

A Prospective Study of Arsenic and Manganese Exposure and Maternal Blood Pressure During Gestation

Faye V. Andrews^{1,2}, Adam Branscum¹, Perry Hystad¹, Ellen Smit¹, Sakila Afroz³, Mostofa Golam³, Omar Sharif³, Mohammad Rahman³, Quazi Quamruzzaman³, David C. Christiani⁴, Molly L. Kile¹

¹Oregon State University, College of Public Health and Human Sciences, Corvallis, Oregon, USA; ²Oregon Clinical and Translational Research Institute, Oregon Health and Sciences University; ³Dhaka Community Hospital Trust, Dhaka, Bangladesh; ⁴Harvard T.H. Chan School of Public Health, Department of Environmental Health, Harvard University.

INTRODUCTION

- Bangladesh has widespread arsenic and manganese groundwater contamination that affects approximately 60 million individuals
- Metal exposures are risk factors for increased blood pressure (BP)
- Few studies have examined the role of arsenic and manganese on the cardiovascular system during pregnancy

HYPOTHESES

- Women with higher arsenic and manganese exposures will experience greater increases in diastolic and systolic BP levels during pregnancy
- Body mass index modifies the effect of arsenic and manganese on BP

Table 1: Characteristics of cohort at enrollment. All participants have at least two measurements of systolic and diastolic BP.

Characteristics	At enrollment (n= 1522)
Systolic BP at Baseline	
Low (Below 90 mmHg)	42 (2.8%)
Normal (90-120 mmHg)	1316 (86.5%)
Elevated (Over 120 mmHg)	164 (10.8%)
Diastolic BP at Baseline	
Low (Below 60 mmHg)	33 (2.2%)
Normal (60-80 mmHg)	1266 (83.2%)
Elevated (Above 80 mmHg)	223 (14.7%)
Age (years)	
Mean (SD)	22.9 (4.19)
BMI (kg/m²)	
Mean (SD)	20.5 (3.19)
Education	
No school attendance	226 (14.8%)
Primary School	509 (33.4%)
Secondary School and Higher	787 (51.7%)
Monthly Household Income (Taka)	
>3,000	247 (16.2%)
3,001-4,000	382 (25.1%)
4,001-5,000	467 (30.7%)
5,001+	401 (26.3%)
Cook Fuel Type	
Clean Fuel	1038 (68.2%)
Less Clean Fuel	476 (31.3%)
Preterm Birth (> 37 Weeks Gestation)	
No	921 (60.5%)
Yes	256 (16.8%)
Missing	345 (22.7%)
Type of Birth	
Vaginal	766 (50.3%)
Cesarean	411 (27.0%)
Missing	345 (22.7%)
Clinic Location	
Sirajdikhan	815 (53.5%)
Pabna	707 (46.5%)
Drinking Water Arsenic at enrollment (µg/L)	
Mean (SD)	43.4 (102)
Median [Min, Max]	2.00 [0.500, 1400]
Drinking Water Manganese at enrollment (µg/L)	
Mean (SD)	735 (731)
Median [Min, Max]	596 [0.500, 5300]

RESULTS: ARSENIC

- Arsenic exposure had a positive, linear relationship on systolic and diastolic BP over gestation (Figure 1)
- BMI modified the effect of arsenic on BP with overweight individuals experiencing greater changes in BP per month of gestation (Table 2)

Figure 1: Prediction of the exposure-response relationship between drinking water arsenic levels and monthly systolic (A) and diastolic (B) BP based on linear mixed-effect models (n=1,169)

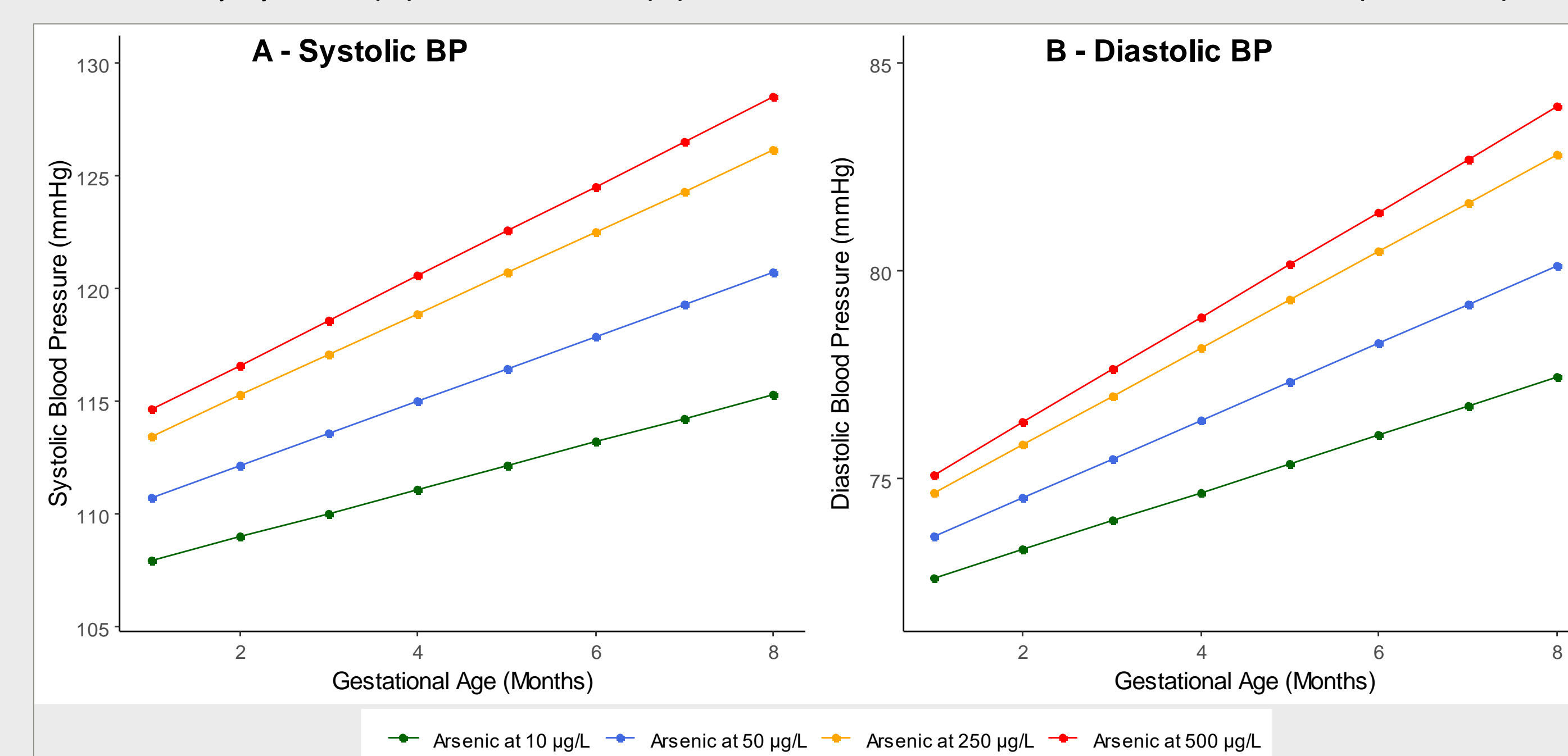


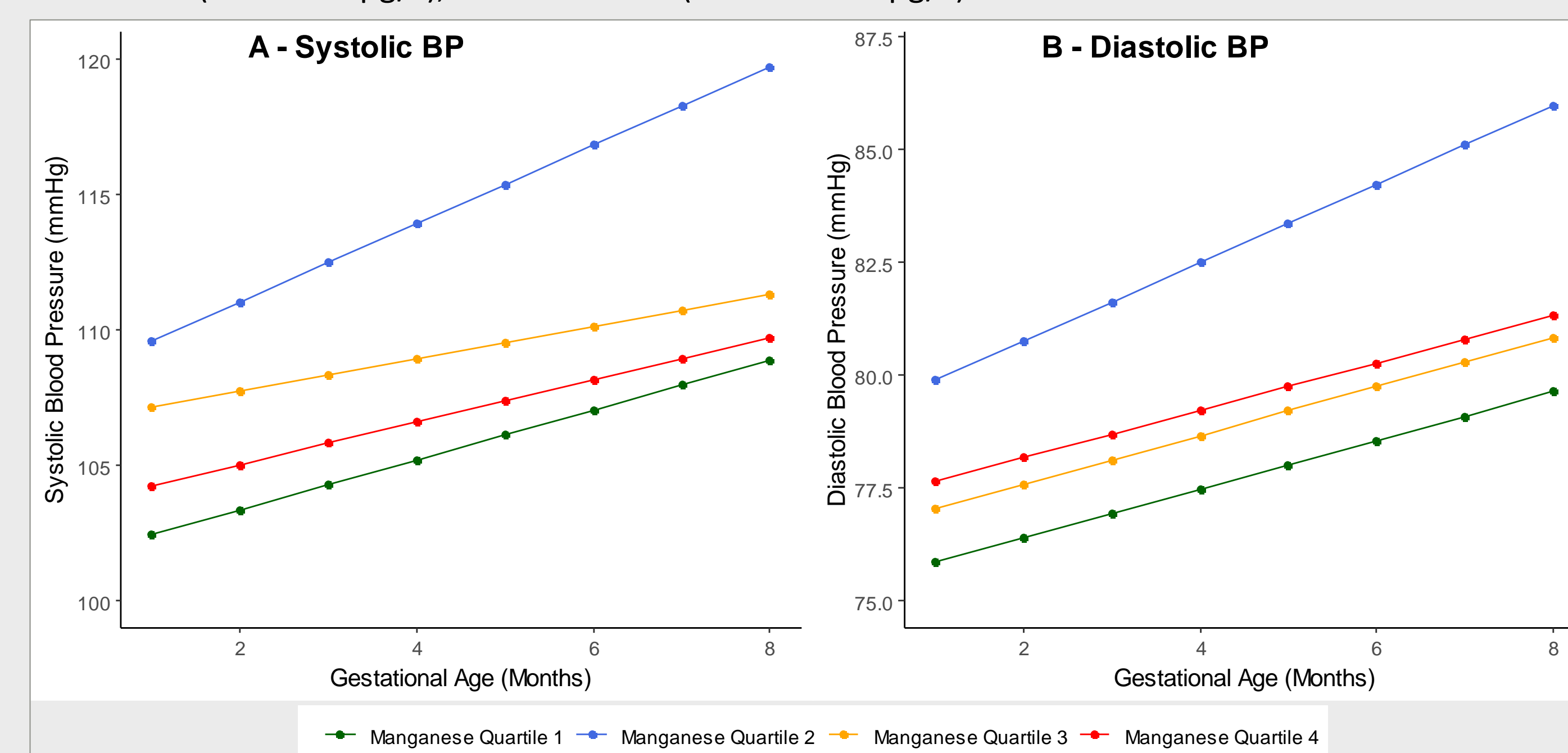
Table 2: Effect modification by Body Mass Index (kg/m²) on the association between drinking water arsenic exposures and change in systolic and diastolic BP (mmHg) per month of gestation among women in Bangladesh (n=1,522)

	Model Type	BP measurements	Systolic Blood Pressure		Diastolic Blood pressure	
			β (95% CI)	P-value	β (95% CI)	P-value
Normal/ Underweight (<23 kg/m²)	Crude (n=1,222)	7996	1.18 (1.12 - 1.25)	<0.001	1.10 (1.06 - 1.15)	<0.001
	Adjusted (n=945)	6389	1.20 (1.13- 1.28)	<0.001	1.11 (1.06 - 1.16)	<0.001
High BMI (23 kg/m² +)	Crude (n=299)	1956	1.45 (1.29- 1.63)	<0.001	1.34 (1.23 - 1.46)	<0.001
	Adjusted (n=224)	1515	1.45 (1.28 - 1.67)	<0.001	1.37 (1.25 - 1.51)	<0.001

RESULTS: MANGANESE

- Manganese exposure had a non-linear relationship with systolic and diastolic BP over gestation where only those participants who were exposed to 160-589 µg/L of manganese had significantly higher BP (Figure 2)
- BMI did not show consistent effect modification

Figure 2: Prediction of the exposure-response relationship between drinking water manganese levels and change in monthly systolic (A) and diastolic (B) BP based on linear mixed-effect models (n=1,169). Manganese Quartile 1: (0.5 – 159 µg/L), Quartile 2: (160 – 589 µg/L), Quartile 3: (590 – 952 µg/L), and Quartile 4: (952.5 – 5300 µg/L)



METHODS

Study design: Prospective cohort examining the effects of metals on maternal health over gestation

Environmental exposure: Arsenic and manganese drinking water levels (µg/L) measured by ICPMS

Internal measurements: Arsenic and manganese toenail levels (µg/g) measured by ICPMS

Outcome: Repeated measures of diastolic and systolic blood pressure (BP) (mmHg) over gestation with up to 8 time points

Statistical Analysis: Multivariate linear mixed models with covariates: age, education, monthly income, Body Mass Index (kg/m²) (BMI), birth gestational age, birth type, clinic location, natural log arsenic or manganese, and the interaction of BMI and exposure

DISCUSSION

- Women with higher arsenic and manganese exposures had significantly higher monthly increases in systolic and diastolic BP during their pregnancies. This effect was modest but accumulated over time that was dose dependent.
- Overweight women at enrollment experienced greater changes in systolic and diastolic BP over gestation arsenic for any arsenic and manganese exposure levels.

Strengths:

- Large, prospective cohort of relatively health women with low tobacco use, no clinical obesity, and no self-reported history of pre-existing CVD
- Environmental and internal measurements of metal exposures minimizes misclassification of exposure
- Repeated measurements of systolic and diastolic BP to evaluate changes over gestation

Limitations:

- Baseline BP measurements did not occur at the same gestational week for every woman in cohort due to rolling recruitment
- BP measurements were not taken at the time of delivery

Future Studies:

- Possible additive and multiplicative mixture effects of metal exposures on gestational BP changes

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Oregon State University