U.S. Environmental Protection Agency:
Air Quality and its Affect on Heart Rates

Particulate matter and ozone levels are associated with alterations in heart rate variability, a measure of autonomic or involuntary nervous system control of cardiac function, among individuals living in eastern Massachusetts.

Lead Agency:

U.S. Environmental Protection Agency

Agency Mission:

The mission of the U.S. Environmental Protection Agency (EPA) is to protect public health and safeguard the natural environment.

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Partner Agency:

Harvard School of Public Health

General Description:

The EPA-funded Harvard Particulate Matter Center conducted a series of studies that focused on how air particles or particulate matter (PM) affect the rhythm of the human heart. The Harvard researchers found that particulate matter and ozone levels were associated with alterations in heart rate variability, a measure of cardiac function that is under autonomic or involuntary control, among individuals living in eastern Massachusetts. Harvard PM Center researchers have begun to examine different biologic control pathways that may play a role in the effect of PM on the heart. In addition, they are investigating the specific sources of PM that may be most important in influencing health responses in this study population, participants in the Normative Aging Study (NAS), a large longitudinal study established in 1963 by the U.S. Veterans Administration, because different types of particles may affect different biological pathways.

Heart rate variability reflects autonomic control of the rhythmic activity of the heart. The 2280 men enrolled in the Normative Aging Study were originally confirmed to be free of known chronic medical conditions, and active, continuing participants are examined every three years. This study analyzed information for 603 persons examined between

2000 and 2003. Ambient fine air particles (PM2.5) and black carbon measurements were obtained from a monitoring site located 1 kilometer from the clinic and were evaluated in relation to the clinical measurements. Researchers found that ozone and ambient $PM_{2.5}$ and black carbon concentrations, averaged over the previous 4 hours to 48 hours, were associated with reductions in heart rate variability. The greatest reductions were observed among hypertensive individuals and those with ischemic heart disease. Ambient black carbon concentrations were further found to be associated with increased C-reactive protein and fibrinogen levels in blood samples. These results suggest that the effects caused by PM could be brought about through pathways involving the autonomic nervous system and systemic inflammation.

More recent studies in the Normative Aging Cohort found that the effects of traffic-related PM are modulated by biologic markers of specific pathways that may be involved in the disease process. Particle exposure could increase adverse responses including oxidative stress, inflammation, and thrombosis (blood clots), leading to alterations in cardiac autonomic function and cardiovascular problems such as heart attacks. Researchers examined these effects using white blood cell counts, C-reactive protein, sediment rate, and fibrinogen from blood samples collected from study participants. Traffic-related PM components, black carbon, and particle number were related to increased levels of inflammatory and thrombotic markers, with associations most consistent for the blood clotting factor, fibrinogen. The association was strongest when exposures were averaged over the 4-weeks prior to the measurement.

Excellence: What makes this project exceptional?

This project has shown that markers of PM from traffic are associated with alterations in autonomic control of heart rhythms, which may increase the risk of cardiovascular disease and death from heart disease. The relation between particle pollution and cardiac effects was determined in a the Normative Aging Study which provides very strong evidence for the observed link because new clinical data and information on risk factors is collected on the participants every 3 to 5 years. Subsequent studies in this cohort have confirmed the original observations and provided stronger evidence that traffic-related particle pollution is associated with cardiac autonomic control and inflammation.

Significance: How is this research relevant to older persons, populations and/or an aging society?

Reductions of heart rate variability over long periods has been associated with increased risk of mortality in middle-aged and elderly subjects, in patients with diabetes, and in survivors of heart attacks and other cardiovascular diseases. Researchers found that ozone and ambient $PM_{2.5}$ and black carbon concentrations and particle number, averaged over the previous 4 hours to 48 hours, were associated with reductions in heart rate variability. The greatest reductions were observed among hypertensive individuals and those with ischemic heart disease. Individuals with these pre-existing conditions appear to be more susceptible to the adverse effects of PM exposure.

Effectiveness: What is the impact and/or application of this research to older persons?

This research indicates that older people, especially people with pre-existing health conditions, should be very cautious about their time spent outside on days when the air quality is poor. It reinforces the need for alerts on days with large amounts of fine particle pollution in the air. It also underscores the need to rigorously enforce and periodically re-evaluate the National Ambient Air Quality Standards for particulate matter.

Innovativeness: Why is this research exciting or newsworthy?

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