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Maternal exposure to airborne particulate matter during pregnancy and lactation induces kidney injury in rat dams and their male offspring: the role of vitamin D in pregnancy and beyond

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Objectives: Little is known about the transgenerational effects of maternal exposure to particulate matter (PM) on the offspring kidney health. This study investigated the effect of maternal administration of PM or PM with vitamin D during pregnancy and lactation on renal injury in rat dams and their offspring.
Methods: Nine pregnant Sprague–Dawley rats received oral administration of normal saline, airborne PM suspension (5 days/week) or PM with vitamin D (cholecalciferol, 1,000 IU/kg, 3 days/week) from gestational day 11 to postpartum day 21. Kidneys of rat dams (N=3 per each group) and their male offspring (n=6 per each group) were taken for histological analysis, western blotting, and immunohistochemistry on postpartum or postnatal day 21.
Results: Each group of rat dams and their offspring showed similar body weight on postpartum or postnatal day 21. However, maternal PM exposure increased glomerular damage and tubulointerstitial injury in both dams and pups, which were attenuated by vitamin D administration. In rat dam kidneys, PM increased the protein expression of vitamin D receptor (VDR), klotho, and tumor necrosis factor-α, and these changes were lessened by vitamin D. The expression of renin, nuclear factor erythroid 2-related factor 2 (Nrf2), and nuclear factor-kB (NF-kB) p50 decreased in rat dams exposed to PM. In offspring kidneys, exposure to maternal PM reduced the expression of VDR, renin, angiotensin converting enzyme (ACE), nrf2, and NF-kB p50, while increasing cytochrome P450 24A1 expression. Maternal vitamin D administration with PM enhanced the activities of VDR, ACE and NF-kB p50 in their offspring kidneys. Maternal PM exposure increased intrarenal CD68-positive macrophage infiltration in both dams and offspring, which were attenuated by vitamin D administration.
Conclusions: PM exposure during pregnancy and lactation may exert transgenerational renal impairment, and maternal vitamin D intake could attenuate PM-induced kidney damage partially in mothers and their offspring.

Figure 1. Glomerular damage and tubulointerstitial injury in rat dams and their male offspring.

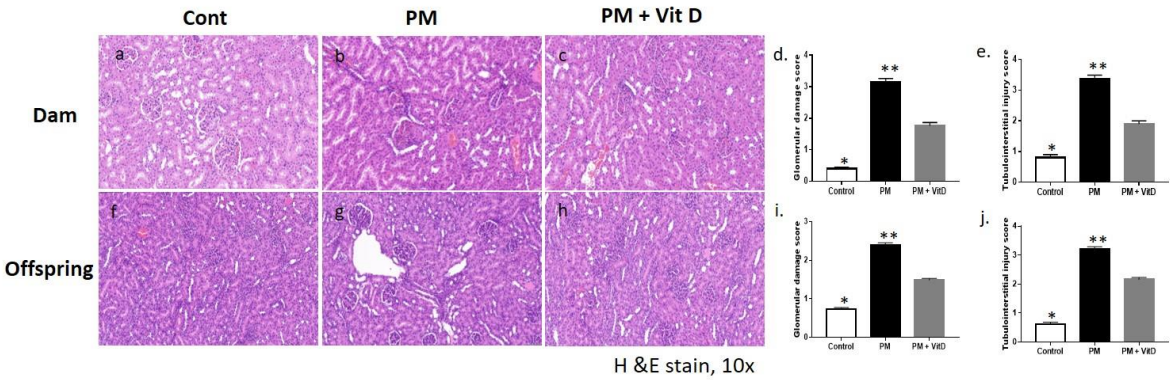

Table 1. The concentration of WSOC, ions, and elements in PM samples

Ions	Mass fraction of total measured ion content (%)	Atmospheric ion concentrations (ug/m^3)	Elements	Mass fraction of total measured elemental content (%)
WSOC	14.4	5.33	Fe	48.3
NO_3^-	30.1	11.1	Pb	23.6
SO_4^{2-}	13.3	4.91	Cu	11.3
Cl^-	3.98	1.47	Mn	7.15
F^-	0.22	0.08	As	3.52
Br^-	0.02	0.01	Cr	3.11
NH_4^+	16.8	6.20	Ni	2.23
Na^+	14.3	5.27	Cd	0.75
Ca^{2+}	3.45	1.28	Be	0.04
K^+	2.45	0.91		
Mg^{2+}	1.0	0.37		