Does air pollution reduce cancer survival? New findings from SEER Program cohorts

Jonathan M. Samet, MD, MS

Dean and Professor

Colorado School of Public Health

Aurora, Colorado

Correspondence to: Jonathan M. Samet, 13001 E. 17th Place, Aurora, CO 80045, Phone: 303.724.7304, Email: Jon.Samet@CUAnschutz.edu

© The Author(s) 2021. Published by Oxford University Press. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.
Air pollution causes cancer[1]; does it also affect outcomes for those developing cancer? Are people with cancer at increased risk for the excess mortality associated with air pollution exposure? Innovatively using cancer patient data from the Surveillance, Epidemiology, and End Results (SEER) Program, Coleman et al. address these questions in this issue of the journal.[2] Their findings come from two separate, but overlapping cohorts constructed within the SEER Program database: one composed of 5.6 million people with incident cancer and the second composed of 2.3 million five-year cancer survivors. Long-term air pollution exposure, indexed by particulate matter less than 2.5 microns in aerodynamic diameter (PM$_{2.5}$), was estimated for the county of residence using a model that combines regulatory modeling data with other predictors of air pollution levels. Such model estimates have now been widely used in studies of air pollution and health and have well-established accuracy.[3]

Particulate matter air pollution has been causally linked to increased risk for mortality, as documented in studies from the early 1990s forward.[4] Recent studies at contemporary levels of air pollution in North America and Europe continue to show that risk for premature death increases with higher exposure to PM$_{2.5}$, particularly for cardiovascular and respiratory deaths.[5] Some groups are particularly susceptible: older persons and those with cardiovascular, respiratory, and metabolic diseases. Should people with cancer and five-year survivors be added to the populations at risk from longer-term exposure to air pollution?

For overall mortality, Coleman et al. find only a very small excess risk (hazard ratio (HR)=1.01 per 10 $\mu$g/m$^3$ increase in PM$_{2.5}$, 95% confidence interval (CI) = 1.00-1.03), contrasting with the higher level of risk associated with PM$_{2.5}$ observed in general population cohorts.[2] There is a robust database from cohort studies for comparison, summarized in a recent
systematic review of more than 100 such studies carried out in support of revision of the World Health Organization’s Air Quality Guidelines.[5] In that review, the estimated summary relative risk (per 10 μg/m³ of PM$_{2.5}$) was 1.08 (prediction interval = 1.05-1.11) for all-cause mortality. The contrasting findings for all-cause mortality between the cancer patient cohorts and the general population cohorts likely reflects the predominance of deaths from cancer in the full cohort (74% of deaths) and in the five-year survivor cohort (46% of deaths). The hazard ratio for death from cancer was not increased in either cohort (HR=0.99).

Based on the overall cohort, Coleman et al. do report that PM$_{2.5}$ exposure is associated with increased risk for death from cardiopulmonary causes (HR=1.25, 95% CI = 1.21-1.30) including pneumonia/influenza (HR=1.55, 95% CI = 1.33-1.80).[2] Perhaps reflecting the better health status of longer-term survivors, the hazard ratios are mostly lower, but statistically significantly elevated, in the five-year survivor cohort. For comparison, the meta-analysis provided relative risk estimates per 10 μg/m³ increase of PM$_{2.5}$ of 1.11 for circulatory causes, 1.10 for respiratory causes, and 1.12 for lung cancer. The hazard ratios from the full SEER Program cohort are not uniformly higher than the comparison estimates from the meta-analysis and the estimates for the five-year survivors are quite close to those from the meta-analysis.

These overall analyses are complemented by explorations of heterogeneity in the association of PM$_{2.5}$ with increased cardiopulmonary mortality across cancer types, stage and treatment, and demographics. These analyses were exploratory and compromised by smaller sample sizes within categories. Several prior reports on air pollution and cancer survival have involved people with lung cancer.[6] In the present report, lung cancer mortality was not
increased, while cardiopulmonary mortality was statistically significantly increased in this subgroup of the overall cohort.[2] Eckel et al. examined overall survival of 352,053 lung cancer patients identified through the California Cancer Registry in relation to average air pollution exposures estimated for the residence location.[7] The hazard ratio was statistically significantly increased for overall mortality (HR=1.16 per 5.3 μg/m³ increase of PM$_{2.5}$, 95% CI = 1.16-1.17) and the effect decreased for those with regional and distant stages compared with localized disease. A 2013 report by Xu et al. respiratory cancer survival and air pollution exposure using SEER data from Los Angeles and Hawaii.[8] In this study, PM$_{2.5}$ was statistically significantly associated with both overall mortality and lung cancer specific mortality. Coleman et al. did not stratify by SEER registry location, but such analyses could be carried out as patterns of pollution exposure vary across the SEER sites with California residents having the highest estimated exposures.

Thus, the findings of the new study by Coleman et al. represent a substantial contribution to the existing evidence on air pollution and cancer survival, which has been scant and most abundant for lung cancer. There is a single report on air pollution and survival of breast cancer patients, using California SEER data.[9] From a clinical perspective, the most important finding is the lack of association of overall survival of cancer patients with particulate matter air pollution, the most widely used index of ambient air pollution exposure. The SEER database used is large and the confidence intervals around the null HR are narrow. Survival following the diagnosis of cancer has myriad determinants. The findings of Coleman et al. suggest that particulate matter air pollution is not one of these determinants.
The authors highlight the statistically significant associations of PM$_{2.5}$ with cardiovascular and respiratory mortality. Given the rising number of cancer survivors, this group is yet another population at increased risk from air pollution. However, the increased risk among cancer patients and particularly among five-year survivors is not greater than observed in general population cohorts. Nonetheless, the findings of Coleman et al. confirm that air pollution continues to have adverse effects at the exposures experienced in recent decades, adding to the substantial evidence that supports the need for air quality management that reduces the health risks of air pollution.

**Funding**

Author has no funding to disclose.

**Notes**

Role of the funder: Not applicable

Author Disclosures: Author has no competing interests to disclose.

**Data Availability**

Not applicable.

**References**

1. IARC. *IARC Scientific Publication NO.161. Air Pollution and Cancer*: World Health Organization; 2013.
2. Coleman NC, Ezzati M, Marshall JD, et al. Fine particulate matter air pollution and mortality risk among U.S. cancer patients and survivors. JNCI: Cancer Spectrum 2020.

3. Hammer MS, van Donkelaar A, Li C, et al. Global Estimates and Long-Term Trends of Fine Particulate Matter Concentrations (1998–2018). Environmental Science & Technology 2020;54(13):7879-7890.

4. U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019). In. Washington, D.C.: U.S. Environmental Protection Agency; 2019.

5. Chen J, Hoek G. Long-term exposure to PM and all-cause and cause-specific mortality: A systematic review and meta-analysis. Environment International 2020; https://doi.org/10.1016/j.envint.2020.105974:105974.

6. Hart JE. Air pollution affects lung cancer survival. In: BMJ Publishing Group Ltd; 2016.

7. Eckel SP, Cockburn M, Shu Y-H, et al. Air pollution affects lung cancer survival. Thorax 2016;71(10):891-898.

8. Xu X, Ha S, Kan H, et al. Health effects of air pollution on length of respiratory cancer survival. BMC Public Health 2013;13(1):800.

9. Hu H, Dailey AB, Kan H, et al. The effect of atmospheric particulate matter on survival of breast cancer among US females. Breast cancer research and treatment 2013;139(1):217-226.