**Supplementary Table 2:** Associations between exposure to ambient air pollutants and autism spectrum disorder (ASD)

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| --- | --- | --- | --- | --- | --- | --- |
| **Author, year** | **Pollutant(s)** | **Exposure window** | **┼Key association** | **Exposure measurement** | **Effect estimates** | **Overall study quality** |
| Becerra, 2013 (17) | PM2.5 | Gestation | **+** | Daily averages for the gaseous pollutants and 24-hr measurements of PM2.5 (col­lected every 6 and 3 days, respectively) were then averaged over the different pregnancy periods | aOR: 1.07 (95% CI: 1.00-1.15) per 4.68-µg/m3 increase in PM2.5 and aOR: 1.07 (95% CI: 1.01-1.12) per 5.54 ppb increase in NO2. | \*\* |
| NO2 | Gestation | **+** |
| Chen, 2018 (50) | PM2.5 | Birth till childhood (0-3 yrs) | **+** | Ground measured PM2.5 data from 1497 stations of China National Environmental Monitoring Center (CNEMC).  Daily concentrations of PM2.5 via Random Forests Models Participants' mean exposures during the first three years of life estimated according to their home addresses and dates of birth | Cumulative ORs per IQR increase in PM2.5 from birth-3 yrs: 1.78 (95% CI: 1.14, 2.76).  ORs for 1st year of life: 1.07 (95% CI: 0.80, 1.43), ORs for 2nd year of life: 1.50 (95% CI: 1.01, 2.22), ORs for 3rd year of life: 1.78 (95% CI: 1.05, 3.02) | \*\*\* |
| 1st year of life | **-** |
| 2nd year of life | **+** |
| 3rd year of life | **+** |
| Flanagan, 2023 (48) | PM2.5 | Gestation | **+** | A Gaussian plume air dispersion model to extrapolate total PM2.5 concentrations at a 100 m, then aggregated into yearly concentrations to derive annual mean concentrations | ORs of 1.34 (95% CI 1.05–1.70) for all-source PM2.5, 1.18 (95% CI 1.01–1.39) for PM2.5 from small-scale residential heating, 1.46 (95% CI 1.15–1.85) for PM2.5 from tailpipe exhaust, and 1.36 (95% CI 1.10–1.68) for PM2.5 from vehicle wear-and-tear | \*\*\* |
| Geng, 2019 (20) | PM2.5 | Birth till childhood (0-3 yrs) | **+** | Monthly exposure predictions of PM2.5 from U.S Embassy Beijing Air Quality Monitor. Monthly average concentrations for participants estimated as per residential address | OR 1.018, 95% CI: 1.009-1.032; p = 0.018.  ASD odds higher for higher PM2.5 concentrations,  3rd quartile OR = 2.03; (95%CI: 1.13–5.54; p = 0.015)  4th quartile OR = 4.15 (95%CI: 2.04–9.45; p = 0.002)  Correlation between serum levels of PM2.5 and the Autism Severity CARS score (r = 0.259; p = 0.010) | \*\* |
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| Gong, 2014 (89) | NOx | Gestation through Childhood | **-** | Relevant residential addresses of the study subjects were geocoded, and NOx levels were estimated at these coordinates from the dispersion models to calculate annual average concentrations for NOx | First Year of Life  ASD (OR: 0.86, 95% CI: 0.44-1.67)  ADHD (OR:1.06, 95% CI: 0.71-1.59)  Similar results for exposures during each trimester of pregnancy and at 9 years of age | \*\*\* |  |
| 1st Trimester | **-** |  |
| 2nd Trimester | **-** |  |
| 3rd Trimester | **-** |  |
| 1st year of life | **-** |  |
| 9th year of life | **-** |  |
| Gong, 2017 (90) | NOx | Gestation through Infancy |  | Relevant residential addresses of the study subjects were geocoded and NOx levels were estimated at these coordinates from the dispersion models to calculate annual average concentrations for NOx | During Gestation:  aOR: 1.02 (95% CI: 0.94, 1.10) for ASD per 20-ug/m3 increase of NOx  aOR: 1.06 (95% CI: 0.89, 1.26) for ASD with ID, and  aOR: 1.01 (95% CI: 0.93, 1.10) for ASD without ID]  Similar results during 1st year of life | \*\*\* |  |
| Gestation | **-** |  |
| 1st year of life | **-** |  |
| Guxens, 2016 (91) | PM2.5 | Gestation | **-** | NO2, NOx and PM2.5 were estimated for birth addresses by land-use regression models with backwards extrapolation to obtain average pregnancy concentrations | No association found after adjusting for several socioeconomic status variables and urbanicity | \*\*\* |  |
| NO2 | Gestation | **-** |  |
| Iyanna, 2023 (93) | PM2.5 | Gestation | **-** | Daily estimates of air pollutants were aggregated to derive average exposures for each pollutant during two time periods: 1) pregnancy and 2) exposure during the participant’s first year of life (date of birth to first birthday) | SRS Total T-scores and NO2 exposure during prenatal (ʙ = 0.4, 95% CI: 0.7, 1.6) and first year of life (ʙ = 0.7, 95% CI: 0.3, 1.6). | \*\*\* |  |
| NO2 | Gestation | **-** |  |
| Jo, 2019 (21) | PM2.5 | Pre-gestation through Infancy | **+** | Birth certificate residential addresses were geocoded using MapMarker USA Version 28.0.0.11. Monthly averages for PM2.5 and NO2 between 1998–2009 were obtained from data compiled from the EPA regional air quality monitoring network | Significant associations per 6.5 ug/m3 PM2.5 exposure:  Pre-gestation: (HR = 1.11, 95% CI: 1.03, 1.20),  Gestation (HR = 1.17 per 6.5 ug/m3, 95% CI: 1.04, 1.33),  the first trimester (HR = 1.10, 95% CI: 1.02, 1.19) and  the third trimester (HR = 1.08, 95% CI: 1.00, 1.18)  First year of life (HR = 1.21, 95% CI: 1.05) | \*\* |  |
| Pre-gestation | **+** |  |
| 1st Trimester | **+** |  |
| 3rd Trimester | **+** |  |
| 1st year of life | **+** |  |
| NO2 | Pre-gestation through Infancy | **-** |  |
| Joa, 2019 (22) | PM2.5 | Gestation through Infancy | **-** | Birth certificate residential addresses were geocoded using MapMarker USA Version 28.0.0.11. Monthly averages for PM2.5 and NO2 between 1998–2009 were obtained from data compiled from the EPA regional air quality monitoring network | Increased ASD risk per 6.5 µg/m3 PM2.5 in boys (HR = 1.18, 95% CI: 1.08, 1.27).  No associations were observed among girls (HR = 0.90 per 6.5 µg/m3, 95% CI: 0.76, 1.07) | \*\* |  |
| Gestation | **+** only in boys |  |
| Infancy |  |  |
| NO2 | Gestation through Infancy | **-** |  |
| Jung, 2013 (53) | NO2 | Childhood | **+** | Monthly average data 70 Taiwan Environmental Protection Agency (EPA) monitoring station to obtain yearly mean concentrations, which were then assigned to individuals by post-code levels | Increased ASD risk per 10-ppb increase in NO2 over preceding years: 1st year HR: 4.43 (95% CI: 3.33-5.90), 2nd yr HR: 4.75 (95% CI: 3.54-6.39), 3rd year HR: 3.56 (95% CI: 2.60-4.87), 4th yr HR: 3.14 (95% CI: 2.25-4.39); with a cumulative 340% risk increase per 10 ppb increase in NO2 level (95% CI 3.31–5.85) | \*\*\* |  |
| 1st yr Preceding | **+** |  |
| 2nd yr Preceding | **+** |  |
| 3rd yr Preceding | **+** |  |
| 4th yr Preceding | **+** |  |
| Kaufman, 2019 (23) | PM2.5 | Gestation through Infancy | **+** | Daily PM2.5 estimates for 2005–2012 from US EPA’s Fused Air Quality Surface Using Downscaling model to each participant based on the mother’s census tract of residence at birth. 24-hour-average PM2.5 estimates calculated across the 3 trimesters, entire pregnancy period, the 1st and 2nd years after birth. Cumulative Exposure Index (CEI) based on pregnancy through the 2nd year after birth | For each IQR increase in PM2.5  Pregnancy to 2nd yr: aOR=1.17 (95% CI: 0.98, 1.40)  1st year: aOR=1.11 (95% CI: 1.00, 1.23) | \*\* |  |
| 1st Trimester | **-** |  |
| 2nd Trimester | **-** |  |
| 3rd Trimester | **-** |  |
| 1st year of life | **+** |  |
| Kim, 2022 (33) | PM2.5 | Childhood (short-term) | **+** | PM2.5 levels were estimated using the Integrated Multi-Scale Air Quality System for Korea. Data on NO2 levels in each region were obtained from 318 fixed-site monitoring stations of the National Ambient Air Monitoring Information System | Short-term exposure to PM2.5 and NO2 was associated with a higher risk of hospital admissions for ASD.  PM2.5 levels at lag day 1 and NO2 levels at lag day 5 were associated with a higher risk of hospital admissions for ASD (RR=1.17, 95% CI 1.10 to 1.25 for PM2.5; RR=1.09, 95%CI 1.01 to 1.18 for NO2) | \* |  |
|  | NO2 | Childhood (short-term) | **+** |  |
| Lee, 2023 (26) | PM2.5 | Gestation | **+** | The measured data PM2.5 and NO2 from January 2015 to December 2018 were extracted from the Korea Environment Corporation and matched based on the mother’s health insurance claim registration area during pregnancy | For entire gestation:  ORs for PM2.5 were 1.05 (95% CI:1.04-1.06).  ORs for NO2 1.44 (95% CI: 1.36-1.55)  Similar significant associations for both pollutants throughout all trimesters | \*\* |  |
| 1st Trimester | **+** |  |
| 2nd Trimester | **+** |  |
| 3rd Trimester | **+** |  |
| NO2 | Gestation | **+** |  |
| 1st Trimester | **+** |  |
| 2nd Trimester | **+** |  |
| 3rd Trimester | **+** |  |
| Magen-Molho, 2021 (34) | PM2.5 | Gestation through Childhood | **-** | Daily estimates of PM2.5 concentrations were available from spatiotemporally resolved hybrid models Individual-level average exposure estimates for each child according to the official maternal address at birth, birth date, and gestational age at birth were assigned and all the addresses at the house level geocoded | Postnatal exposures to NOx (OR= 1.19, 95% CI = 1.02, 1.38)  Postnatal exposures to NO2(OR = 1.20, 95% CI = 1.00, 1.43) | \* |  |
| NOx | Gestation through Childhood |  |  |
| Gestation | **-** |  |
| Childhood | **+** |  |
| NO2 | Gestation | **-** |  |
| Childhood | **+** |  |
| McGuinn, 2020 (29) | PM2.5 | Pre-gestation through Infancy |  | A satellite-based model to assign daily averages during 3 months before pregnancy; each trimester of pregnancy; the entire pregnancy; and the first year of life | OR for PM2.5 exposure during the first year of life: 1.3 (95% CI: 1.0, 1.6) per 1.6 µg/m3 increase in PM2.5 | \*\* |  |
| Pre-gestation | **-** |  |
| 1st Trimester | **-** |  |
| 2nd Trimester | **-** |  |
| 3rd Trimester | **-** |  |
| 1st year of life | **+** |  |
| Oudin, 2019 (54) | NOx | Gestation | **+** | The modelled concentration of (NOx) linked to the geocoded residential address of mothers. Trimester-specific exposure quartiles as well as average exposure levels during the full pregnancy were then calculated. In the main analysis, year-specific quartiles were used | aORs for a 10 ug/m3 increase in NOx for 1st trimester: 1.15 (95% CI: 1.01-1.31).  aOR for 3rd trimester: 1.39 (95% CI: 1.01–1.9) and  aOR all pregnancy: 1.40 (95% CI: 1.02–1.93) | \*\*\* |  |
| 1st Trimester | **+** |  |
| 2nd Trimester | **-** |  |
| 3rd Trimester | **+** |  |
| Pagalan, 2019 (73) | PM2.5 | Gestation | **-** | Monthly mean exposures PM2.5, NOx), and NO2 at the maternal residence during pregnancy were estimated with temporally adjusted, high-resolution land use regression models | Exposure to NO (aOR, 1.07 [95% CI, 1.01-1.13])  ORs in male children were higher than female in stratified models | \*\*\* |  |
| NOx | **+** |  |
| NO2 | **-** |  |
| Pham, 2022 (49) | PM2.5 | Gestation | **+** | Satellite-based land-use regression (LUR) models were used to estimate annual mean exposure to nitrogen dioxide (NO2, units: parts per billion (ppb)) and PM2.5 (units: µg/m3) at each infant’s residential address in their birth year (2010–2013) | Exposures to PM2.5 with symptoms of ASD at age of 2 years. [ʙ=0.17 units per µg/m3 increase; 95% CI (0.02, 0.32); p=0.02] ASP raw score diagnosis and OR=1.64 (95% CI: 1.07-2.52) for ASD borderline/clinical range (>60, borderline/clinical range) at age 2 years | \*\*\* |  |
| NO2 | Gestation | **-** |  |
| Rahman, 2022 (46) | PM2.5 | Gestation | **+** | Weekly averages of mother's daily gestational exposure | The cumulative HR for the first two trimesters was 1.14 per IQR (7:4 ug/m3) increase in PM2:5 (95% CI: 106, 123).  HR for entire pregnancy: (HR: 1.17, 95% CI: 1.08-1.27).  Sex-stratified PM2:5 associations during pregnancy were stronger among boys [boys HR = 1:19 (95% CI: 1.09, 1.31) | \*\*\* |  |
| 1st Trimester | **+** |  |
| 2nd Trimester | **+** |  |
| 3rd Trimester | **-** |  |
| NO2 | Gestation | **-** |  |
| Rahman, 2023 (47) | PM2.5 | Gestation | **+** | Monthly estimates of PM2.5 were obtained from the WUACAG hybrid model (version V4.NA.02) and SO-CTM model. Exposures to PM2.5 were assigned to maternal address during the entire pregnancy, first trimester, second trimester, and third trimester | Prenatal PM2.5 with ASD [HR 1.10 (95% CI: 1.02, 1.19) in SO-CTM model] and  [HR 1.07 (95% CI:1.02, 1.11) in WUACAG Hybrid Model] | \*\*\* |  |
| Raz, 2015 (95) | PM2.5 | Pre-gestation through Infancy |  | Monthly ambient exposure predictions of airborne particulate matter ≤ 2.5 μm (PM2.5) were generated from nationwide expansions of previously validated spatiotemporal models | aOR per IQR higher PM2.5 (4.40 ug/m3) during pregnancy: 1.50 (95% CI: 1.22, 2.03).  In a mutually adjusted model including all three PM2.5 exposure models, ASD was significantly associated only with exposure during the pregnancy period (OR=1.63, 95% CI: 1.08-2.47) | \*\*\* |  |
| Pre-gestation | **-** |  |
| Gestation | **+** |  |
| 1st year of life | **-** |  |
| Raz, 2018 (28) | NO2 | Gestation through Infancy |  | The estimates were calculated using an area-weighted average of the nitrogen dioxide estimates of the exposure model in the relevant grid points that comprise the small statistical areas or the city boundaries | Increased risk of ASD (per 5.85-ppb increment during pregnancy OR= 1.08 (95% CI: 1.01, 1.15) and during the 9-month period after birth OR = 1.09 (95% CI: 1.02, 1.18) | \*\* |  |
| Gestation | **+** |  |
| 1st year of life | **+** |  |
| Santos, 2023 (37) | PM2.5 | Gestation through Infancy |  | An estimated average annual level for PM2.5, NO2 for each five time periods: first, second and  third trimesters of pregnancy, full pregnancy and the first year of the child’s life and assigned birth address | Increased ASD severity with PM2.5 exposure during the first trimester (p = 0.002; OR = 1.14, 95%CI: 1.05-1.23) and full pregnancy (p = 0.04; OR = 1.07, 95%CI: 1.00-1.15) | \* |  |
| 1st Trimester | **+** |  |
| Full pregnancy | **+** |  |
| 1st year of life | **-** |  |
| NO2 | Gestation through Infancy | **-** |  |
| Talbott, 2015 (51) | PM2.5 | Pre-gestation through Infancy | **+** | A land use regression (LUR) model to create person- and time-specific PM2.5 estimates for individual (pre-pregnancy, trimesters one through three, pregnancy, years one and two of life) and cumulative (starting from pre-pregnancy) key developmental time periods | Year 2 of life: per 2.84 μg/m3 (IQR) of PM2.5: aOR: 1.45 (95% CI: 1.01–2.08, p: 0.042)  Pre-pregnancy through year 2: aOR: 1.51 (95% 1.01-2.26, p: 0.046) | \*\*\* |  |
| Pre-gestation | **-** |  |
| Gestation | **-** |  |
| Ist year of life | **-** |  |
| 2nd year of life | **+** |  |
| Volk, 2013 (45) | PM2.5 | Gestation through Infancy | **+** | The CALINE4 line-source air quality dispersion model to estimate average concentrations of PM2.5 and NO2 for the specific locations and time periods (trimesters of gestation and first year of life) for each participant | Regional exposure measures of NO2 and PM2.5 during throughout pregnancy (aOR 1.81[95% CI: 1 .37-3.09]; 2.08 [95% CI: 1.93-2.25]), second trimester ( aOR 1.61 [95% CI: 1.15-2.25]; aOR 1.48 ]95% CI: 1.40-1.57]), third trimester (aOR 1.64 [95% CI:1.18-2.29]; aOR 1.40 [95% CI: 1.11-1.77) respectively, and during the first year of life (exposure to NO2: aOR, 2.06 [95% CI: 1.37-3.09]; exposure to PM2.5: AOR, 2.12 [95% CI: 1.45-3.10]  Whereas exposure to only NO2 during the first trimester were significantly associated with increased odds of autism (aOR 1.44 [95% CI: 1.05-1.20]) | \*\*\* |  |
| 1st Trimester | **-** |  |
| 2nd Trimester | **+** |  |
| 3rd Trimester | **+** |  |
| 1st year of life | **+** |  |
| NO2 | Gestation through Infancy | **+** |  |
| 1st Trimester | **+** |  |
| 2nd Trimester | **+** |  |
| 3rd Trimester | **+** |  |
| 1st year of life | **+** |  |
| Wang, 2021 (52) | NO2 | Gestation | **+** | Daily average value of each air pollutant from the hourly measurements made by the 69 automatic monitoring stations at township levels maintained by Environmental Protection Administration on Taiwan Island from 1 January 1995 to 31 December 2000 | An increase of 10 ppb in the level of NO2 in the first, second, and third trimester was associated with an HR of 1.39 (95% CI: 1.22-1.58), 1.25 (95% CI: 1.10-1.42), and 1.18 (95% CI:1.03-1.34), 1.42 (95% CI: 1.22-1.66) for entire pregnancy, respectively | \*\*\* |  |
| 1st Trimester | **+** |  |
| 2nd Trimester | **+** |  |
| 3rd Trimester | **+** |  |

**┼**: [**+**] Statistically significant, [**-**] Statistically Non – significant