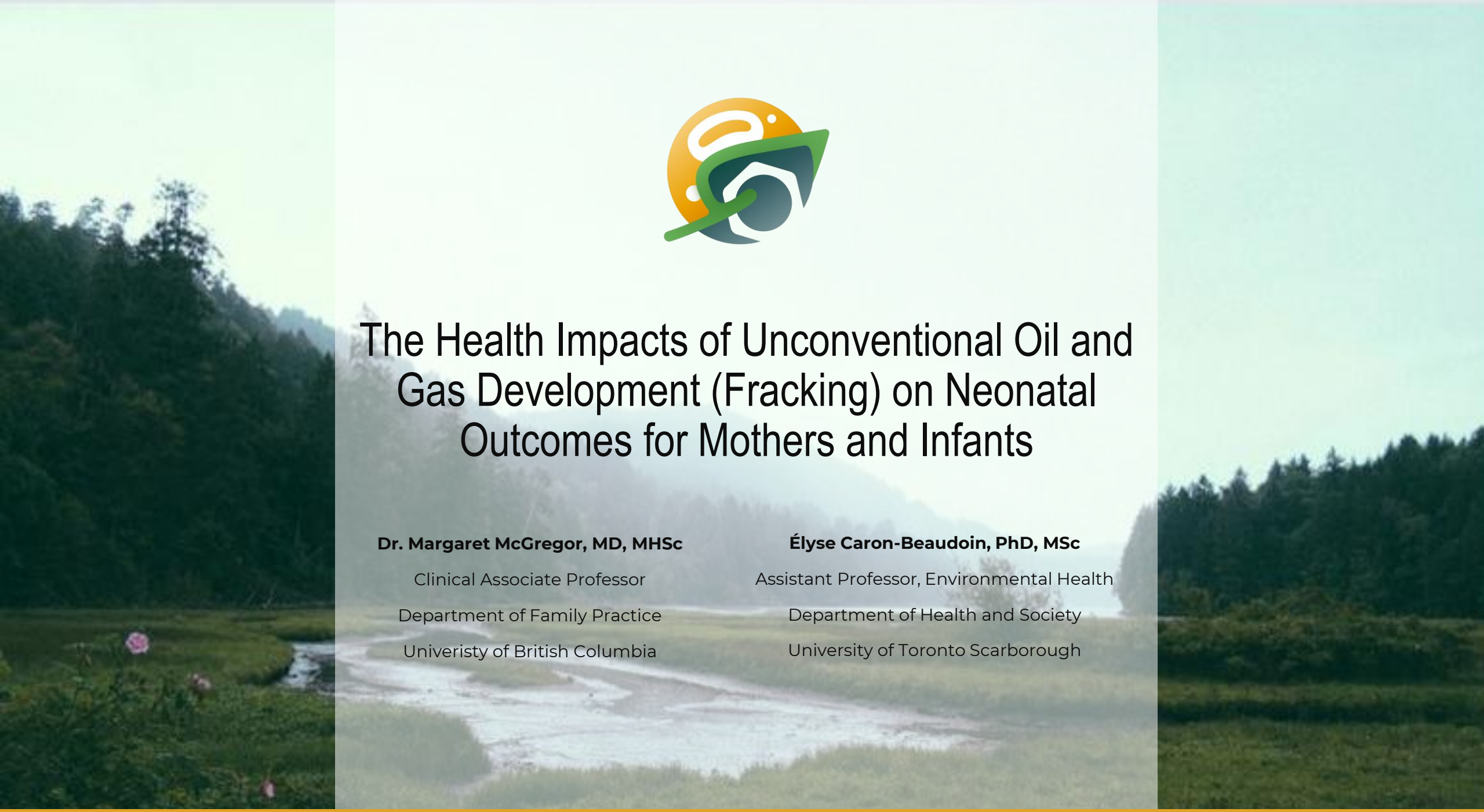

The Health Impacts of Unconventional Oil and Gas Development (Fracking) on Neonatal Outcomes for Mothers and Infants

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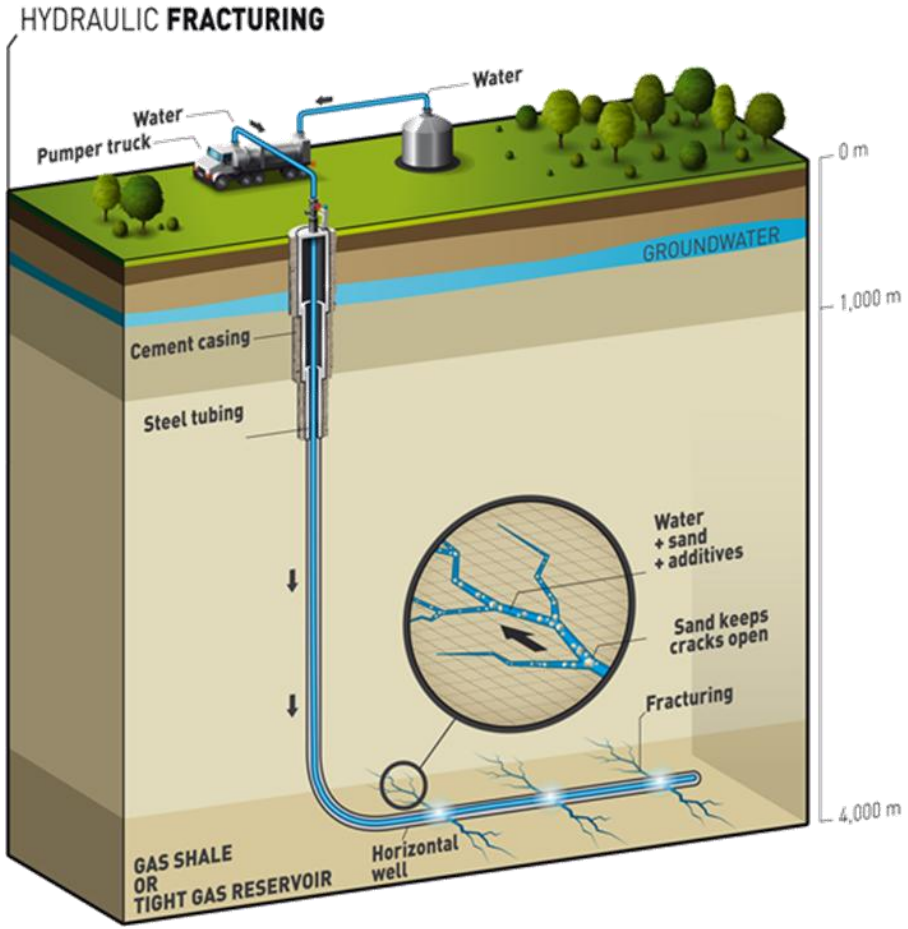
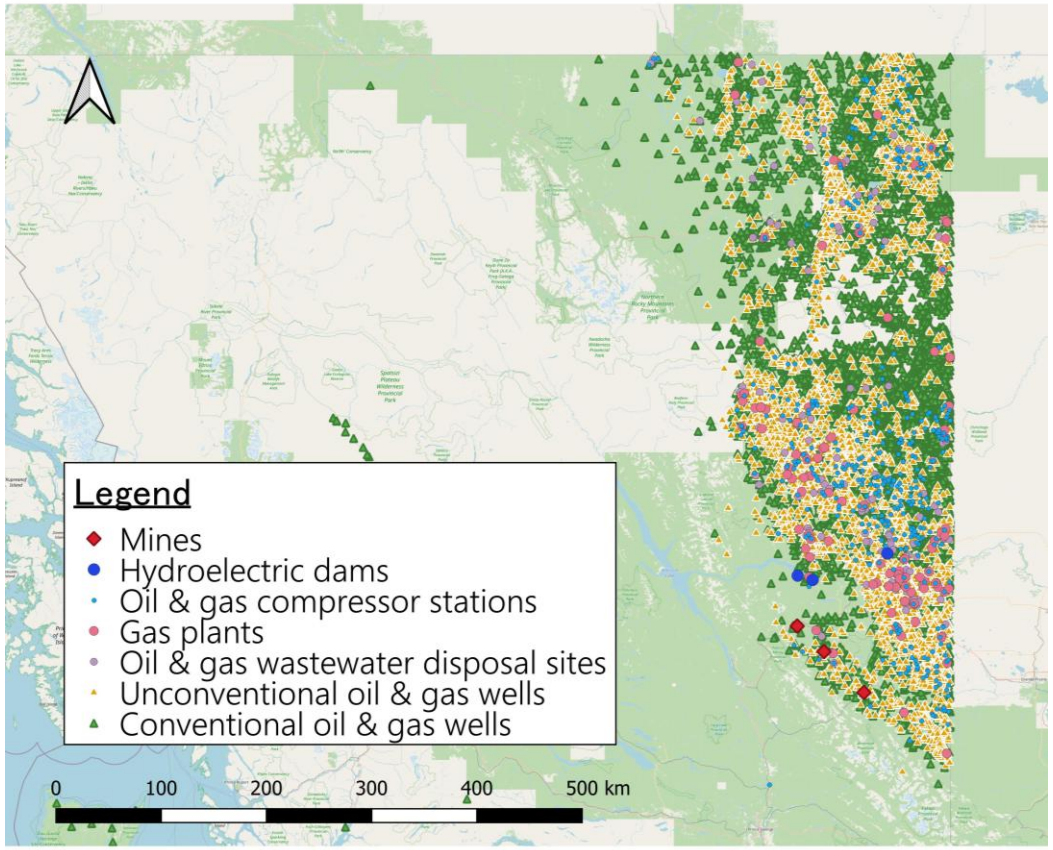
UNCONVENTIONAL OIL AND GAS (UOG)



- **Pad preparation phase:** site preparation activities involving surveys, permit approvals, land or surface access and removal of vegetation
- **Drilling phase:** wells are drilled vertically and then horizontally deep down in the rock formation. Holes are punctured in the horizontal section of the casing
- **Hydraulic fracturing/stimulation phase:** injecting large volumes of fluid (water, sand, chemicals) in rock formation to create fractures, freeing the trapped natural gas
- **Production phase:** natural gas flow free from the shale layers. It is transferred to storage tanks and delivered by pipelines

OIL AND GAS IN BRITISH COLUMBIA



Potential contamination by:

- Volatile organic compounds (VOCs)

References

Crowe *et al.* 2016; Gilman *et al.* 2013; Macey *et al.* 2014; Vengosh *et al.* 2014

- Trace and radioactive elements naturally occuring in the rock formation

References

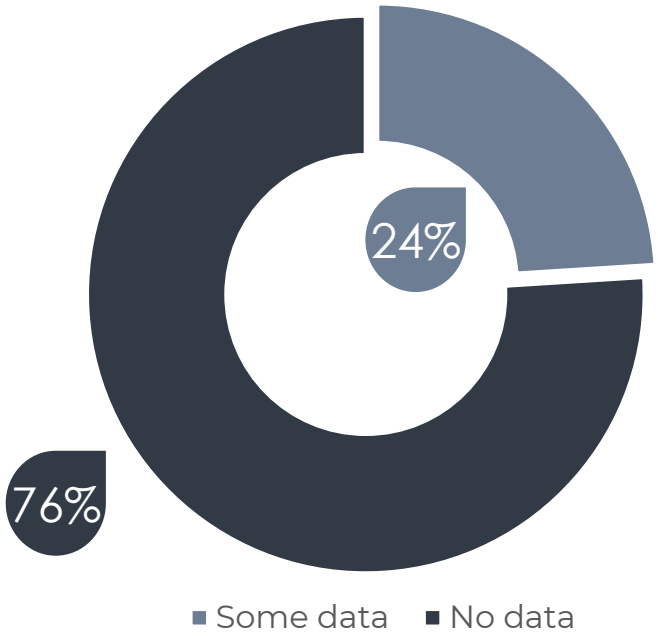
Lester *et al.* 2015; Pichtel 2016, Wisen *et al.* 2019a,b

In British Columbia (BC)

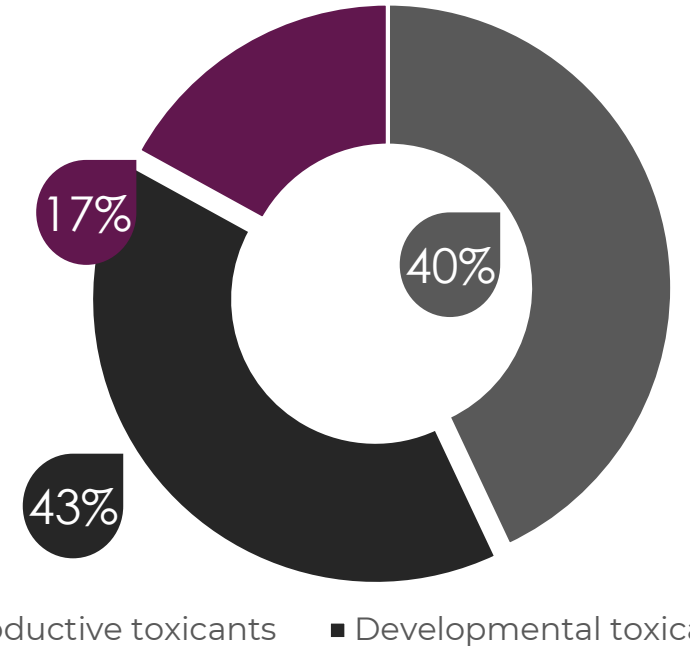
- Montney Formation ≈ 67% of the province's production

SCIENTIFIC LITERATURE: TOXICOLOGY

Toxicological data on chemicals in hydraulic fracturing fluids



Chemicals with toxicological data



Data from Elliott et al. 2016

EXPERIVA

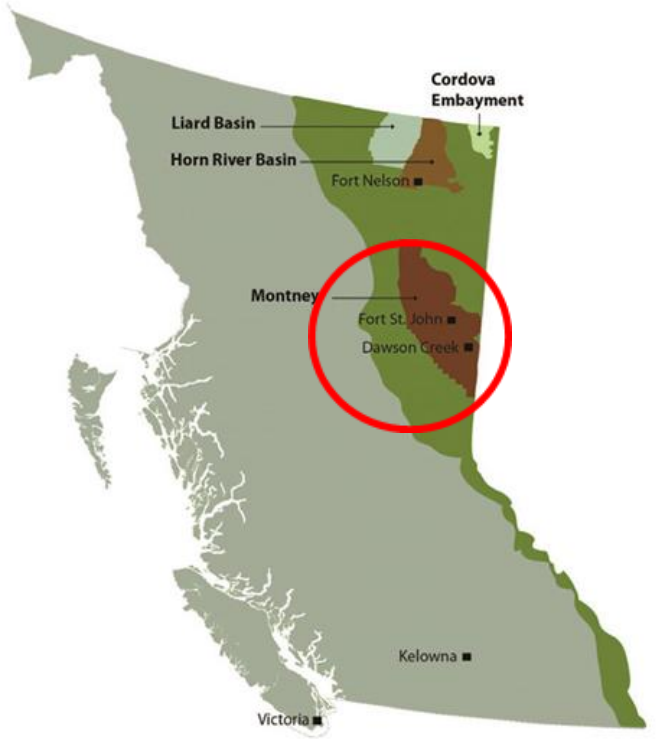
Exposures in the Peace River Valley

Gestational exposure to chemicals related to oil and gas and their potential mechanisms of toxicity in Northeast British Columbia

METHODS

Recruitment

- From May to August 2019
- 3 medical clinics, 1 midwifery clinic
- Treaty 8 Tribal Association, West Moberly and Saulteau First Nations
- Recruited 85 participants
- 90% of pregnant individuals that were met participated



METHODS

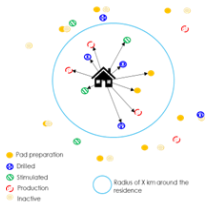
Recruitment
(85 participants)

Questionnaire

Environmental sampling
(indoor air & tap water)

Biomonitoring sampling
(urine, hair, nails)

Oxidative and chronic stress biomarkers
(urine)

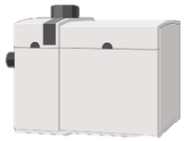


Oil and gas activity metrics
- All wells
- Conventional wells
- UOG wells

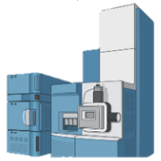
Density of wells around home

Inverse distance weighted (ID^2W) metrics based on proximity of wells to home

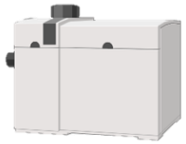
VOCs
(indoor air & tap water)



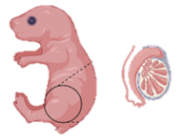
Trace elements
(tap water)

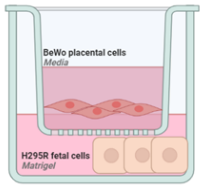


VOC metabolites
(urine)

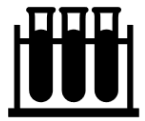


Trace elements
(urine, hair & nails)



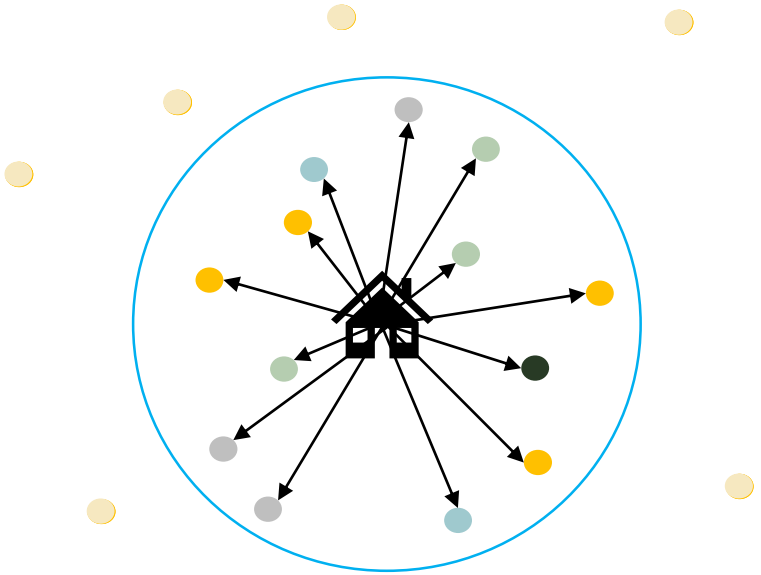


Endocrine disruption potential
(fetal testis & feto-placental cellular model)



Lab-made mixtures
(VOC metabolites & trace elements)

METHODS: OIL & GAS ACTIVITY METRICS



- Wells in pad preparation
- Wells in drilling
- Wells in hydraulic fracturing
- Wells in production
- Conventional wells

Radius of X km around the residence

- IDW method: based on the density and proximity of oil & gas wells to residences or postal codes

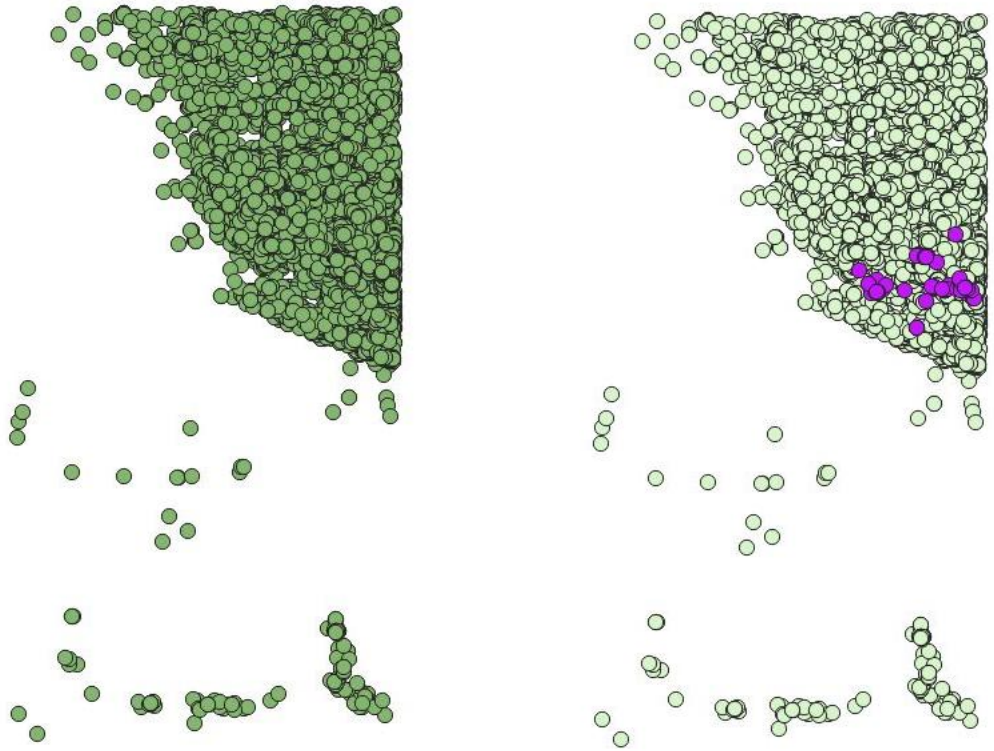
$IDWx = \Sigma^{n}_{i=1} * (1/d^2i)$
X = radius (buffer distance)
i = given well inside the radius
di = distance between a given well and the residence
n= total number of wells inside the radius

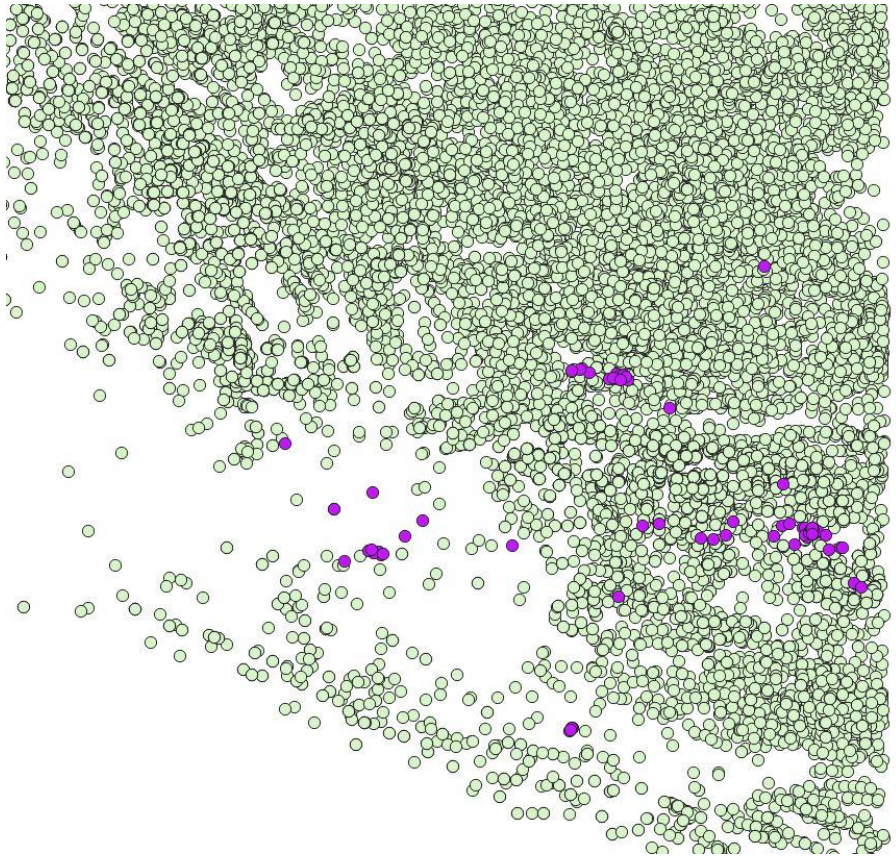
RESULTS: CHARACTERISTICS OF THE PARTICIPANTS

Median age	Indigenous	Median GA	Previous pregnancies
			
29 years old	20%	23 weeks	68%

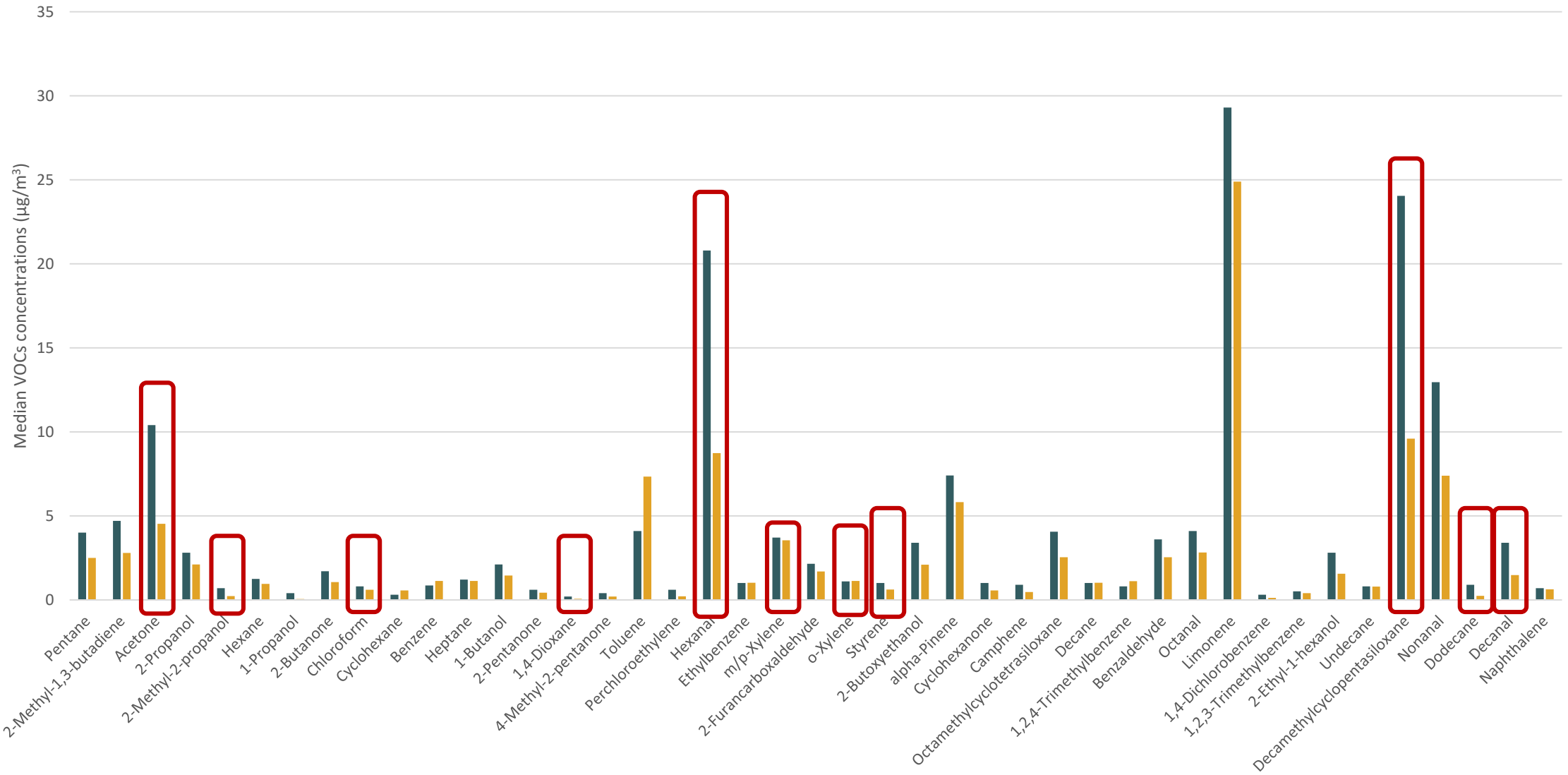
Smoking	Secondhand smoke	Attached garage	City water
			
8%	23%	22%	51%

RESULTS: DENSITY/PROXIMITY OF WELLS



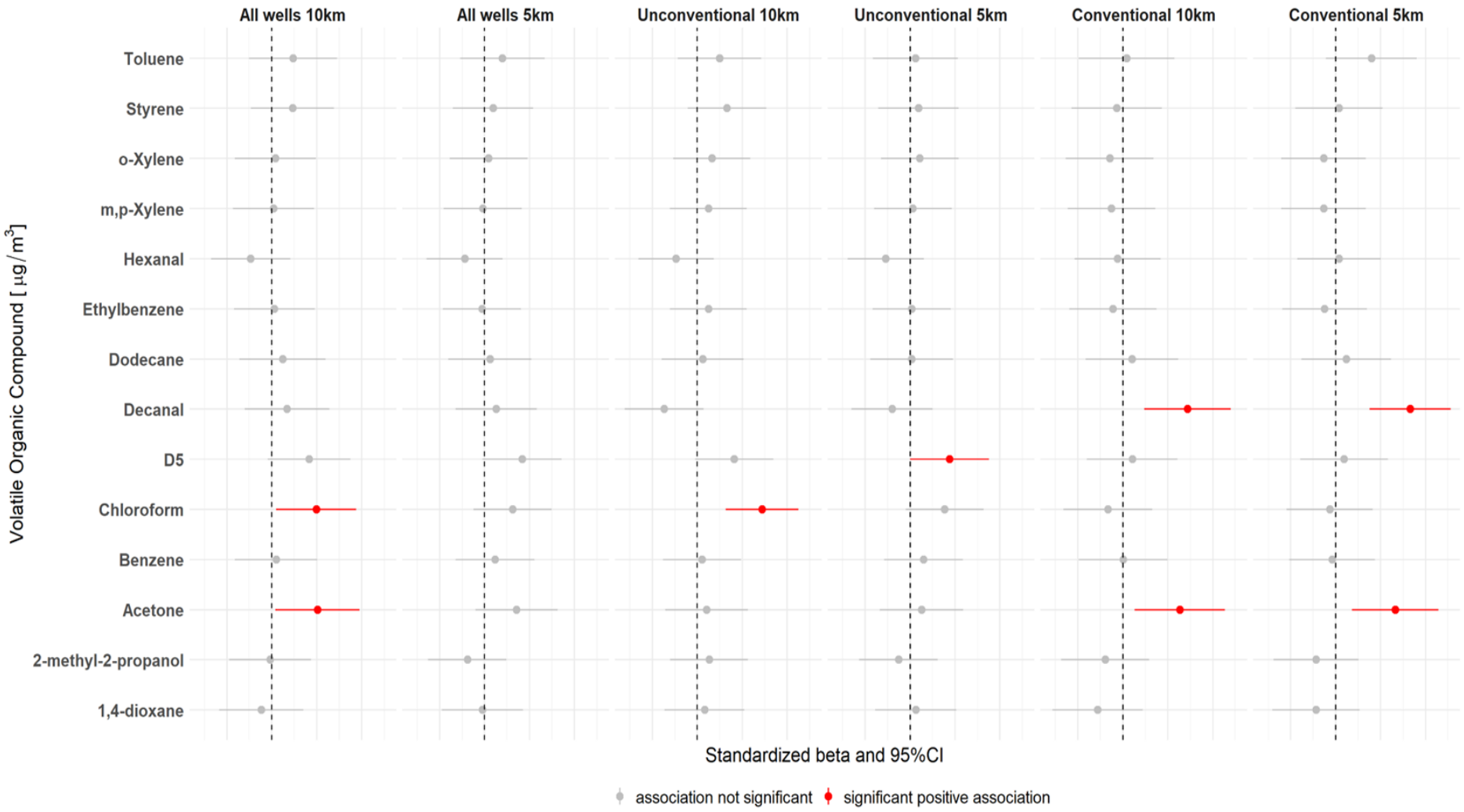


RESULTS: INDOOR AIR VOCs



Caron-Beaudoin *et al. 2021. STOTEN*

RESULTS: ASSOCIATIONS BETWEEN VOC AND OIL & GAS METRICS



Coreen Daley, MEnvSc
PhD candidate

Daley et al., 2025, IJHEH

RESULTS: URINARY TRACE ELEMENTS

Trace elements	EXPERIVA study			CHMS 2nd cycle (women 20–39 years old)		NHANES 9th cycle (women 6–79 years old)	
	Detection frequency (% of all samples)	Median	95th percentile	Median	95th percentile	Median	95th percentile
Aluminum	98	6.82	23.04	NA	NA	NA	NA
Arsenic	100	5.24	41.02	6.60	76.00	5.94	48.20
Barium	98	2.87	13.59	NA	NA	1.39	5.25
Cadmium	98	0.12	0.32	0.34	0.85	0.19	0.92
Chromium	99	0.24	0.76	NA	NA	NA	NA
Cobalt	100	0.88	3.16	0.27	0.89	0.53	1.70
Copper	100	9.17	23.23	9.60	17.00	NA	NA
Gallium	97	0.17	0.63	NA	NA	NA	NA
Iron	100	6.26	19.50	NA	NA	NA	NA
Lead	94	0.20	0.78	0.38	1.10	0.32	1.22
Lithium	100	28.15	94.28	NA	NA	NA	NA
Manganese	70	0.16	0.73	<0.20	0.61	< 0.13	0.64
Nickel	100	1.41	3.77	1.20	3.90	NA	NA
Selenium	100	56.26	121.53	46.00	88.00	NA	NA
Strontium	100	194.88	463.34	NA	NA	109.00	291.00
Thallium	99	0.20	0.41	0.21	0.57	0.19	0.46
Vanadium	96	0.19	0.53	<0.10	<0.10	NA	NA
Zinc	100	215.67	593.79	250.00	540.00	NA	NA

Claustre *et al. 2022. JESEE*

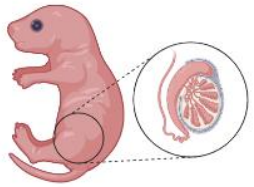
RESULTS: OXIDATIVE STRESS AND ANTIOXIDANT URINARY BIOMARKERS

Exposure Metrics	SOD	GST	CAT	aMT6s	MDA	8-OHdG
All – ID^{2}W no buffer	-0.134	-0.004	0.144	-0.128	0.092	**-0.237***
All - ID^{2}W 10 km	-0.150	-0.020	0.172	-0.142	0.093	**-0.236***
All - ID^{2}W 5 km	-0.153	-0.023	**0.182**†	-0.144	0.089	**-0.242***
All - Density 10 km	-0.118	0.038	-0.032	-0.049	0.080	-0.103
All - Density 5 km	-0.148	-0.007	0.071	-0.119	0.068	**-0.226**†
UOG - ID^{2}W no buffer	**-0.228***	-0.017	0.115	-0.146	0.030	**-0.281***
UOG - ID^{2}W 10 km	**-0.224***	-0.028	0.142	-0.163	0.038	**-0.290***
UOG - ID^{2}W 5 km	**-0.218***	-0.031	0.152	**-0.173**†	0.043	**-0.299***
UOG - Density 10 km	**-0.196**†	0.034	-0.052	0.006	0.003	-0.075
UOG - Density 5 km	-0.184	-0.013	0.063	-0.099	0.019	**-0.205**†

Matthew Day, MEnvSc
PhD candidate

Day et al., 2024. Tox Sci

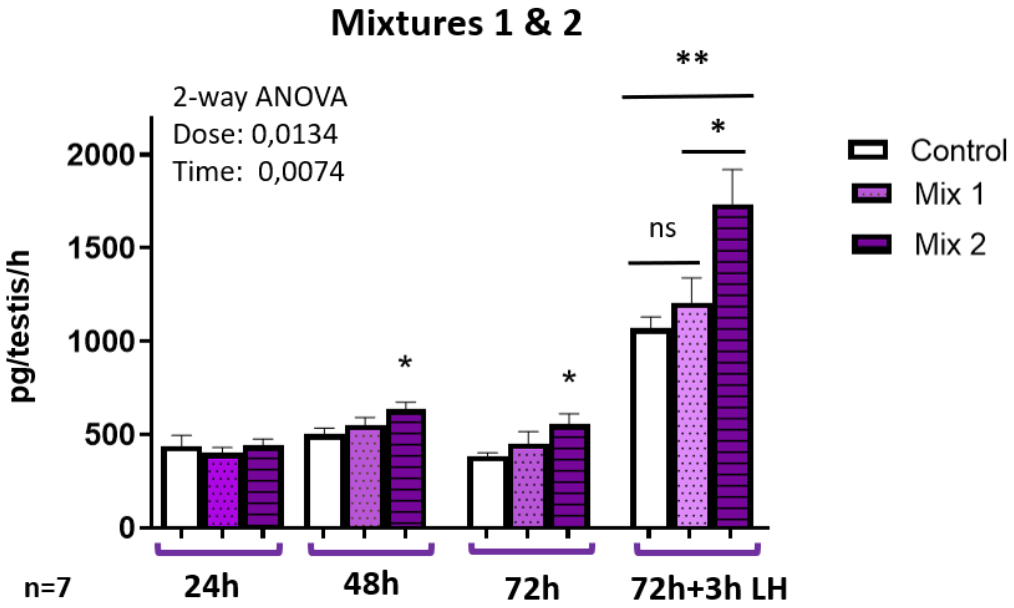
RESULTS: ENDOCRINE DISRUPTION BY TRACE ELEMENTS



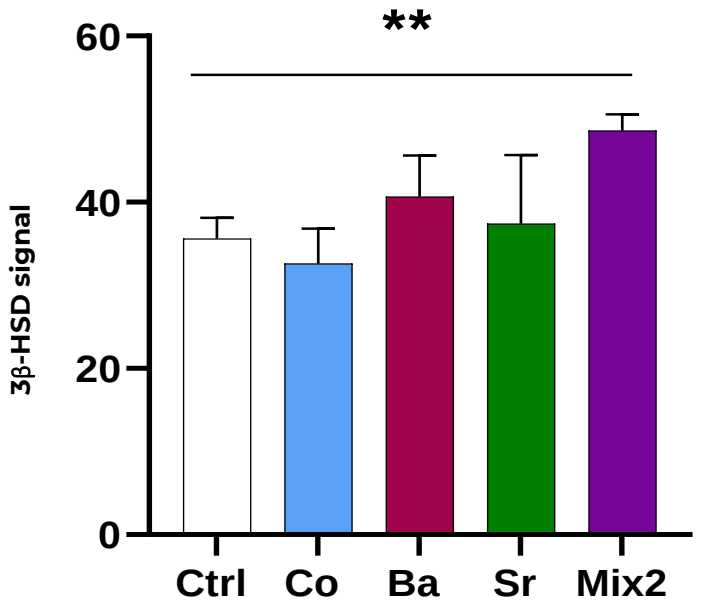
Mixture of the 5 elements increased testosterone secretion at the mid-range concentrations

Ghida Balbaaki, MSc
PhD candidate

Testosterone secretion



3β-HSD expression level



Mix1 : Mixture of the 5 trace elements (aluminum, manganese, barium, cobalt & strontium) at the lowest concentration of each (5 ug/l for Mn, Sr, Al, Ba and 0.05 ug/l for Co))
Mix2 : Mixture of the 5 trace elements at the mid-range concentration of each (50 ug/l for Mn, Sr, Al, Ba and 0.5 ug/l for Co))

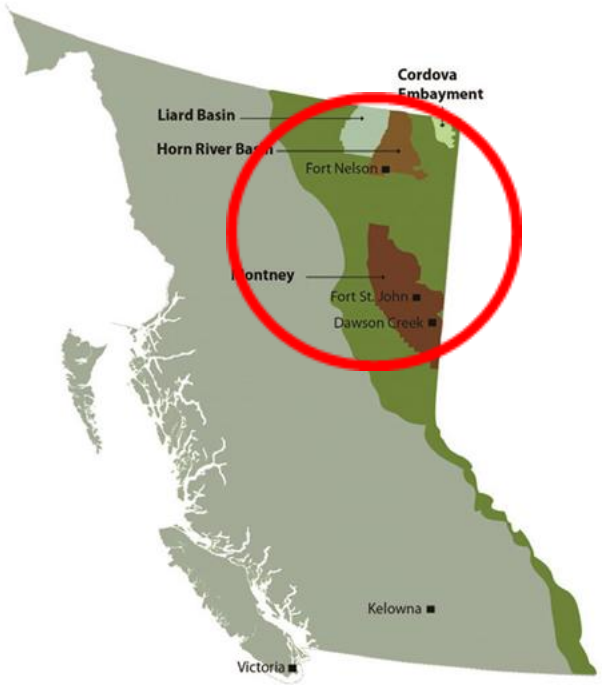
Balbaaki et al., 2024. Environmental Pollution

EPIDEMIOLOGICAL STUDIES

Proximity and density of oil and gas wells
and birth/maternal outcomes in Northeastern British Columbia

OBJECTIVE

To evaluate associations between maternal residential proximity to oil and gas wells and birth outcomes using birth records from the Fort St John hospital between January 1 2007 to December 31 2016

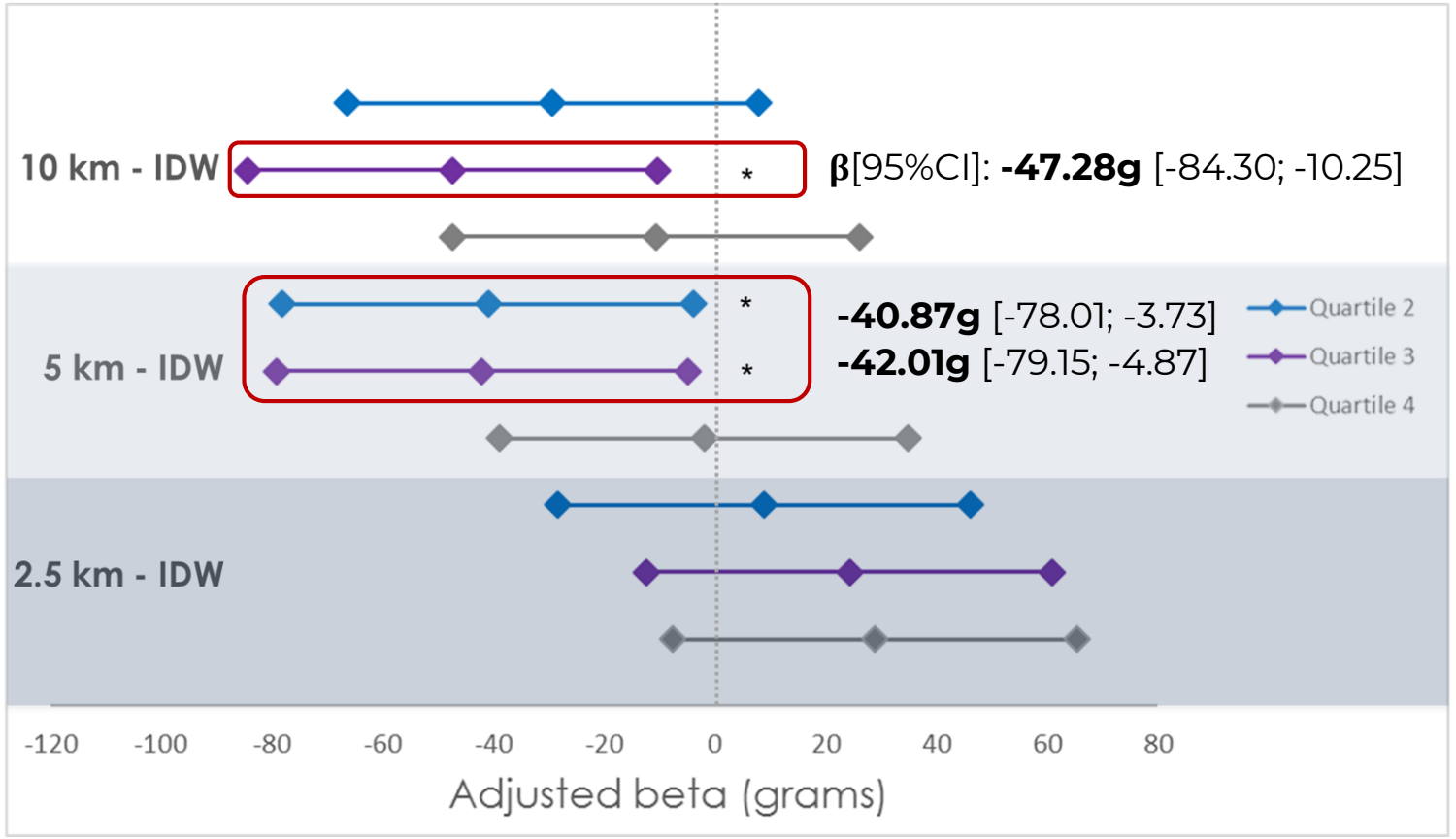


RESULTS: CHARACTERISTICS OF BIRTH COHORT

Previous pregnancies	Smoking	SGA	Preterm birth
			
58%	12%	Yes:10% ?: 1087	Yes: 4% ?: 1087

RESULTS: BIRTHWEIGHT

Adjusted beta coefficients for the association of well density/proximity metrics and **birthweight**

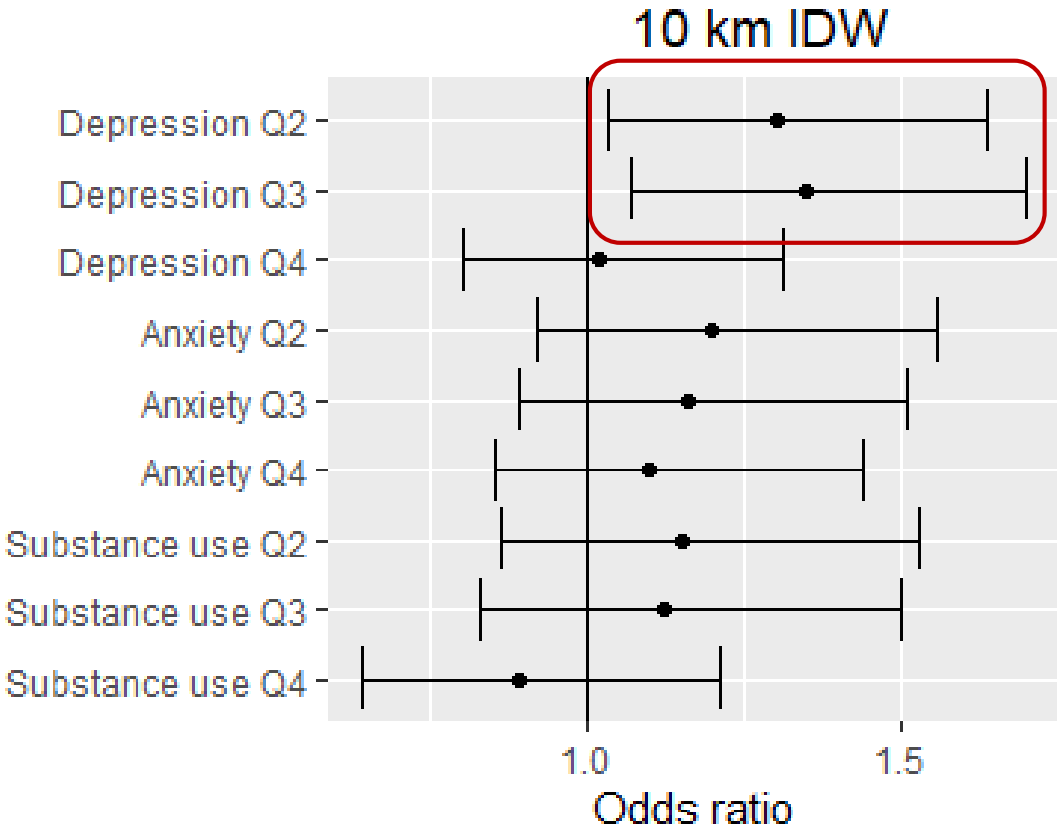


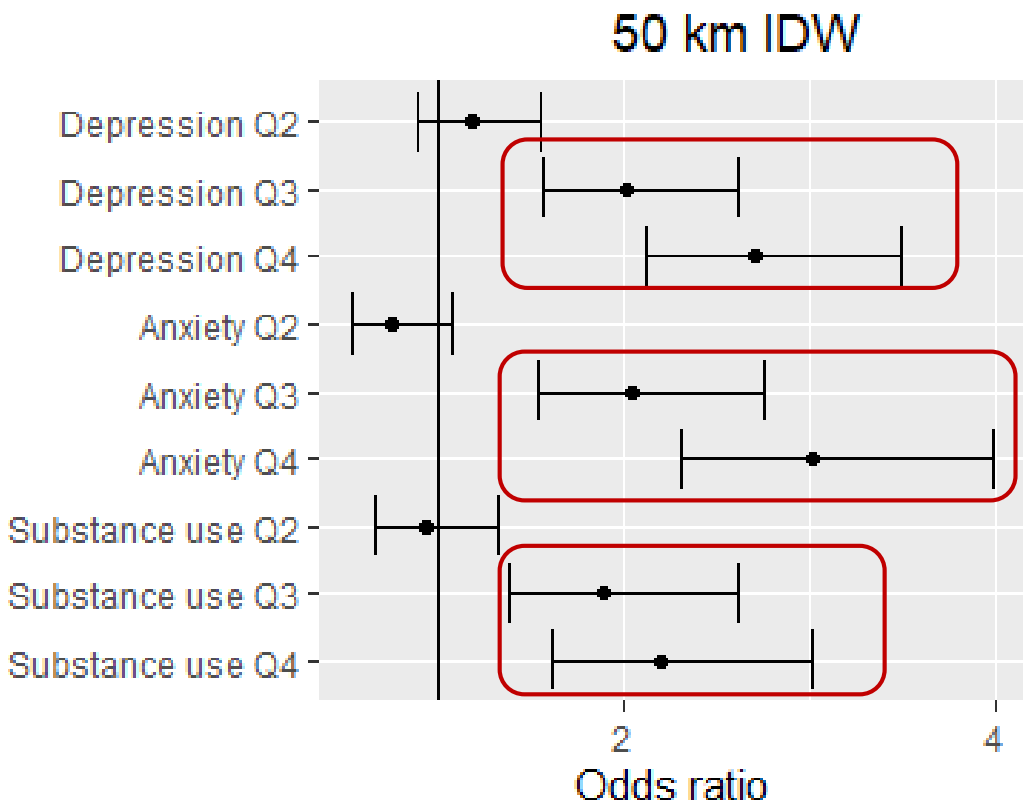
Adjusted for parity, infant's sex assigned at birth, mother's age and smoking
Full-term singleton birth in the Fort St John hospital, BC, Canada, from January 1 2007 to December 31 2016 (n=5018)
* p-value < 0.05

Caron-Beaudoin *et al. 2020. JESEE*

RESULTS: MATERNAL MENTAL HEALTH AND SUBSTANCE USE

Adjusted odds ratio for the association of well density/proximity metrics and maternal depression, anxiety and substance use





Adjusted for maternal age at delivery, parity, and smoking
Full-term singleton birth in the Fort St John hospital, BC, Canada, from January 1 2007 to December 31 2016 (n=5018)
* p-value < 0.05

Aker et al.. 2022. IJHEH

CONCLUSIONS

- Epidemiological and toxicological literature suggests risk for poorer birth and maternal outcomes.
- Important lack of data on exposure assessment and mechanisms of toxicity
- Evidence of higher exposure levels to VOC and trace elements in the EXPERIVA study participants compared to the general Canadian population
    - Preliminary evidence that density and proximity of oil and gas wells contribute to the residential levels of VOC
- Density and proximity of oil and gas wells was associated with altered antioxidant urinary markers
- Mixtures of trace elements at concentrations similar to EXPERIVA induce endocrine disruption in lab-based models

NEXT STEPS

ONGOING EPIDEMIOLOGICAL STUDIES

- **To evaluate associations between maternal residential proximity to phase-specific oil and gas activity and:**
  - Preterm birth and birthweight
  - Apgar scores
  - Congenital disorders

Coreen Daley, MEnvSc
PhD candidate

Jannie Leung, MSc
PhD candidate

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CIHR IRSC
Canadian Institutes of Health Research
Instituts de recherche en santé du Canada

NSERC CRSNG

SSHRC CRSH
Social Sciences and Humanities Research Council of Canada
Conseil de recherches en sciences humaines du Canada

Fonds de recherche Santé Québec

DATA SCIENCES INSTITUTE

UNIVERSITY OF TORONTO

TREATY 8 TRIBAL ASSOCIATION
LIVING IN HARMONY WITH NATURE

Saulteau FIRST NATIONS

WEST MOBERLY FIRST NATIONS

TEAM

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- Saulteau First Nation
- Treaty 8 Tribal Association
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- Marianne Hatzopoulou, UofT
- Heather MacLean, UofT
- Amira Aker, Boston U
- Margaret McGregor, UBC
- Tim Takaro, SFU
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- Mary Kang, McGill
- Lisa Ronald, C2E2
- Ulrike Meyer, UBC
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- Romain Chesnaux, UQAC
- Miranda Doris, UofT
- Jad Zalzal, UofT
- Jannie Leung, UTSC
- Coreen Daley, UTSC
- Matthew Day, UTSC
- Yifan Wu, UTSC
- Ghida Balbaaki, INRS
- Sonje Juul, UCalgary

THANK YOU!

MERCI !

FROM BENCH
TO COMMUNITIES
LAB

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