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The association of environmental factor and CKD in South Korea: a cross-sectional study using the Korea National Health and Nutrition Examination Survey (KNHANES)

Semin Cho[1], Jeong Min Cho[1], Soojin Lee[2], Sehoon Park[4], Jin Kyung Kwon[4], Jin Hyuk Paek[3], Woo Yeong Park[3], Kyubok Jin[3], Dong Ki Kim[4], Yaerim Kim[3]
[1]Department of Internal Medicine-Nephrology, Chung-Ang University Gwangmyeong Hospital, Korea, Republic of
[2]Department of Internal Medicine-Nephrology, Eulji University Hospital, Korea, Republic of
[3]Department of Internal Medicine-Nephrology, Keimyung University Dongsan Medical Center, Korea, Republic of
[4]Department of Internal Medicine-Nephrology, Seoul National University Hospital, Korea, Republic of

Objectives : It is well known that various environmental factors including air pollution increase the risk of kidney disease. We aimed to elucidate the risk of chronic kidney disease according to the indoor air quality and urinary volatile organic compounds (VOCs) using data from the Korea National Health and Nutrition Examination Survey (KNHANES).
Methods : The ratio of indoor and ambient particulate matter (PM) 2.5 and urine creatinine-corrected VOCs concentration (BMA, 2MHA, 3,4MHA, PGA, MA, SPMA, 3HPMA, BPMA and DHBMA) were extracted from the KNHANES VIII (2019–2021) dataset. CKD was defined as estimated glomerular filtration rate (eGFR) less than 60 mL/min/1.73m^2, and the association between environmental factors and CKD was analyzed through multiple linear regression model.
Results : A total of 1,319 participants was analyzed in this study. The indoor PM2.5 concentration and the ambient PM2.5 concentration did not show a statistically significant association with CKD respectively. However, the highest quartile of the ratio of indoor to ambient PM2.5 concentration was associated with increased risk of CKD (odds ratio, 4.28; 95% confidence interval, 1.43–12.75, p-value 0.009) after adjustment of age, sex, comorbidities, and window opening status. The urinary concentration of several VOCs (3,4MHA [3,4-Methylhexanoic Acid], PGA [Phenylglyoxylic Acid], MA [Maleic Acid], DHBMA [Dihydroxybenzene Mercapturic Acid]) have been found to have statistically significant association with reduced kidney function. ([3,4MHA] odds ratio(OR), 5.86; 95% confidence interval(95% CI), 1.30–26.45; p-value 0.023; [PGA] OR, 14.30; 95% CI, 1.53–133.78; p-value 0.014; [MA] OR, 5.38; 95% CI, 1.03–28.12; p-value 0.040; [DHBMA] OR, 4.14; 95% CI, 0.77–22.21; p-value 0.054).
Conclusions : In this cross-sectional study, the indoor air quality of PM2.5 relative to the ambient PM2.5 was associated with the deterioration of kidney function and urinary VOCs concentration showed the association with declined kidney function which could be used to be a predictive marker of CKD.

Table 1.JPG

Table 1. Risk of CKD according to indoor air quality index

		% (SE)	Model 1	Model 2	Model 3	Model 4
Indoor PM2.5	Tertile 1	1.92 (0.73)	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	0.71 (0.39)	0.37 (0.09, 1.44)	0.37 (0.09, 1.50)	0.38 (0.08, 1.76)	0.34 (0.08, 1.59)
	Tertile 3	2.65 (0.87)	1.39 (0.52, 3.74)	1.09 (0.39, 3.02)	1.04 (0.38, 2.88)	0.97 (0.37, 2.50)
	P for trend		0.489	0.773	0.839	0.924
Ambient PM2.5	Tertile 1	1.71 (0.77)	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.68 (0.64)	0.98 (0.30, 3.23)	0.64 (0.18, 2.29)	0.50 (0.14, 1.85)	0.72 (0.20, 2.54)
	Tertile 3	1.82 (0.72)	1.066 (0.33, 3.46)	0.85 (0.26, 2.85)	0.72 (0.23, 2.26)	0.88 (0.30, 2.61)
	P for trend		0.913	0.842	0.678	0.873
Indoor PM2.5 / Ambient PM2.5	Tertile 1	0.75 (0.35)	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.40 (0.57)	1.89 (0.55, 6.52)	1.82 (0.51, 6.54)	1.93 (0.52, 7.23)	1.52 (0.41, 5.60)
	Tertile 3	3.01 (0.97)	4.13 (1.40, 12.19)	4.62 (1.50, 14.23)	5.28 (1.71, 16.31)	4.28 (1.43, 12.75)
	P for trend		0.010	0.009	0.005	0.009

Data are presented as % (standard error)
Model 1 was non-adjusted.
Model 2 was adjusted for age and sex.
Model 3 was adjusted for variables in model 2 and BMI, smoking history, alcohol consumption and comorbidities (hypertension, diabetes mellitus).
Model 4 was adjusted for variables in model 3 and window opening status.

Table 1.JPG

Table 2. Risk of CKD according to urinary VOCs concentration

		% (SE)	Model 1	Model 2	Model 3
BMA	Tertile 1	1.06 (0.52)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.91 (0.72)	1.81 (0.67, 4.90)	1.06 (0.35, 3.17)	1.14 (0.39, 3.33)
	Tertile 3	1.26 (0.65)	1.18 (0.28, 4.99)	0.44 (0.11, 1.76)	0.48 (0.12, 1.95)
	P for trend		0.757	0.173	0.235
2MHA	Tertile 1	1.52 (0.69)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.07 (0.58)	0.70 (0.17, 2.93)	0.55 (0.14, 2.17)	0.62 (0.16, 2.48)
	Tertile 3	1.60 (0.63)	1.05 (0.39, 2.86)	1.04 (0.38, 2.81)	1.06 (0.27, 4.08)
	P for trend		0.892	0.898	0.952
3,4MHA	Tertile 1	0.41 (0.21)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.97 (0.78)	4.88 (1.38, 17.29)	4.70 (1.35, 16.39)	4.27 (1.27, 14.42)
	Tertile 3	1.67 (0.62)	4.11 (1.13, 14.88)	4.82 (1.31, 17.70)	5.49 (1.14, 26.33)
	P for trend		0.042	0.011	0.036
PGA	Tertile 1	0.08 (0.08)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.41 (0.62)	17.35 (1.94, 155.10)	14.10 (1.58, 125.70)	11.88 (1.36, 103.56)
	Tertile 3	3.05 (0.97)	38.16 (4.77, 305.54)	15.76 (1.91, 130.30)	14.13 (1.58, 126.71)
	P for trend		<0.001	0.006	0.031
MA	Tertile 1	0.23 (0.20)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	2.31 (1.07)	10.07 (1.44, 70.50)	6.70 (0.92, 48.53)	8.52 (1.31, 55.49)
	Tertile 3	1.87 (0.62)	8.09 (1.32, 49.62)	4.19 (0.65, 26.92)	4.43 (0.77, 25.55)
	P for trend		0.007	0.204	0.172
SPMA	Tertile 1	0.51 (0.30)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	0.84 (0.43)	1.63 (0.35, 7.60)	0.58 (0.11, 3.11)	0.49 (0.09, 2.65)
	Tertile 3	3.2 (1.03)	6.39 (1.80, 22.67)	1.65 (0.37, 7.38)	1.41 (0.25, 7.85)
	P for trend		0.001	0.221	0.395
3HPMA	Tertile 1	0.78 (0.34)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.29 (0.66)	1.66 (0.44, 6.32)	0.79 (0.19, 3.21)	0.78 (0.20, 3.12)
	Tertile 3	2.20 (0.81)	2.85 (0.93, 8.70)	1.13 (0.35, 3.60)	1.01 (0.32, 3.12)
	P for trend		0.054	0.713	0.907
BPMA	Tertile 1	1.7 (0.83)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.33 (0.51)	0.78 (0.23, 2.67)	0.46 (0.12, 1.71)	0.59 (0.18, 1.93)
	Tertile 3	1.11 (0.61)	0.65 (0.16, 2.71)	0.24 (0.06, 0.95)	0.24 (0.06, 0.92)
	P for trend		0.549	0.048	0.032
DHBMA	Tertile 1	0.24 (0.17)	1 (reference)	1 (reference)	1 (reference)
	Tertile 2	1.17 (0.57)	4.85 (0.83, 28.26)	2.38 (0.36, 15.73)	2.33 (0.37, 14.63)
	Tertile 3	3.11 (1.18)	13.19 (2.73, 63.77)	5.19 (0.94, 28.53)	5.32 (1.02, 27.85)
	P for trend		0.001	0.042	0.026

Data are presented as % (standard error)
Model 1 was non-adjusted.
Model 2 was adjusted for age and sex.
Model 3 was adjusted for variables in model 2 and BMI, smoking history, alcohol consumption and comorbidities (hypertension, diabetes mellitus).
Abbreviation: CKD, chronic kidney disease; VOC, volatile organic compounds; BMA, Benzyl Mercapturic Acid; 2MHA, 2-Methylhippuric Acid; 3,4MHA, 3,4-Methylhexanoic Acid; PGA, Phenylglyoxylic Acid; MA, Maleic Acid; SPMA, S-Phenylmercapturic Acid; 3HPMA, 3-Hydroxypropyl Mercapturic Acid; BPMA, Benzylphenyl Mercapturic Acid; DHBMA, Dihydroxybenzene Mercapturic Acid