHA.114.008348

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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Data Supplement (unedited) at:
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Model 1 adjusted results for association between PM$_{2.5}$ (5 knots) and total cerebral brain volume. The spline indicates a steeper slope at lower levels of exposures. High levels of exposure were associated with higher brain volume, though confidence intervals in this range of the data were wide. Whether this pattern is due to a leveling off in the exposure-response relationship, the influence of outliers, or residual confounding remains unclear.
5 years to atrial fibrillation. Each atrial fibrillation episode was a high-risk period for stroke, and the highest risk occurred within the first 30 days after atrial fibrillation diagnosis. Although we observed a similar rate of ischemic stroke in both groups, this suggests our findings are not simply attributable to the high-risk period after a transient ischemic attack. Our sensitivity analysis stratifying patients by timing of warfarin initiation after atrial fibrillation supports this hypothesis. No difference in stroke rates according to timing of warfarin initiation was observed. In summary, the cumulative incidence of stroke in the first 30 days after warfarin initiation is 4.0% (n=6006). We observed the highest rate of ischemic stroke in older patients with atrial fibrillation, with a CHADS2 score of 6.7. This study was supported by the Ontario Drug Policy Research Network, which is funded by grants from the Ontario Ministry of Health and Long-Term Care. No endorsement by ICES or the MOHLTC is implied. The other authors report no conflicts.

Acknowledgments

The authors acknowledge the contribution of the study participants and the data collection and management teams. The manuscript was prepared by the research team and revised by the principal investigator and co-investigators. The authors are grateful for the support of the Heart and Stroke Foundation of Ontario, which provided funding for the publication of this manuscript. The authors also acknowledge the contributions of the data management team led by Sarah Preis and the statistical analysis team led by Alexa Beiser. The manuscript was reviewed by the editorial board of the journal. The authors declare no conflicts of interest.

References


Table 1. Baseline Characteristics

<table>
<thead>
<tr>
<th>Medication use</th>
<th>CHADS2 score</th>
<th>Stroke in past 5 y</th>
<th>Hypertension</th>
</tr>
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<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>99.77 (6.7)</td>
<td>76.6%</td>
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<tr>
<td>Oral anticoagulant therapy</td>
<td>1</td>
<td>86.32 (58.9)</td>
<td>71.3%</td>
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<td>56.1 (41.0)</td>
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<td>Bridging therapy</td>
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Table 2. Rates of Stroke by Duration of Warfarin Therapy

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<th>Ischemic Stroke During 5-y Follow-Up, n (%)</th>
<th>Rate of Stroke, % per Person-Year (95% CI)</th>
<th>Overall</th>
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CHADS2 indicates score comprised of congestive heart failure, hypertension, age ≥75 years, diabetes, previous stroke, and CI, confidence interval.

Abstract 4

미세먼지에의 장기적인 노출, 주거지역의 주요도로 근접여부 및 뇌 구조의 측정

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(Stroke. 2015;46:1161-1166.)

Key Words: air pollution • brain infarcts • neuroimaging
암의 장기적인 노출과 MRI를 이용한 뇌의 노화 표지와의 관계를 연구하였다.

방법
Framingham Offspring Study의 7번째 조사에 참여한 사람 중 60세 이상이며 치매와 뇌졸중 병력이 없는 사람을 연구에 포함하였다. 노출된 정도(미세먼지[PM2.5]와 주요 도로에서 얼마나 가까운 곳에 거주하는지)와 관리 복용, 해마다 복용, 백색질의 고음영용적(고도의 변형을 했고, 연령대에 비해 광범위한 백색질 고음영용적 확인), 무증상 뇌결손 사이의 연관성을 평가하였다. 분석 모형은 나이, 임상적 공변량, 사회경제적 상태 지표, 시간 경향에 대해 보정하였다.

결과
2.5 μm 이하의 미세먼지가 2 μg/m^3 증가할 때 단백 뇌성은 0.32%씩 감소했으며(95% CI, −0.59 to −0.05), 무증상 뇌결손은 1.46배의 높은 교차비를 보였다(95% CI, 1.10 to 1.94). 주요 도로에서 멀리 떨어져 있다는 것이 거리가 사분위수 범위로 나누었을 때, 한 단계에 대해 로그 변환된 백색질 고음영용적 0.1 증가하였다(95% CI, 0.01 to 0.19). 그러나, 광범위한 백색질이 보이는 경우와는 명확한 연관관계가 관찰되지 않았다.

결론
높은 2.5 μm 이하 미세먼지에 노출된 경우에는 더 작은 뇌성 및 관리 복용이 관리된 뇌 위축, 무증상 뇌결손의 높은 교차비와 연관관계를 보였다. 이러한 결과는 공기 오염이 치매와 뇌결손 증현을 악화시키지 않은 사람들에서 조사 구조적인 연관성의 영향과 관련되어 있음을 시사한다.