INCIDENCE OF HYPERTENSIVE DISORDERS AMONG PREGNANT WOMEN IN PORT HARCOURT METROPOLIS, RIVERS STATE, NIGERIA

John-Okpara Stephena Onolunosen[1*], Francis Anacletus[2], Joel Aluko[3].

[1]African Centre for Excellence in Public Health and Toxicological Research (ACE-PUTOR) ;[2]Department of Biochemistry, University of Port Harcourt; [3]Department of Nursing, University of Illorin.

***Corresponding author's email**: *stephena_john-okpara@uniport.edu.ng*

Article History

Received: 13 April 2025
Accepted: 06 May 2025
Published: 05 July 2025

Abstract

Hypertension is a serious health risks for both the expectant mother and the fetus. It is crucial for concern in public health. Individuals with elevated arterial fluid conduit pressure significantly increase their chances of heart-related conditions and chronic kidney disease, accompanied by subsequent increase in death rate. This study assessed incidence of hypertension disorders among pregnant women in Port Harcourt Metropolis. A cross-sectional comparative study was employed. Eighty-two pregnant women (41 each from high environmentally exposed areas and low environmentally exposed areas). An authenticated partially-automated sphygmomanometer was used to ascertain participant's blood pressure before enrolment. A subsequent reading was taken at most for two consecutive minutes when the first reading was ≥140 mmHg for peak arterial fluid conduit force (PBP) or ≥ 90 mmHg for resting arterial fluid conduit force (RBP). Descriptive statistics and independent t-tests were used to compare both groups, with statistical significance set at $p < 0.05$. Participants who met inclusion criterion where 41(50%) pregnant women from both environmentally exposed groups. New cases of hypertension were discovered in 36(87.8%) of participants from the former and 3(7.3%) from the later, while normotensive cases from the former were 5(12.2%) as against 38(92.7%) from the later. The cumulative incidence of hypertension in the former is 39(47.6%) of the whole population used for the research. Incidence of hypertension were more in participants from high environmentally exposed area than in the later. Routine comprehensive screening for

	hypertension in public and private health facilities is recommended.
License: CC BY 4.0♦  **Open Access article**.	**Keywords:** *Hypertension, Incidence, Pregnant Women.*

How to cite this paper: *John-Okpara S. O et al .(2025). Incidence of hypertensive disorders among pregnant women in Port Harcourt metropolis, Rivers State, Nigeria*. *Journal of Public Health and Toxicological Research,* 3: 121-128.

Introduction

Elevated arterial pressure is a crucial issue of concern in public health (WHO, 2023). Individuals experiencing elevated arterial fluid conduit pressure have significantly increased chances of developing heart-related conditions and chronic kidney disease, accompanied by a subsequent increase in mortality rate (Wan et al., 2019). Although other associated factors may predispose to hypertensive disorders such as obesity, parity, gravidity, smoking, socioeconomic and socio-demographic factors, unhealthy diet, lifestyle, and physical inactivity (WHO, 2023). To mitigate potential complications, it is essential to implement effective management strategies for high arterial pressure before conception, during gestation and in the after-birth period (post-partum). Pregnancy-related hypertensive conditions (PRHC), classed as Maternal health complications are inclusive of but not limited to gestational hypertensive conditions (GHC) and pre-eclampsia (PE) (Sears et al., 2018). These two have been documented as a complication of about 5–10% of pregnancies worldwide (Agrawal & Wenger, 2020).

Arterial pressure is the force of blood pushing against the walls of the arteries. Hypertension, or high blood pressure, refers to a situation where by the arterial pressure exceeds the normal range. This condition is a major predisposing factor for the development of other cardiovascular and cerebrovascular diseases, including heart disease, myocardial infarction (heart attack), and stroke. An identification of arterial elevated pressure during gestation requires a peak blood pressure (SBP) of 140 mmHg or more and/or resting blood pressure (DBP) of 90 mmHg or more, measured on two successive instances (Agrawal & Wenger, 2020). The sudden onset of raised arterial pressure presenting after 20th week of gestation and mostly in the last lap of gestation (third trimester) characterized by signs of organ dysfunction (liver and kidney) and elevated urinary protein is termed preeclampsia. Pre-eclampsia (PE) is also explained as a gestation-related hypertensive condition that is marked frequently by high blood pressure and proteinuria, linked to defective placental formation after 20 weeks of pregnancy (Rana., et al., 2019).

The diagnosis of eclampsia is made only when preeclampsia becomes accompanied with seizures presenting a serious health emergency to the gravid mother and baby in utero. However quite unpopular cases of preeclampsia termed “post-partum preeclampsia” exist and presents after the birth of a child and may eventually progress to post-partum eclampsia if seizures present. HELLP (Hemolysis, elevated liver enzyme, low platelet) Syndrome is characterized by hepatic destruction and blood cell abnormalities. It is a severe outcome of preeclampsia or eclampsia although not common, it is serious and potentially life-threating. Thus, the need to highlight the incidence of hypertension to provide a clue on how to avert its enormous consequences. Worldwide hypertension complicates a considerable percentage pregnancies 44-15% posing risks to both mother and fetus (Nath et al., 2021). Dramatic adjustments occurring due to gestation or gravidity in vascular physiology metabolic network and in reproductive organs are capable of disrupting endocrine activities and weakening the immune system this ultimately predisposes gravid females to toxicant exposures (TE) and ultimately brings about a correlated health risks. Heavy metals hold a distinct position in toxicology since unlike organic pollutants they do not undergo degradation or decompose into other substances over time amounting to lower concentration in bioaccumulation in the ecosystem, agriculture, and the human body which eventually presents harmful medical effects that endure over time. The majority of these toxicological metals bind strongly to biological molecules and significantly to tissues and elements such as, mercury and cadmium tend to accumulate in the kidneys. These harmful toxicants have particular characteristics of inducing oxidative stress that may bring about hypertensive disorders in the gravid stage aside other adverse outcome. Although, welfare risks posed to women by most toxicants remain inadequately defined. Investigations on TE prenatally have been more focused on fetal outcomes in contrast to maternal outcomes.

Regarding midwifery, elevated arterial pressure in gestational period is marked by preterm birth, placenta abruption, and cesarean birth (Fraser and Catov, 2023). It also places extra stress on the heart and kidneys. The role of environmental toxicants which may be a major factor in the observed physiologic distribution of hypertensive disorders among prenatal mothers may be a result of alterations in biochemical parameters owing to continuous toxicant exposure within the metropolis and linking findings from bio-specimens together with biomarkers investigated in this thesis and their comparisons with standard reference values for pregnant women attending antenatal from selected

hospitals within the Port Harcourt Metropolis. The study aimed to identify incidence of hypertension among gravid women participating in antenatal care in the chosen hospitals in high (Mbodo) and low (Ozuoba) areas of environmental toxicant exposure within Port Harcourt Metropolis and determine socio-demographic, socio-economic, obstetric, and gynecological risk factors that may be contributory to incidence hypertension among pregnant participants attending ANC in high and low areas of toxicant exposure.

Materials and Methods

This research utilized a cross-sectional comparative study design. This research was undertaken in Mbodo-Aluu (high environmentally exposed area) and Ozuoba (low environmentally exposed areas) due to their proximity to urban expansion sources, industrial pollution sources, and being at high risk for toxic environmental conditions. The semi-urban communities are situated respectively in Ikwerre and Obio/Akpor Local Government Areas of Rivers State, Nigeria, and within the Port Harcourt metropolis. The population consisted of Eighty-two Pregnant women from a heterogeneous population of 154 attending antenatal in one selected health care center and one private hospital in Port-Harcourt metropolis from October, 2023 to June 2024. A non probability sampling technique was employed in this current research .Participants excluded where pregnant females not residing indefinitely in the communities chosen within the Port Harcourt metropolis where the research is to be carried out, gravid females not receiving antenatal care services in the chosen health facilities which will be used for the research, pregnant women already in labor, pregnant women with known pre-existing medical conditions or those on medication known to affect blood pressure were excluded from the study and pregnant women in their first or second trimester.

An authenticated partially-automated sphygmomanometer, equipped having a sleeve width suitable for the circumference of the arm, was utilized to ascertain participants blood pressure before enrolment and when the first arterial fluid conduit force reading was ≥140 mmHg for peak arterial fluid conduit force (PBP) or ≥ 90 mmHg for resting arterial fluid conduit force (RBP) on any pregnant participant, a subsequent reading was taken at most for two consecutive minutes. Combi 2 strips was used to detect protein in urine samples, medical, socio-economic, socio-demographic ,obstetric and gynecological history data were collected from participant's folders at the study enrolment. The number of participants was determined based on similar studies, such as Jedidiah et al. (2024), who used a sample size of 60 in their research on the impact of gas flaring on electrolytes in pregnant women. Given the need for a slightly larger sample to enhance statistical power and account for potential variability, this study sample size was increased using the non-response formula N/(1 - 0.25) = 60/(1 - 0.27) = 60/0.73 = 82.

Ethical clearance was gotten from the board of ethics and research, Port Harcourt University. A formal introductory letter stating the research intent was addressed and presented in person to the chief medical directors of the two selected hospitals to be used for the purpose of the research. After verbal consent from one and written consent from the other were obtained, the primary investigator visited the various clinics on their antenatal scheduled day and time in each month, a self-introduction was made and the intent of the research was disclosed to the medical team in each hospital. Support from medical staff was solicited and obtained. Consent from pregnant participants was obtained verbally after explaining the research intent, disclosing the necessary permit granted to carry out the present study in the hospital(s), and discussing its importance to midwifery practice and the possible avoidable risks. Descriptive statistics and independent t-tests were used to compare exposure groups, with statistical significance set at $p < 0.05$.

Results

The results of the study are shown below

Table 1: Incidence of hypertension among pregnant participants attending ANC in high and low regions of environmental toxicant exposure N=84, n=41

Hypertensive status N=82,n=41	Systolic mean±SD/diastolic mean±SD	Urinary protein(mg/dl) meam±SD	Frequency hypertensive cases(%)	None hypertensive cases(%)
High exposure area n=41	158±7.90/98±5.16	7.08±1.56	36 (87.8)	5 (12.2)
Low exposur	117.58±6.93/72.74±4.84	5.5±1.04	3 (7.3)	38 (92.7)

e area, n=41				

Table 2: Socio demographic characteristics linked with HTDP among pregnant participants attending ANC in high and low regions of environmental toxicant exposure N=84, n=41.

Categories	High exposure, n=41(%)	New onset hypertension, n=36 (%)	Normotensive, n=5 (%)	Low exposure, n=41 (%)	New onset hypertension n=3 (%)
Age(years)					
25-29	15(36.6)	12(33.3)	3(60.0)	13(31.7)	1(33.3)
30-34	16(39.0)	14(38.9)	2(40.0)	14(34.1)	1(33.3)
35-39	10(24.4)	10(27.8)	0(0.00)	14(34.1)	1(33.3)
Education					
Illiterate	12(29.3)	10(27.8)	2(40.0)	10(24.4)	1(33.3)
Primary	5(12.2)	4(11.1)	1(20.0)	5(12.2)	1(33.3)
Secondary	10(24.4)	9(25.0)	1(20.0)	14(34.1)	1(33.3)
Tertiary	11(26.8)	10(27.8)	1(20.0)	8(19.5)	0(0.00)
Post graduate	3(7.3)	3(8.3)	0(0.0)	4(9.8)	0(0.0)

Table 3: Socio Economic Characteristics linked with HTDP among pregnant participants attending ANC in high and low regions of environmental toxicant exposure N=84, n=41.

occupation	H E n=41 %	NoH n=36 %	Nmt n=5 %	L E n=41 %	NoH N=3 %	Nmt n=38 %
House wife	10(24.4)	9(25.0)	1(20.0)	8(19.5)	1(13.3)	7(18.4)
Student	5(12.2)	4(11.1)	1(20.0)	4(9.8)	0(0.0)	4(10.5)
Civil servant	15(36.6)	13(36.1)	2(40.0)	14(34.1)	1(33.3)	13(34.2)
Self employed	6(14.4)	5(13.9)	1(20.0)	8(19.5)	0(0.0)	8(21.1)
Unemployed	5(12.2)	5(13.9)	0(0.0)	7(17.1)	1(3.3)	6(15.8)
Marital status						
Single	5(12.2)	4(11.1)	1(20)	6(14.6)	0(0.0)	6(115.8)
Married	30(73.2)	27(75)	3(60)	29(70.0)	1(33.3)	28(73.7)
Separated	4(9.8)	3(8.3)	1(20.0)	3(7.3)	1(33.3)	2(5.3)
Widow	2(4.9)	2(5.6)	0(0.0)	3(7.3)	1(33.3)	2(5.3)

Table 4: Obstetric risk factors of Pregnant Participants with new Incidence of Hypertension, in high and low exposure areas of Port Harcourt metropolis, N=82, n=41.

Parity (LB)	H E n=41 %	NoH n=36 %	Nmt n=5 %	L E n=41 %	NoH N=3 %	Nmt n=38 %
0	1(36.6)	0(0.0)	1(20.0)	2(4.9)	0(0.0)	1(2.6)
1	20(48.8)	18(50.0)	2(40.0)	18(43.9)	1(33.3)	17(44.7)
2	15(36.6)	14(38.9)	1(20.0)	14(34.1)	1(33.3)	13(34.2)
3+	5(12.2)	4(11.1)	1(20.0)	7(17.1)	1(33.3)	6(15.8)
Gravidity Total pregna						
1	15(36.6)	13(36.1)	2(40.0)	()	0(0.0)	14(36.8)
2	18(43.9)	17(42.2)	1(20.0)		1(33.3)	18(47.4)
3	6(14.	5(13.	1(20.		1(33.	4(10.

	6)	9)	0)		3)	5)
4+	2(4.9)	1(2.8)	1(20.0)		1(33.3)	2(5.3)
G.A(weeks) 30-31 wks			31 wks			
28-31	10(24.4)	9(25.0)	1(20.0)	12(29.3)	1(33.3)	11(28.9)
32-35	14(34.1)	12(33.3)	2(40.0)	13(39.0)	1(31.7)	12(31.6)
36-39	17(41.7)	15(41.7)	2(40.0)	16(39.0)	1(33.3)	15(39.5)

HE=High exposure n=41(%), NoH=New onset hypertension n=36(%), Nmt=Normotensive n=5 (%), LE= Low exposure n=41 (%), NoH= New onset hypertension, n=3 (%), Mmt= Normotensive, n=38(%)

Discussion

Table 1 above presents the incidence of hypertension across the various clinics under research. New cases were discovered in the majority of the study participants from surroundings with higher lethal contact and lesser from minimal contact areas, while cases that remained normotensive from high environmentally exposed areas were lower as against higher percentage of normotensive participants from low environmentally exposed areas. It also provides information on urinary protein levels in both regions. The results corroborate with that of Savitri, 2020 whose research aimed at studying socio-demographic characteristics in cases of hypertension in gestation and its related predicting factors in the higher level of health care system (tertiary). In the works, new cases of PIH were discovered to be 8.16% in gravid females participating tertiary hospitals visit with most of the research subjects being rural dwellers. Findings of this present research are however tilted towards gestational hypertension.

Tables 2, 3 and 4 presented above, provide insights into the possible predisposing circumstances that may have aided the development of hypertensive irregularities in both regions of study. For instance, maternal age is a well-documented predisposing factor for hypertensive variations in gestation (Liu et al., 2015), as maternal vascular compliance decreases with age, making older women more susceptible to hypertension. The research findings revealed that in the high-exposure group, new-onset hypertension was more common among women aged 30–34 years and 35–39 years. It also aligns with previous studies by Poon et al., 2019. In contrast, in the low-exposure group, new-onset hypertension was evenly distributed among women aged 25–39 years, with no clear age-related pattern. It can be argued that older women may have had chronic exposure to low levels of toxicants, even at concentrations below regulatory limits, accumulated in the body and heightened the risk of adverse health effects (Dominici et al., 2022) including hypertensive disorders in pregnancy.

Findings of Table 2 and 3 are in agreement with the research of Vinojj et al., 2024. The authors carried out a survey on gravid women in the republic of Suriname. In their work on “Possible risk factors and their potential associations with combined heavy metal exposure in pregnant women in the republic of Surname”. They reported that the determining factors of exposure among pregnant participants were females of low socio-economic status residing in rural areas, advanced maternal age, and a comparatively low level of formal education and monthly household income.

Most of the research participants were classed under lower socioeconomic status based on their level of education and their employment status. A greater proportion of hypertensive females in the high toxicant contact area were illiterate compared to those with higher education, such as postgraduate degrees. Similarly, in the low-exposure group, all hypertensive women had only primary or secondary education, with no cases among those with tertiary or postgraduate education. This trend suggests that lower education levels may contribute to a lack of awareness about hypertension risk factors, poor diet choices, and limited access to quality healthcare, which are critical in preventing pregnancy-induced hypertension. Studies by Aje et al., 2021 have also demonstrated a strong correlation between maternal education and pregnancy outcomes, further supporting the importance of antenatal health education programs.

The occupational status of pregnant women can also be an influencing factor with regard to exposure to stress and lifestyle factors that may contribute to hypertensive disorders. Majority of hypertensive females in both peak and minimal-contact groups were civil servants and housewives.

This suggests that both sedentary lifestyles (common among civil servants) and socioeconomic dependence (observed in housewives) may contribute to the onset of hypertension during pregnancy. Unemployed women also had a relatively high prevalence of hypertension which was more in low exposure areas and may be linked to financial constraints and stress-related factors. Conversely, self-employed women and students had lower rates of hypertension, possibly due to increased physical activity and lower occupational stress. Similar findings have been reported by Odimegwu et al., 2020, who highlighted the role of economic stress in pregnancy-related hypertension.

Marital status and hypertension was also examined, revealing that a high proportion of hypertensive women were married (more in high exposure, than in low exposure areas). This finding suggests that marriage-related stress and partner-related factors may have contributed to hypertension risk. Interestingly, in the low-exposure group, 1 out of 3 hypertensive women was separated or widowed (33.3%), suggesting that psychosocial stress from marital instability might be a contributing factor to hypertensive disorders. Studies by Ghosh et al., 2022 have similarly demonstrated that single or widowed women have a higher risk of developing pregnancy-related hypertension due to reduced emotional and financial support systems.

Parity and gravidity are other significant predictors of hypertensive disorders in pregnancy. Table 4 presented those first-time pregnancies (prim gravidae) had the highest prevalence of new-onset hypertension in high exposure areas than in low exposure areas. This trend is consistent with medical literature, which suggests that null parity is a major risk factor for gestational hypertension due to the maternal vascular system's first-time exposure to pregnancy-induced physiological changes (Roberts et al., 2021). On the other hand, women with multiple previous pregnancies (gravida 4+) had the lowest incidence of hypertension in high exposure areas, as compared to the higher numbers seen in low exposure areas, indicating that multiparty may provide some level of adaptive physiological advantage against hypertensive disorders.

Gestational age and the onset of hypertension was examined also. In the peak-contact group, the highest proportion of hypertensive cases occurred in women at 36–39 weeks' gestation, closely followed by those at 32–35 weeks. The late onset of hypertension suggests the likelihood of gestational hypertension, which is a common complication in high-risk pregnancies. In the low-exposure group, hypertensive cases were more evenly distributed across gestational ages, but the risk remained highest in the third trimester. These findings are in agreement with studies by Steegers et al., 2022 which confirm that hypertensive disorders are more likely to manifest in late pregnancy due to increased circulatory demands and endothelial dysfunction. However, one major limitation of the current research was its inability to examine blood pressure variations across the three trimesters along with urinary protein investigation. As a result, the observed disorder of hypertensive disease during gestation within the age group may be a coincidence.

The outcome of this research analysis underscore the significant role of socio-demographic, socio-economic and obstetric determinants in the development of new cases of hypertension among pregnant women in the metropolis of Port Harcourt .One major limitation of the present research was the limited number of participants enrolled in the study which may have an influence on generalization of the research findings. Given these findings, it is recommended that targeted antenatal care interventions be implemented, particularly for older, less-educated, unemployed, or prim gravid women. Health education programs should focus on lifestyle modifications, early hypertension screening, and environmental risk assessments to reduce the burden of hypertensive disorders in pregnancy.

Conclusion

The study concluded that there was high incidence of hypertension as new cases of hypertension were discovered in majority of the study participants from surroundings with higher lethal contact very few from minimal contact areas, while cases that remained normotensive from high exposure areas were also low as against very high incidence from low exposure areas.

There is therefore a need to urgently introduce routine frequent comprehensive screening for hypertension in public and private health facilities irrespective of parity, gravid status, or gestational age and provide screening tools in order to reduce the detect alterations in these parameters early and make more concerted efforts that are necessary to mitigate environmental risk factors of hypertension in the study area.

Acknowledgement:

Conflict of interest:
The authors declare no conflict of interest.
Financial support:
The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

References

Agrawal, A., & Wenger, N. K. (2020). Hypertension during pregnancy. *Current Hypertension Reports, 22*, 64. https://doi.org/10.1007/s11906-020-01070-0

Amin, K. A., Homeida, A. M., El Mazoudy, R. H., Hashim, K. S., & Garelnabi, M. (2019). Dietary lipids in health and disease. *Journal of Lipids, 2019*, 5729498. https://doi.org/10.1155/2019/5729498

Dominici, F., Zanobetti, A., Schwartz, J., Braun, D., Sabath, B., Wu, X. (2022). Assessing adverse health effects of long-term exposure to low levels of ambient air pollution: Implementation of causal inference methods. *Research Reports Health Effects Institute, 2022*(211), 1–56. PMID: 36193708; PMCID: PMC9530797.

Fraser, A., & Catov, J. M. (2023). Placental syndromes and long-term risk of hypertension. *Journal of Human Hypertension, 37*(7), 671–674. https://doi.org/10.1038/s41371-023-00802-4

Gambelunghe, A., Sallsten, G., Borné, Y., Forsgard, N., Hedblad, B., Nilsson, P. (2016). Low-level exposure to lead, blood pressure, and hypertension in a population-based cohort. *Environmental Research, 149*, 157–163. https://linkinghub.elsevier.com/retrieve/pii/S0013935116301876

Ifenkwe, J. C., Nwanjo, H. U., Nwosu, D. C., Solomon, E. A., & Bot, Y. S. (2018). Heavy metal bioaccumulation and lipid peroxidation damage in residents of a gas flaring community. *International Journal of Advances in Scientific Research and Engineering, 4*(7). https://doi.org/10.31695/IJASRE.2018.32810

Liu, X., Ruan, Y., Liu, Y., & Zhang, W. (2015). Relationship between maternal age and hypertensive disorders in pregnancy. *Zhonghua Yi Xue Za Zhi, 95*(1), 19–22. [In Chinese]. PMID: 25876802.

Min, K. S., Sano, E., Ueda, H., Sakazaki, F., Yamada, K., Takano, M., & Tanaka, K. (2015). Dietary deficiency of calcium and/or iron, an age-related risk factor for renal accumulation of cadmium in mice. *Biological & Pharmaceutical Bulletin, 38*(10), 1557–1563. https://doi.org/10.1248/bpb.b15-00362

National Institute of Environmental Health Sciences. (2024). *Exposure Science*. Retrieved from https://www.niehs.nih.gov/health/topics/science/exposure

Nguyen, H. L., Leermakers, M., Osan, J., Torok, S., & Baeyens, W. (2005). Heavy metals in Lake Balaton: Water column, suspended matter, sediment, and biota. *Science of the Total Environment, 340(1–3),* 213–230. https://doi.org/10.1016/j.scitotenv.2004.07.032

Poon, L. C., Nguyen-Hoang, L., Smith, G. N., Bergman, L., O'Brien, P., Hod, M., ... Jacobsson, B. (2023). Hypertensive disorders of pregnancy and long-term cardiovascular health: FIGO best practice advice. *International Journal of Gynecology & Obstetrics, 1–9.* https://doi.org/10.1002/ijgo.14540

Rana, S., Lemoine, E., Granger, J. P., & Karumanchi, S. A. (2019). Preeclampsia: Pathophysiology, challenges, and perspectives. *Circulation Research, 124(7),* 1094–1112.

Ranaa, M. N., Tangponga, J., & Rahman, M. (2018). Toxicodynamics of lead, cadmium, mercury, and arsenic-induced kidney toxicity and treatment strategy: A mini review. *Toxicology Reports, 5*, 704–713.

Roeters van Lennep, J. E., Tokgözoğlu, L. S., Badimon, L. (2023). Women, lipids, and atherosclerotic cardiovascular disease: A call to action from the European Atherosclerosis Society. *European Heart Journal, 44,* 4157–4173.

Savitz, D. A., Stein, C. R., Elston, B. (2012). Relationship of perfluorooctanoic acid exposure to pregnancy outcome based on birth records in the mid-Ohio Valley.

Environmental Health Perspectives, 120(8), 1201–1207. https://doi.org/10.1289/ehp.1104752

Sazakli, E. (2024). Human health effects of oral exposure to chromium: A systematic review of the epidemiological evidence. *International Journal of Environmental Research and Public Health, 21*(4), 406.

Sears, C. G., Braun, J. M., Ryan, P. H., Xu, Y. Y., Werner, E. F., Lanphear, B. P. (2018). The association of traffic-related air and noise pollution with maternal blood pressure and hypertensive disorders of pregnancy in the HOME study cohort. *Environmental International, 121,* 574–581.

Seely, E. W., & Ecker, J. (2014). Chronic hypertension in pregnancy. *Circulation, 129*(12), 1254–1261. https://doi.org/10.1161/CIRCULATIONAHA.113.003904

Ubong, I. U., Obunwo, C., & Faafa, A. (2016, August). Essential and non-essential metals in soft drinks consumed and sold in Port Harcourt, Nigeria. *RA Journal of Applied Research*, *2*(8). https://doi.org/10.18535/rajar/v2i8.04

Vigeh, M., Yunesian, M., Shariat, M., Niroomanesh, S., & Ramezanzadeh, F. (2011). Environmental carbon monoxide related to pregnancy hypertension. *Women & Health, 51*(8), 724–738.

Wan, E. Y. F., Yu, E. Y. T., Chin, W. Y., Fong, D. Y. T., Choi, E. P. H., & Lam, C. L. K. (2019). Association of blood pressure and risk of cardiovascular and chronic kidney disease in Hong Kong hypertensive patients. *Hypertension, 74,* 331–340. https://doi.org/10.1161/HYPERTENSIONAHA.119.13123

World Health Organization. (2023). *Hypertension*. Retrieved March 19, 2025, from https://www.who.int/news-room/fact-sheets/detail/hypertension.