Long-term Exposure to Fine Particulate Matter and Breast Cancer Incidence in the Danish Nurse Cohort Study

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Abstract

Background: An association between air pollution and breast cancer risk has been suggested, but evidence is sparse and inconclusive.

Methods: We included 22,877 female nurses from the Danish Nurse Cohort who were recruited in 1993 or 1999 and followed them for incidence of breast cancer (N=1,145) until 2013 in the Danish Cancer Register. We estimated annual mean concentrations of particulate matter with diameter <2.5 µg/m³ (PM_{2.5}) and <10 µg/m³ (PM_{10}), and nitrogen dioxide (NO₂) at nurses’ residences since 1990 using an atmospheric chemistry transport model. We examined the association between the 3-year running mean of each pollutant and breast cancer incidence using a time-varying Cox regression.

Results: We found no association between breast cancer and PM_{2.5} (HR, 0.99; 95% confidence interval, 0.94–1.10 per interquartile range of 3.3 µg/m³), PM_{10} (1.02; 0.94–1.10 per 2.9 µg/m³), or NO₂ (0.99; 0.93–1.05 per 7.4 µg/m³).

Conclusions: Air pollution is not associated with breast cancer risk.

Impact: Exposure to air pollution in adulthood does not increase the risk of breast cancer, but more data on the effects of early exposure, before first birth, are needed.

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Introduction

Traffic-related air pollution is a risk factor for lung cancer and classified as a carcinogen to humans. Experimental data provide some evidence of a link between a number of carcinogens in air pollution and breast cancer, including polycyclic aromatic hydrocarbons, which can cause mammary tumors in laboratory animals (1). Epidemiologic data are mixed, with case-control studies (2) detecting association and cohort studies (3–5) finding no association between air pollution and breast cancer incidence. The latest Canadian case–control study found a 26% to 32% increased risk of premenopausal breast cancer, per 10 ppb increase in nitrogen dioxide (NO₂; ref. 2). Three cohort studies did not detect association between breast cancer incidence and NO₂ (3). PM with diameter <2.5 µg/m³ (PM_{2.5}), or PM with diameter <10 µg/m³ (PM_{10}); refs. 3, 4), or nitrogen oxides NOx (5). Only two studies had data on PM_{2.5} and PM_{10} (3, 4). Here, we examined the association between long-term exposure to PM_{2.5}, PM_{10}, and NO₂ at the residence and incidence of breast cancer in the nationwide, prospective Danish Nurse Cohort (DNC).

Materials and Methods

The DNC consists of 28,731 Danish female nurses (>44 years), recruited in 1993 (19,898) or 1999 (8,833) when they answered a questionnaire on working conditions, weight, height, lifestyle, and reproductive factors. Using the unique personal identifying number, we linked nurses to the Central Population Register to obtain residential address history (1971–2013) and vital status information and to the Danish Cancer Register for diagnosis of primary invasive breast cancer (International Classification of Diseases-10 code C50) between cohort baseline (1993 or 1999) and 2013, and any other cancer prior to cohort baseline. We used the Danish integrated air pollution modeling system (THOR and AirGIS) to estimate human exposure to outdoor air pollution at address level (6). We estimated annual mean concentration of PM_{2.5}, PM_{10}, and NO₂ at the residential addresses for nurses with complete information on residential address history 80% of the time between 1990 and 2013 and used the 3-year running mean of each pollutant concentrations as the main exposure proxy. We used the time-varying Cox proportional hazards regression to model association between breast cancer incidence and air pollution, with age as the underlying time scale, and stratified by year of birth, in three steps: age adjusted; adjusted additionally for smoking, alcohol consumption, physical activity,
Results

Of the 28,731 nurses, we excluded 1,924 with cancer and 3 with inactive vital status before cohort baseline, and 3,927 with missing data on address or confounder, leaving 22,877 for final analyses. A total of 1,145 nurses developed breast cancer during mean follow-up of 16 years. Nurses with breast cancer were more likely nulliparous, HT users, and current smokers (Table 1). We found no association between breast cancer incidence and PM$_{2.5}$, PM$_{10}$, or NO$_2$ (Table 2), and no interaction by smoking status, BMI, or level of urbanization (results not shown). We detected stronger (Pinteraction = 0.07) association between breast cancer and PM$_{2.5}$ in premenopausal (1.06; 0.94–1.18) than in postmenopausal (0.93; 0.85–1.05) women, and in past (1.19; 0.97–1.44) and current (1.05; 0.92–1.20) than in never HT users (0.95; 0.85–1.05; P = 0.06).

Discussion

We found no association between long-term exposure to air pollution and breast cancer incidence in DNC in agreement with other cohort (2, 3, 5), and in contrast to a case–control study (2). We found moderately stronger associations in pre- than in postmenopausal women, in agreement with two studies (2, 3). We present novel findings of enhanced association between PM$_{2.5}$...
and breast cancer in past and ever HT users, which needs replication.

Ours and most other recent studies (2–5) examined air pollution exposure during adulthood, relatively close to breast cancer onset, which may not be the relevant exposure window for the development of breast cancer. A study found significantly increased breast cancer risk with exposure to traffic emissions at first childbirth, but no risk associated with later exposure windows (9), in line with growing evidence of relevance of early smoking on breast cancer risk (10).

We benefited from having a nationwide cohort of female nurses, with larger air pollution exposure contrast, detailed information on breast cancer risk factors, objective validated information on breast cancer onset, and a state-of-the-art high-resolution air pollution model with data on PM. Weakness of our study is lack of data on air pollution levels during puberty and early adulthood.

Results of our study contribute to growing evidence of a lack of association between exposure to air pollution in adulthood and postmenopausal breast cancer, but association with early exposure windows cannot be excluded. Studies with data on exposure to air pollution early in life and premenopausal breast cancer are needed.

Disclosure of Potential Conflicts of Interest
No potential conflicts of interest were disclosed.

References

Authors’ Contributions
Conception and design: Z.J. Andersen, K.K. Andersen, J. Brandt, E.V. Bräuner
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Table 2. Association between air pollution and breast cancer among the 22,877 nurses from DNC

<table>
<thead>
<tr>
<th>Unit</th>
<th>Model 1* HR (95% CI)</th>
<th>Model 2* HR (95% CI)</th>
<th>Model 3* HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM₂.₅ g/m³</td>
<td>1.03 (0.94–1.13)</td>
<td>1.02 (0.93–1.12)</td>
<td>1.00 (0.91–1.09)</td>
</tr>
<tr>
<td>PM₁₀ g/m³</td>
<td>1.04 (0.95–1.14)</td>
<td>1.03 (0.95–1.12)</td>
<td>1.02 (0.94–1.13)</td>
</tr>
<tr>
<td>NO₂ g/m³</td>
<td>1.03 (0.97–1.10)</td>
<td>1.02 (0.96–1.08)</td>
<td>1.00 (0.94–1.07)</td>
</tr>
</tbody>
</table>

*Adjusted for age.
†Model 1 additionally adjusted for smoking (status and intensity), alcohol use, BMI, and physical activity.
‡Model 3 also adjusted for parity, age at first birth, age at menarche, hormone therapy use, oral contraceptive use, and menopausal status.
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