RSNA Press Release

Air Pollution Exposure Linked to Faster Spinal Bone Loss

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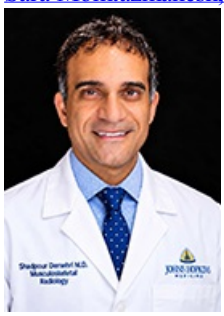
At A Glance

- Higher recent exposure to air pollution is linked with faster loss of spinal bone mineral density.
- Nitrogen dioxide (NO_2) exposure in the year prior to measurement showed the strongest link.
- An AI tool helped researchers assess spinal bone loss using chest CT scans from 1,245 people across six U.S. metropolitan areas.

CHICAGO – Higher recent exposure to air pollution from traffic and other sources is associated with slightly faster bone loss in the spine among older adults in metropolitan areas, according to a large new study being presented next week at the annual meeting of the Radiological Society of North America (RSNA).



Sara Momtazmanesh, M.D.



Shadpour Demehri, M.D.

"Air pollution may affect bone as well as the heart and lungs," said lead author Sara Momtazmanesh, M.D., postdoctoral research fellow, Department of Radiology and Radiological Science at Johns Hopkins University School of Medicine in Baltimore, Maryland. "In our study, higher recent exposure to nitrogen dioxide was linked to modestly faster loss of spine bone density."

Nitrogen dioxide (NO_2) is a harmful, reddish-brown gas that contributes to smog and acid rain. Vehicle exhaust and power plant emissions are major sources.

Loss of vertebral bone mineral density (BMD) can weaken the spine and increase the risk of fractures. These fractures can cause chronic pain, height loss and a hunched back. In severe cases, spinal curvature can crowd internal organs and affect breathing.

In this secondary analysis, the researchers used AI to help assess vertebral BMD in 1,245 participants (median age 66) using two noncontrast chest CT scans per participant taken approximately six years apart. The participants were

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part of the ongoing Multi-Ethnic Study of Atherosclerosis (MESA), a large, diverse U.S. cohort of adults without diagnosed cardiovascular disease at baseline who have been followed prospectively for decades to study the development and progression of subclinical cardiovascular disease.

Outdoor air pollution levels at each participant's home address were estimated using air-quality monitoring data, traffic patterns and local land-use information. Participants lived in New York, Chicago, Los Angeles, Baltimore, St. Paul and Forsyth County, North Carolina.

The open-source AI tool was used to automatically identify and outline individual vertebrae on the CT scans, allowing researchers to calculate bone density in the spongy inner bone, where age-related bone loss can appear earlier.

"Routine chest CT scans hold information about bone health that usually goes unused," said senior author Shadpour Demehri, M.D., professor of radiology and radiological science, Johns Hopkins University School of Medicine. "AI can measure it automatically and track it over time, making it possible to study environmental effects on bone in large populations."

People with higher recent exposure to NO_2 lost bone density in the middle of the spine at a slightly faster rate. The statistically significant difference in bone loss between exposure groups at the 25th and 75th percentiles was approximately 1.5 mg/cm³ over six years, less than 1% of typical starting bone density.

"Timing may matter," Dr. Momtazmanesh said. "The clearest link was with nitrogen dioxide exposure in the year before the first scan, and it was less consistent for exposure averaged over the preceding decade. That fits with how bone renews itself, in remodeling cycles of about seven months, but it could also reflect less precise long-term estimates."

The study found no consistent associations between fine particulate matter ($PM_{2.5}$) and vertebral bone loss. $PM_{2.5}$ consists of tiny particles that can lodge deep inside the lungs and enter the bloodstream. Sources include vehicle exhaust, industrial emissions and wildfire smoke.

An exploratory subgroup analysis by race and ethnicity found a different pattern. "$PM_{2.5}$ was linked to faster bone loss in non-Hispanic Black participants (0.66 mg/cm³ per year faster for each 1.8 µg/m³ increase in $PM_{2.5}$), even though $PM_{2.5}$ showed no consistent link in the overall study group," Dr. Momtazmanesh said.

Dr. Demehri emphasized that pollutants cannot be fully separated, so the study cannot definitively establish whether NO_2 itself accounted for the association with bone loss. Further research is needed to determine whether the association between air pollution and bone loss is temporary, cumulative or persistent over many years.

"For bone health, the established steps still matter most: staying physically active, including weight-bearing exercise, getting enough calcium and vitamin D, not smoking, limiting alcohol and asking your doctor whether bone density testing is right for you," Dr. Demehri said. "More broadly, if our findings are confirmed, they would add bone health to the reasons cleaner air matters."

Co-authors are Quincy A. Hathaway, M.D., Ph.D., Michael P. Bancks, Ph.D., David A. Bluemke, M.D., Ph.D., R. Graham Barr, M.D., Dr.P.H., Benjamin M. Smith, M.D., M.S., Wendy S. Post, M.D., M.S., Matthew J. Budoff, M.D., João A.C. Lima, M.D., M.B.A., and Joel D. Kaufman, M.D., M.P.H.
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Video (MP4):

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Video. Sara Momtazmanesh, M.D., discusses her research, which found that higher recent exposure to air pollution is associated with slightly faster bone loss in the spine among older adults in metropolitan areas.

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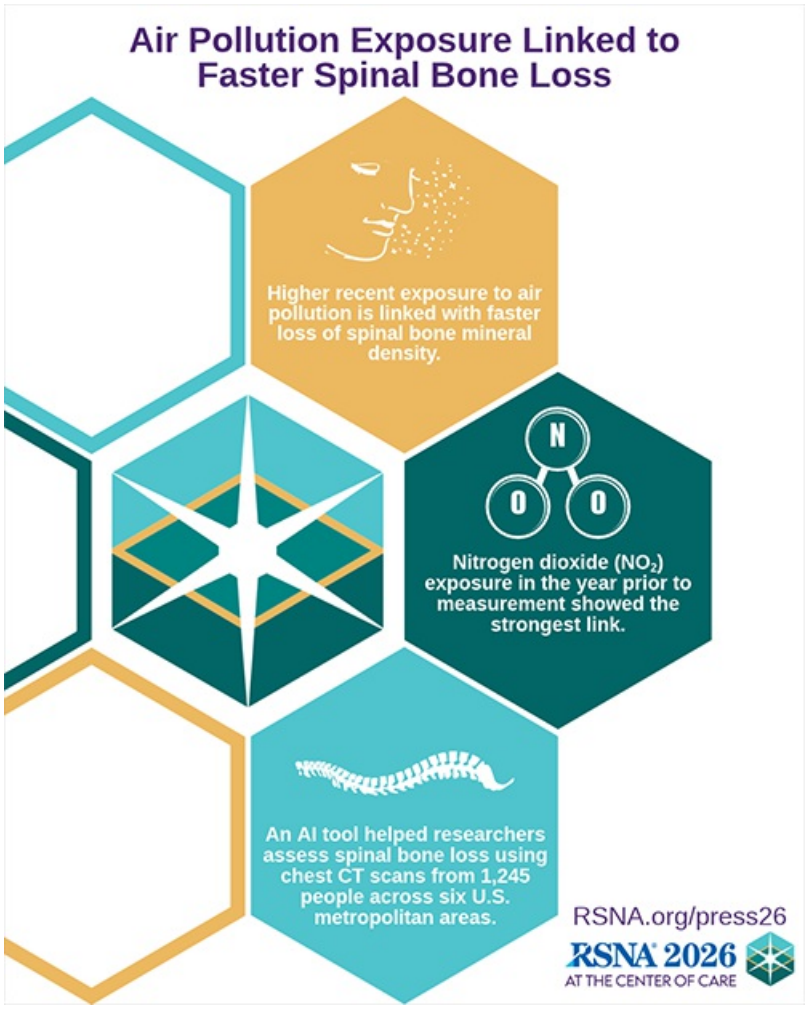

Infographic

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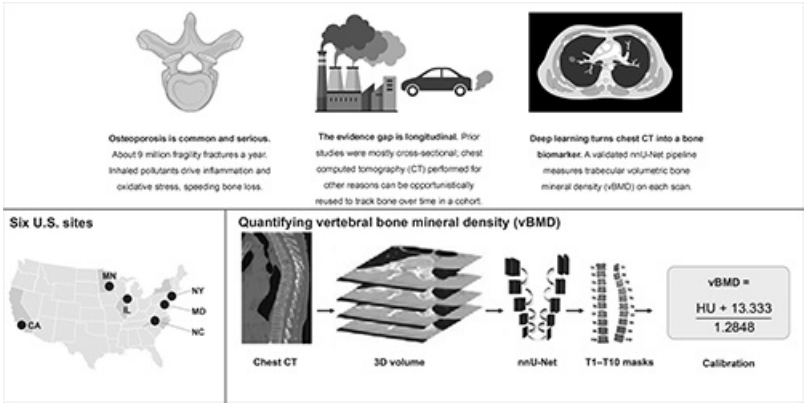

Figure 1. Study rationale, setting and deep learning–based vertebral bone mineral density (vBMD) measurement on serial chest CT in the Multi-Ethnic Study of Atherosclerosis (MESA). **Top** Study rationale. **Bottom left** The six MESA sites: Forsyth County (NC), New York (NY), Baltimore (MD), St. Paul (MN), Chicago (IL) and Los Angeles (CA). **Bottom right** vBMD pipeline. Noncontrast chest CT volumes from Exam 5 (2010–2012) and Exam 6 (2016–2018) were segmented with TotalSegmentator-v2, a deep learning (nnU-Net) model, into T1–T10 vertebral body masks; cortical voxels were removed to isolate trabecular bone. Each vertebra's median HU was converted to vBMD (mg/cm³) with a linear equation derived from Exam 5 scans with calcium hydroxyapatite phantoms, applied at both exams. The outcome was the annual change in T6–T10 vBMD.

Resources:

Abstract

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