The association between air pollution level and breast cancer risk in Taiwan

Yu-Chia Li, Dr*a,b, Jeng-Yuan Chiou, PhDc, Cheng-Li Lin, MSd, James Cheng-Chung Wei, MD PhDe,f,g, Ming-Hsin Yeh, MD PhDh,i,j

Abstract
Breast cancer has the highest incidence of cancer among women in Taiwan, and air pollutants have been documented to have multiple adverse effects on human health. There is no relevant data, there has been no research in Taiwan to discuss the relevance of air pollutants to breast cancer, and evidence is sparse and inconclusive.

Air quality data used in this study was collected from the 78 air quality monitoring stations situated in 74 municipalities in Taiwan during 2000 to 2011. The daily measurements taken at each monitoring station represented the level of exposure for each participant residing in that zone. The air pollution concentration is partitioned based on the concentration level in Quartile. We calculate the annual average air pollutants concentration (CO, NO, NO2, PM2.5, THC, and CH4) and the long-term average exposure levels of these pollutants until diagnosis of breast cancer, ending the study period for each individual.

Patients who were living in areas with the highest air pollutants concentration (Quartile 4) had the most people diagnosed with breast cancer (CO:1.47%, NO:1.41%, NO2:1.63%, PM2.5:0.91%, THC:1.53%, CH4:2.33%). The patients who were exposed to Quartile 1 level of CO, NO, and NO2 concentration were the oldest, and other patients who were exposed to Quartile 4 level of CO, NO, and NO2 concentration were living in the areas of highest urbanization. Patients exposed to Quartile 4 level concentrations of air pollutants were associated with highest hazards ratios for breast cancer incidences.

Most participants who were exposed to the highest concentration of air pollutants (CO, THC and CH4) had a significantly higher risk of breast cancer. If we can improve air pollution in the environment, we can reduce the incidence of breast cancer and save precious medical resources.

Abbreviations: CIs = confidence intervals, HRs = hazards ratios, ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification, LHID2000 = Longitudinal Health Insurance Database 2000, NHIRD = National Health Insurance Research Databases, PM = particulate matter.

Keywords: air pollution, breast cancer, PM2.5, Taiwan

1. Introduction
Breast cancer has the highest incidence of cancer among women in Taiwan, and the rate is increasing year by year.[1] On the basis of statistics from the National Health Insurance Research Databases (NHIRD), the incidence and mortality of breast cancer has grown to 69.1 and 12.0 per 100,000 population, respectively.[1]

Many clinical studies have revealed that cancer is related closely to ambient particulate matters (PMs), where the air pollution is a ubiquitous and complex mixture of pollutants.[2] PM of diameter up to 10 μm (PM10) and fine PM, up to 2.5 μm (PM2.5), are known as a significant risk factor for human health status.[3] Outdoor air pollution and airborne PM were considered...
as the group 1 of carcinogen for humans by the International Agency for Research on Cancer. An American study suggests that exposure to high levels of PM may have injurious effects on the length of survival to breast cancer, particularly among women who were diagnosed with early stage cancers. Furthermore, a Japanese study found that PM2.5 levels estimated from the measured PM10 levels has significant association with the mortality of breast, endometrial, and ovarian cancers. However, there is currently no relevant data and research conducted in Taiwan to discuss the relevance of PM2.5 to breast cancer. Thus, we investigated the correlation of breast cancer with common air pollutants by using a nationwide, population-based database in Taiwan.

2. Methods

2.1. Data source

In this retrospective cohort study, we used the data from Longitudinal Health Insurance Database 2000 (LHID2000). LHID2000 is a subset of the NHIRD. The LHID2000 has adopted a sample of one million beneficiaries who were retrieved from NHIRD in 2000. Taiwan launched a National Health Insurance program on March 1, 1995, and 99.9% of Taiwan’s population was enrolled in 2014. NHIRD contains demographic information, records of clinical visits, hospitalizations, diagnoses, prescriptions, medical costs for reimbursement and residential area. This study uses the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) to categorize disease diagnoses based on inpatient data. This retrospective cohort study was approved by the Chung Shan Medical University Institutional Review Board, number CS19009.

Quality monitoring stations adjacent to, or sharing the same district codes with, the patients’ residential area were the sources of the environmental data. Quality monitoring stations, which were built by Taiwan Environment Protection Administration, collect various air concentrations, temperature, and humidity data. Air quality data used in this study was collected from 78 air quality monitoring stations situated in 74 municipalities. The measurement period was from 2000 to 2011. The daily measurements taken at each monitoring station represented the level of exposure for each participant residing in that zone. We calculated the annual average air pollutant concentration (CO, NO, NO2, PM2.5, THC, and CH4) to estimate the annual exposure air concentration for each subject. We then computed the long-term average exposure levels of these pollutants until diagnosis of breast cancer, ending the study period for each individual.

2.2. Covariates and outcome

This research data is analyzed in combination with the LHID 2000 and the air quality database. People residing in the area where an air quality monitoring station was located and those in LHID2000 were selected as the study population. The main end point of the study was breast cancer (ICD-9-CM 174.9). All patients were followed from January 1, 2000 until the diagnosis of breast cancer (ICD-9-CM code 174.9), withdrawal from the NHI, or December 31, 2011. This study excludes those who were diagnosed with breast cancer before 2000. Confounding factors such as age, monthly income, and urbanization level were considered. Monthly incomes were divided to 4 groups: <14,400 TWD, 14,400–18,300 TWD, 18,301–21,000 TWD, and 21,000 TWD. Urbanization levels were divided to 4 levels, with level 1 being the highest urbanization area, and level 4 being the lowest. The air pollution concentration is partitioned based on the concentration level in Quartile.

2.3. Statistical analysis

The Chi-Squared test was used to analyze the difference in monthly income, urbanization level, and the incidence of breast cancer. The Student t test was used to analyze the continuous variables like age in different air quality levels. The incidence of breast cancer (per 10,000 person per year) was classified to 4 levels of air pollutant concentrations. Cox proportional hazard regression analysis was used to assess the risk of breast cancer for each pollutant quartile level (Quartiles 2–4), and was compared with Quartile 1 (reference group). The cox proportional hazard regression with hazards ratios (HRs), and 95% confidence intervals (CIs) were used for evaluating the associations between urban air pollutants levels and diagnosis of breast cancer after adjusting age, sex, monthly income, and urbanization level. All analyses were conducted using SAS software version 9.4 (SAS Institute Inc., Cary, NC) for Windows 10 and the significance level was set at a 2-tailed P < .05.

3. Results

A total of 98,011 patients with CO concentration data, 98,017 patients with NO and NO2 concentration data, 96,645 patients with PM2.5 concentration data, and 74,016 patients with THC and CH4 concentration data were analyzed. The sociodemographic factors and urbanization level of patients with CO, NO, NO2, PM2.5, THC and CH4 are demonstrated in Tables 1–6. Table 1 shows the baseline characteristics of participants exposed to 4 levels of CO concentration. There were more patients that lived in the highest CO concentration areas (27.4%). Compared with the other CO concentration stratification, those exposed to the Quartile 1 level of CO concentration were the oldest. The distributions of monthly incomes and urbanization levels were similar. Patients living in the highest urbanization areas were exposed to the highest CO concentration (53.9%), and patients who lived in the highest CO concentration had the most people diagnosis breast cancer (1.47%).

Table 2 presents the baseline characteristics of participants exposed to 4 levels of NO concentration. The patients who were exposed the Quartile 1 level of NO concentration were also the oldest. The distributions of monthly incomes and urbanization levels were also similar. Patients who lived in the highest urbanization areas and monthly income is 14,400 to 18,300 were dominant. Patients who lived in the highest NO concentration also had the most people diagnosed with breast cancer (1.41%).

In Table 3, there were more patients living in the Quartile 3 level of NO2 concentration areas (30.1%) compared to other Quartile levels. The patients who were exposed to the Quartile 1 level of NO2 concentration were the oldest, while those exposed to the Quartile 3 level of NO2 concentration were the youngest. Most patients living in the highest NO2 concentration areas also lived in areas of high urbanization and have monthly incomes between 14,400 and 18,300. Patients who lived in the highest NO concentration also had the most people diagnosis breast cancer (1.63%).
There were more patients living in the lowest level of PM$_{2.5}$ concentration areas (29.1%) in Table 4. Patients who were exposed to the Quartile 4 level of PM$_{2.5}$ concentration were the oldest, and those exposed to the Quartile 2 level of PM$_{2.5}$ concentration were the youngest. Patients who lived in the highest PM$_{2.5}$ concentration area also had the highest level of breast cancer diagnosis (0.91%). Although the higher the PM$_{2.5}$ concentration in statistics, the higher the diagnosis of breast cancer, but there is no statistically significant difference in the P value (P value = .36). I think PM$_{2.5}$ may cause a higher risk of breast cancer, but it will not increase as the concentration of PM$_{2.5}$ increases.

Tables 5 and 6 demonstrates the distributions of age, monthly income, and urbanization levels in THC and CH4 data. The distributions of monthly incomes and urbanization levels were similar between gas concentration stratification in THC and CH4 data. Patients who lived in the highest THC concentration and CH4 concentration also had the most people diagnosis breast cancer (1.53% and 2.33%, respectively).

Table 7 presents the associations between pollutant levels and the risk of breast cancer. The adjusted hazard ratios of breast cancer after exposure to the Quartile 2, Quartile 3, and Quartile 4 levels were compared with those after exposure to the Quartile 1 level. With an interquartile range increase in each pollutant, adjusted HRs were significant. Compared to the lowest quartile of each air pollutant, subjects who were exposed to the highest quartile (Quartile 4) had a significantly higher risk of breast cancer (CO: adjusted HR = 1.85 [95% CI: 1.54–2.21]; NO:

| Table 1 | Baseline characteristics of participants exposed to various annual average concentrations of CO. |
|---------|-----------------------------------------------------|
| **CO N = 98,011** | |
| **Variables** | **Q1 N = 23,892** | **Q2 N = 25,227** | **Q3 N = 22,007** | **Q4 N = 26,884** |
| | n | % | n | % | n | % | n | % |
| Age | | | | | | | | |
| Mean, SD$^*$ | 40.6 | 15.6 | 38.7 | 14.8 | 38.2 | 14.7 | 38.7 | 14.7 |
| Monthly income (NTD)$^†$ | | | | | | | | |
| <14,400 | 3686 | 15.4 | 4178 | 16.6 | 3734 | 17.0 | 4460 | 16.6 |
| 14,400–18,300 | 7720 | 32.3 | 9485 | 37.6 | 8920 | 40.5 | 10,084 | 37.5 |
| 18,300–21,000 | 7576 | 31.7 | 6029 | 23.9 | 4281 | 19.5 | 6051 | 22.5 |
| ≥21,000 | 4910 | 20.6 | 5536 | 21.9 | 5072 | 23.1 | 6289 | 23.4 |
| Urbanization level$^‡$ | | | | | | | | |
| 1 (highest) | 5278 | 22.1 | 6180 | 24.5 | 9031 | 41.0 | 14,481 | 53.9 |
| 2 | 7507 | 31.4 | 11,318 | 44.9 | 5208 | 23.7 | 7542 | 28.1 |
| 3 | 3992 | 16.7 | 3559 | 14.1 | 4875 | 22.2 | 3260 | 12.1 |
| 4 (lowest) | 7115 | 29.8 | 4170 | 16.5 | 2893 | 13.2 | 1601 | 5.96 |
| Outcome | | | | | | | | |
| Breast cancer | 193 | 0.81 | 234 | 0.93 | 240 | 1.09 | 395 | 1.47 |

Chi-Squared test.
$^*$ One-way ANOVA.
$^†$ Monthly income, new Taiwan Dollar (NTD), 1 NTD is equal to 0.03 USD.
$^‡$ The urbanization level was categorized by the population density of the residential area into 4 levels, with level 1 as the most urbanized and level 4 as the least urbanized.

| Table 2 | Baseline characteristics of participants exposed to various annual average concentrations of NO. |
|---------|-----------------------------------------------------|
| **NO N = 98,017** | |
| **Variables** | **Q1 N = 23,723** | **Q2 N = 24,488** | **Q3 N = 22,297** | **Q4 N = 27,509** |
| | n | % | n | % | N | % | n | % |
| Age | | | | | | | | |
| Mean, SD$^*$ | 40.4 | 15.6 | 39.3 | 15.0 | 37.5 | 14.6 | 38.8 | 14.7 |
| Monthly income (NTD)$^†$ | | | | | | | | |
| <14,400 | 3700 | 15.6 | 4130 | 16.9 | 3664 | 16.4 | 4567 | 16.6 |
| 14,400–18,300 | 7498 | 31.6 | 9383 | 38.3 | 9177 | 41.2 | 10,152 | 36.9 |
| 18,300–21,000 | 7817 | 33.0 | 5635 | 23.0 | 4614 | 20.7 | 5873 | 21.4 |
| ≥21,000 | 4708 | 19.9 | 5340 | 21.8 | 4842 | 21.7 | 6917 | 25.1 |
| Urbanization level$^‡$ | | | | | | | | |
| 1 (highest) | 5115 | 21.6 | 6090 | 24.9 | 10,295 | 46.2 | 13,470 | 49.0 |
| 2 | 8305 | 35.0 | 8056 | 32.9 | 6914 | 31.0 | 8303 | 30.2 |
| 3 | 2383 | 10.1 | 5930 | 24.2 | 3190 | 14.3 | 4184 | 15.2 |
| 4 (lowest) | 7920 | 33.4 | 4412 | 18.0 | 1898 | 8.51 | 1551 | 5.64 |
| Outcome | | | | | | | | |
| Breast cancer | 202 | 0.85 | 251 | 1.02 | 221 | 0.99 | 389 | 1.41 |

Chi-Squared test.
$^*$ One-way ANOVA.
### Table 3
Baseline characteristics of participants exposed to various annual average concentrations of NO₂.

| Variables                      | NO₂ N = 98,017 |
|--------------------------------|----------------|
|                                | Q1 N = 21,406  | Q2 N = 28,475  | Q3 N = 29,531  | Q4 N = 18,605  | P value       |
|                                | n  | %  | n  | %  | N  | %  | n  | %  |               |
| Age, Mean, SD*                 | 40.6 | 15.6 | 39.2 | 15.1 | 37.9 | 14.4 | 38.8 | 14.8 | <.001         |
| Monthly income (NTD)**         | 3302 | 15.4 | 4888 | 17.2 | 4786 | 16.2 | 3085 | 16.6 | <.001         |
| <14,400                        | 6840 | 32.0 | 10,728 | 37.7 | 11,719 | 39.7 | 6923 | 37.2 |               |
| 14,400–18,300                  | 6923 | 32.3 | 6,839 | 24.0 | 6275 | 21.3 | 3902 | 21.0 |               |
| 18,300–21,000                  | 4341 | 20.3 | 6,020 | 21.1 | 6751 | 22.9 | 4695 | 25.2 |               |
| ≥21,000                        | 510x668 | 510x668 | 510x668 | 510x668 | 510x668 | 510x668 | 510x668 | 510x668 | 510x668 |
| Urbanization level‡            | 5048 | 23.6 | 6844 | 24.0 | 13,671 | 46.3 | 9407 | 50.6 | <.001         |
| 1 (highest)                    | 13,795 | 49.0 | 9097 | 42.1 | 6543 | 28.0 | 5165 | 22.0 |               |
| 2                              | 7702 | 27.4 | 6182 | 28.6 | 8099 | 34.7 | 9145 | 38.9 |               |
| 3                              | 3078 | 10.9 | 3519 | 16.3 | 3358 | 14.4 | 5500 | 23.4 |               |
| 4 (lowest)                     | 3587 | 12.7 | 2798 | 13.0 | 5372 | 23.0 | 3703 | 15.8 |               |
| Outcome                        | 224 | 0.80 | 181 | 0.84 | 179 | 0.77 | 213 | 0.91 | .36           |

Chi-Squared test.
*One-way ANOVA.

### Table 4
Baseline characteristics of participants exposed to various annual average concentrations of PM₂.₅.

| Variables                      | PM₂.₅ N = 161,970 |
|--------------------------------|------------------|
|                                | Q1 N = 28,162    | Q2 N = 21,596    | Q3 N = 23,372    | Q4 N = 23,513    | P value       |
|                                | n  | %  | n  | %  | N  | %  | n  | %  |               |
| Age, Mean, SD*                 | 38.8 | 14.8 | 38.1 | 14.4 | 38.7 | 14.8 | 39.4 | 14.8 | <.001         |
| Monthly income (NTD)**         | 4468 | 15.9 | 3332 | 15.4 | 3665 | 15.7 | 4091 | 17.4 | <.001         |
| <14,400                        | 9853 | 35.0 | 8408 | 38.9 | 8911 | 38.1 | 8753 | 37.2 |               |
| 14,400–18,300                  | 6386 | 22.7 | 4604 | 21.3 | 5932 | 25.4 | 6572 | 28.0 |               |
| 18,300–21,000                  | 7455 | 26.5 | 5252 | 24.3 | 4864 | 20.8 | 4097 | 17.4 |               |
| ≥21,000                        | 13,795 | 49.0 | 9097 | 42.1 | 6543 | 28.0 | 5165 | 22.0 | <.001         |
| Urbanization level‡            | 13,795 | 49.0 | 9097 | 42.1 | 6543 | 28.0 | 5165 | 22.0 |               |
| 1 (highest)                    | 7702 | 27.4 | 6182 | 28.6 | 8099 | 34.7 | 9145 | 38.9 |               |
| 2                              | 3078 | 10.9 | 3519 | 16.3 | 3358 | 14.4 | 5500 | 23.4 |               |
| 3                              | 3587 | 12.7 | 2798 | 13.0 | 5372 | 23.0 | 3703 | 15.8 |               |
| Outcome                        | 224 | 0.80 | 181 | 0.84 | 179 | 0.77 | 213 | 0.91 | .36           |

Chi-Squared test.
*One-way ANOVA.

### Table 5
Baseline characteristics of participants exposed to various annual average concentrations of THC.

| Variables                      | THC N = 74,061 |
|--------------------------------|----------------|
|                                | Q1 N = 19,780  | Q2 N = 18,791  | Q3 N = 18,335  | Q4 N = 17,155  | P value       |
|                                | n  | %  | n  | %  | N  | %  | n  | %  |               |
| Age, Mean, SD*                 | 38.4 | 14.2 | 39.0 | 14.7 | 38.3 | 15.0 | 38.3 | 14.7 | <.001         |
| Monthly income (NTD)**         | 3263 | 16.5 | 3199 | 17.0 | 2971 | 16.2 | 2718 | 15.8 | <.001         |
| <14,400                        | 7772 | 39.3 | 6,720 | 35.8 | 6965 | 37.9 | 6855 | 40.0 |               |
| 14,400–18,300                  | 4774 | 24.1 | 4671 | 24.9 | 4093 | 22.3 | 3783 | 22.1 |               |
| 18,300–21,000                  | 3971 | 20.1 | 4201 | 22.4 | 4316 | 23.5 | 3799 | 22.2 | <.001         |
| ≥21,000                        | 5850 | 29.6 | 4748 | 25.3 | 8529 | 46.5 | 7880 | 45.9 |               |
| Urbanization level‡            | 4917 | 24.9 | 7231 | 38.5 | 4860 | 26.5 | 5765 | 33.6 |               |
| 1 (highest)                    | 4148 | 21.0 | 3108 | 16.5 | 3390 | 18.5 | 2494 | 14.5 |               |
| 2                              | 4865 | 24.6 | 3704 | 19.7 | 1556 | 8.48 | 1016 | 5.92 |               |
| 3                              | 89 | 0.45 | 87 | 0.46 | 248 | 1.35 | 263 | 1.53 | <.001         |

Chi-Squared test.
*One-way ANOVA.
adjusted HRs = 1.63 [95% CI: 1.37–1.95]; and NO2: adjusted HR = 1.79 [95% CI: 1.45–2.15]; PM2.5: adjusted HRs = 1.29 [95% CI: 1.07–1.56]; THC: adjusted HRs = 3.53 [95% CI: 2.76–4.50]; CH4: adjusted HRs = 4.95 [95% CI: 3.92–6.26]).

### Table 6
Baseline characteristics of participants exposed to various annual average concentrations of CH4.

| Variables          | CH4 N = 74061 |
|--------------------|---------------|
|                    | Q1 N = 19406  | Q2 N = 16914  | Q3 N = 24110  | Q4 N = 13631 |
| Age (Mean, SD)*    | 38.2, 14.1    | 38.3, 14.2    | 37.6, 14.4    | 40.8, 16.1   |
| Monthly income (NTD)** | 3185, 16.4 | 2615, 15.5 | 3973, 16.5 | 2373, 17.5 |
| Urbanization level† | 5961, 30.7 | 6416, 37.9 | 9590, 39.8 | 5040, 37.0 |
| Outcome            | 202, 0.46    | 77, 0.46     | 202, 0.84    | 318, 2.33   |

Chi-Squared test.
* One-way ANOVA.

### Table 7
Comparisons of differences in breast cancer incidences and associated HRs in participants exposed to various daily average concentrations of air pollutants.

| Event | PY | IR | cHR | aHR | 95% CI | 95% CI |
|-------|----|----|-----|-----|--------|--------|
| CO    |    |    |     |     |        |        |
| Q1    | 193| 278,407 | 6.93 | Ref. | Ref.  |        |        |
| Q2    | 234| 294,954 | 7.93 | 1.14 | (0.95, 1.38) | 1.19 | (0.98, 1.44) |
| Q3    | 240| 254,873 | 9.42 | 1.36 | (1.13, 1.64) | 1.44 | (1.19, 1.75) |
| Q4    | 395| 310,571 | 12.7 | 1.84 | (1.55, 2.18) | 1.85 | (1.54, 2.21) |
| NO    |    |    |     |     |        |        |
| Q1    | 202| 276,283 | 7.31 | Ref. | Ref.  |        |        |
| Q2    | 251| 285,068 | 8.80 | 1.21 | (1.08, 1.45) | 1.24 | (1.03, 1.50) |
| Q3    | 221| 259,543 | 8.51 | 1.17 | (0.96, 1.41) | 1.20 | (0.99, 1.46) |
| Q4    | 389| 317,928 | 12.2 | 1.68 | (1.41, 1.99) | 1.63 | (1.37, 1.95) |
| NO2   |    |    |     |     |        |        |
| Q1    | 196| 249,256 | 7.86 | Ref. | Ref.  |        |        |
| Q2    | 269| 331,040 | 8.13 | 1.03 | (0.86, 1.24) | 1.07 | (0.89, 1.29) |
| Q3    | 294| 344,485 | 8.53 | 1.09 | (0.91, 1.30) | 1.11 | (0.92, 1.33) |
| Q4    | 304| 214041 | 14.2 | 1.81 | (1.51, 2.17) | 1.79 | (1.48, 2.15) |
| PM2.5 |    |    |     |     |        |        |
| Q1    | 224| 330,849 | 6.77 | Ref. | Ref.  |        |        |
| Q2    | 181| 254,009 | 7.13 | 1.05 | (0.87, 1.28) | 1.11 | (0.92, 1.36) |
| Q3    | 179| 274,489 | 6.52 | 0.96 | (0.79, 1.17) | 1.08 | (0.89, 1.32) |
| Q4    | 213| 275,358 | 7.74 | 1.14 | (0.95, 1.38) | 1.29 | (1.07, 1.56) |
| THC   |    |    |     |     |        |        |
| Q1    | 80 | 233,698 | 3.81 | Ref. | Ref.  |        |        |
| Q2    | 87 | 221,785 | 3.92 | 1.03 | (0.77, 1.30) | 0.90 | (0.74, 1.24) |
| Q3    | 248| 211,402 | 11.7 | 3.10 | (2.44, 3.95) | 3.08 | (2.41, 3.94) |
| Q4    | 263| 197,729 | 13.3 | 3.51 | (2.76, 4.47) | 3.53 | (2.76, 4.50) |
| CH4   |    |    |     |     |        |        |
| Q1    | 90 | 229,472 | 3.92 | Ref. | Ref.  |        |        |
| Q2    | 77 | 199,976 | 3.85 | 0.98 | (0.72, 1.33) | 0.92 | (0.68, 1.25) |
| Q3    | 202| 282,632 | 7.15 | 1.83 | (1.43, 2.24) | 1.76 | (1.37, 2.26) |
| Q4    | 318| 152,533 | 20.9 | 5.39 | (4.27, 6.82) | 4.95 | (3.92, 6.26) |

aHR = adjusted hazard ratio of a multivariate analysis, after adjustment for age, sex, monthly income, and urbanization level; cHR = crude hazard ratio; CI = confidence interval; IR = incidence rate; (per 10,000 person-years); PY = person-years; Ref. = reference group.

### Discussion
In this study, we examined the association between air pollutant levels and risk of adult-onset breast cancer, and showed a significant higher risk in higher pollution level areas. We found...
that while individual characteristics of the urbanization level consistently associated with increased breast cancer risk, the relationship of NO and PM$_{2.5}$ between Q2, Q3 did not show clear correlation.

Previous study suggested that the high incidence rate of female breast cancer in the US was associated with high air pollutants emission regions (NO and CO), which was consistent with our results.[7] However, 2 previous studies found no obvious association between long-term exposure to air pollution and breast cancer incidence,[8,9] while I found traffic-related childhood exposure was not associated with an increase to breast cancer risk.[10] Reding et al showed no significant associations between air pollution and breast cancer risk. On the other hand, they found NO$_2$ was associated with an increased risk of ER+/PR+ breast cancer via their cohort study result.[11] Garcia et al studied the correlation between an increase of breast cancer risk and several air pollutant compounds, including acrylamide, carbon tetrachloride, chloroprene, 4,4'-methylene bis (2-chloroaniline), propylene oxide, and vinyl chloride, but hazard ratios were not statistically significant.[12] In addition, 1 reviewing study summarized the results for 8 case-control studies and 9 cohort studies and suggested little evidence to support a relationship between PM and breast cancer risk.[14] There were also studies that supported our hypothesis. Goldberg et al reported that exposure to ambient NO$_2$ and UFPs may increase the risk of incident postmenopausal breast cancer, especially women with positive estrogen and progesterone receptor status.[13] The different outcomes and conclusions can be explained with climate, cultural differences, or population density, but more studies and analysis are needed in order to draw conclusive correlation between air pollution and breast cancer risk in Taiwan.

There are some limitations in this study. First, there are several confounders, such as demographic variables, lifestyle, diet habits, underlying disease, and genetic background that maybe to effect the incidence of breast cancer. Second, we did not analyze which type of breast cancer is highly associated with air pollutants because it is closely related to the prognosis of breast cancer. In this study, we tried to analyze the relationship between pollutants and the risk of breast individually. But in the real world, these pollutants do not exist individually, they always exist with other molecular compounds. In the future, we may consider collecting more information such as living habits, eating habits, past medical history, or genetic factors for further statistical analysis and using SPSS software to do multivariate analysis may make this research more rigorous and precise.

5. Conclusion

Although the risk factors that increase cancer are numerous and complex, they are often accompanied by more than 1 risk factor. According to research statistics, some air pollutants are closely related to the risk of breast cancer, we are not clear about the time of exposure to air pollution or the mechanism of carcinogenesis. With the progress of urbanization in Taiwan, the effect of environmental air pollution becomes more and more serious, and the incidence rate of cancer in Taiwan is also rising. Ambient air pollution may be an important factor in the increase of breast cancer incidence. Research into environmental chemical exposure helps prevent and promote public health benefits.

Author contributions

Data curation: Yu-Chia Li, Cheng-Li Lin.
Formal analysis: Cheng-Li Lin.
Software: Cheng-Li Lin.
Supervision: James Cheng-Chung Wei, Ming-Hsin Yeh.
Validation: James Cheng-Chung Wei.
Writing – original draft: Yu-Chia Li.
Writing – review & editing: James Cheng-Chung Wei, Ming-Hsin Yeh.

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