

# Air Pollution increase the risk of Attention Deficit Hyperactivity Disorder (ADHD) in Taiwan: a Nationwide Cohort Study

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## Background

In modern society, air pollution is an important environmental threat. And air pollution harms people's health in many aspects. Currently, many researchers showed the association of air pollution and cerebrovascular disease and psychiatric disease, including attention deficit hyperactivity disorder (ADHD). Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder with an estimated worldwide prevalence of 7.2% among children and adolescents. ADHD has been found to be associated with a range of adverse outcomes, including worse academic achievement, other mental disorders, substance use disorders, criminality, unemployment, and increased health system costs and use. ADHD contributes to great burden of the family and society. Therefore, we analyzed the association between children, adolescents ADHD and air pollution in Taiwan.

## Method

In this national cohort study, we used two nation-scale databases, the national health insurance claims database and the air quality-monitoring database of Taiwan. We enrolled the children or adolescents born between 2000 to 2013. We selected the patients for ADHD by two strict criteria: (1) ADHD was diagnosed by a certificated psychiatric doctor in Taiwan; (2) patients should receive the drug of methylphenidate. The air pollutants of interest included carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>) and particles with aerodynamic diameter less than 2.5 μm (PM<sub>2.5</sub>). A residential area was defined according to the location of the clinic or hospital that the patients most frequently visited for treating acute upper respiratory tract infections. Cox proportional regression model was used to evaluate the hazard ratio (HR) of varied air pollutants to ADHD.

## Result

A total of 1,147 ADHD cases (2.70%, 1,147/42,512) were identified during the follow-up period with 41,365 non-ADHD cases (97.30%, 41,365/42,512). A large proportion of ADHD cases was boy (83%) and been diagnosed within the age of 6-11 years (74.98%). In the Cox regression model with adjustment for age, gender, urbanization level, residential area, comorbidities, the adjusted HRs were that PM<sub>2.5</sub> = 1.27 (95% CI 1.24-1.30), NO<sub>2</sub> = 1.06 (95% CI 1.05-1.08), and CO = 2.78 (95% CI 2.20-3.52) (all P < 0.0001) respectively.

## Conclusion

Air pollutants, including PM<sub>2.5</sub>, NO<sub>2</sub>, and CO, may be associated with an increased risk of ADHD in children or adolescents in Taiwan.

## Key Words

Attention Deficit Hyperactivity Disorder, air pollution, PM<sub>2.5</sub>, NO<sub>2</sub>, CO

**Table 1. Cox model with hazard ratios and 95% confidence intervals of ADHD in patients exposed to various daily average concentrations of air pollutants.**

Variables	Crude		Adjusted model 1			Adjusted model 2			Adjusted model 3		
	HR (95% CI)	P value	HR (95% CI)	P value	VIF	HR (95% CI)	P value	VIF	HR (95% CI)	P value	VIF
<b>PM<sub>2.5</sub> (μm/m<sup>3</sup>), daily average</b>	1.01(1.00-1.02)	0.0057	1.27(1.24-1.3)	<.0001	1.67	-	-	1.54	-	-	1.37
<b>NO<sub>2</sub> (ppb), daily average</b>	1.05(1.04-1.06)	<.0001	-	-	-	1.06(1.05-1.08)	<.0001	-	-	-	-
<b>CO (ppm), daily average</b>	2.94(2.44-3.53)	<.0001	-	-	-	-	-	-	2.78(2.2-3.52)	<.0001	-
<b>Gender</b>											
Girl	1.00(reference)		1.00(reference)			1.00(reference)			1.00(reference)		
Boy	4.53(3.88-5.28)	<.0001	3.74(3.19-4.37)	<.0001		3.76(3.21-4.39)	<.0001		3.75(3.21-4.38)	<.0001	
<b>Age group</b>											
0-5	1.00(reference)		1.00(reference)			1.00(reference)			1.00(reference)		
6-11	10.07(3.22-31.54)	<.0001	5.05(1.61-15.85)	0.0055		7.38(2.36-23.09)	0.0006		7.58(2.42-23.73)	0.0005	
12-17	10.66(3.40-33.44)	<.0001	4.42(1.41-13.92)	0.011		7.04(2.24-22.11)	0.0008		7.27(2.32-22.83)	0.0007	
<b>Comorbidities (ref=non-)</b>											
Autistic Spectrum Disorder	13.79(11.29-16.85)	<.0001	3.64(2.88-4.6)	<.0001	1.05	3.42(2.71-4.33)	<.0001	1.05	3.39(2.68-4.29)	<.0001	1.05
Intellectual Disability	14.84(12.36-17.81)	<.0001	5.56(4.49-6.89)	<.0001	1.05	5.59(4.5-6.94)	<.0001	1.05	5.57(4.48-6.93)	<.0001	1.05
Oppositional Defiant Disorder (ODD) or Conduct Disorder (CD)	32.05(26.74-38.41)	<.0001	12.12(9.98-14.72)	<.0001	1.01	13.11(10.82-15.89)	<.0001	1.01	13.2(10.89-16)	<.0001	1.01
Tic Disorder or Tourette syndrome	7.34(5.86-9.19)	<.0001	2.99(2.36-3.8)	<.0001	1.01	3.5(2.78-4.4)	<.0001	1.01	3.54(2.81-4.45)	<.0001	1.07

Abbreviation: HR, hazard ratio; CI, confidence interval

Model 1: adjusted for PM<sub>2.5</sub>, age, gender, urbanization level, residential area, and comorbidity in Cox proportional hazards regression

Model 2: adjusted for NO<sub>2</sub>, age, gender, urbanization level, residential area, and comorbidity in Cox proportional hazards regression

Model 3: adjusted for CO, age, gender, urbanization level, residential area, and comorbidity in Cox proportional hazards regression