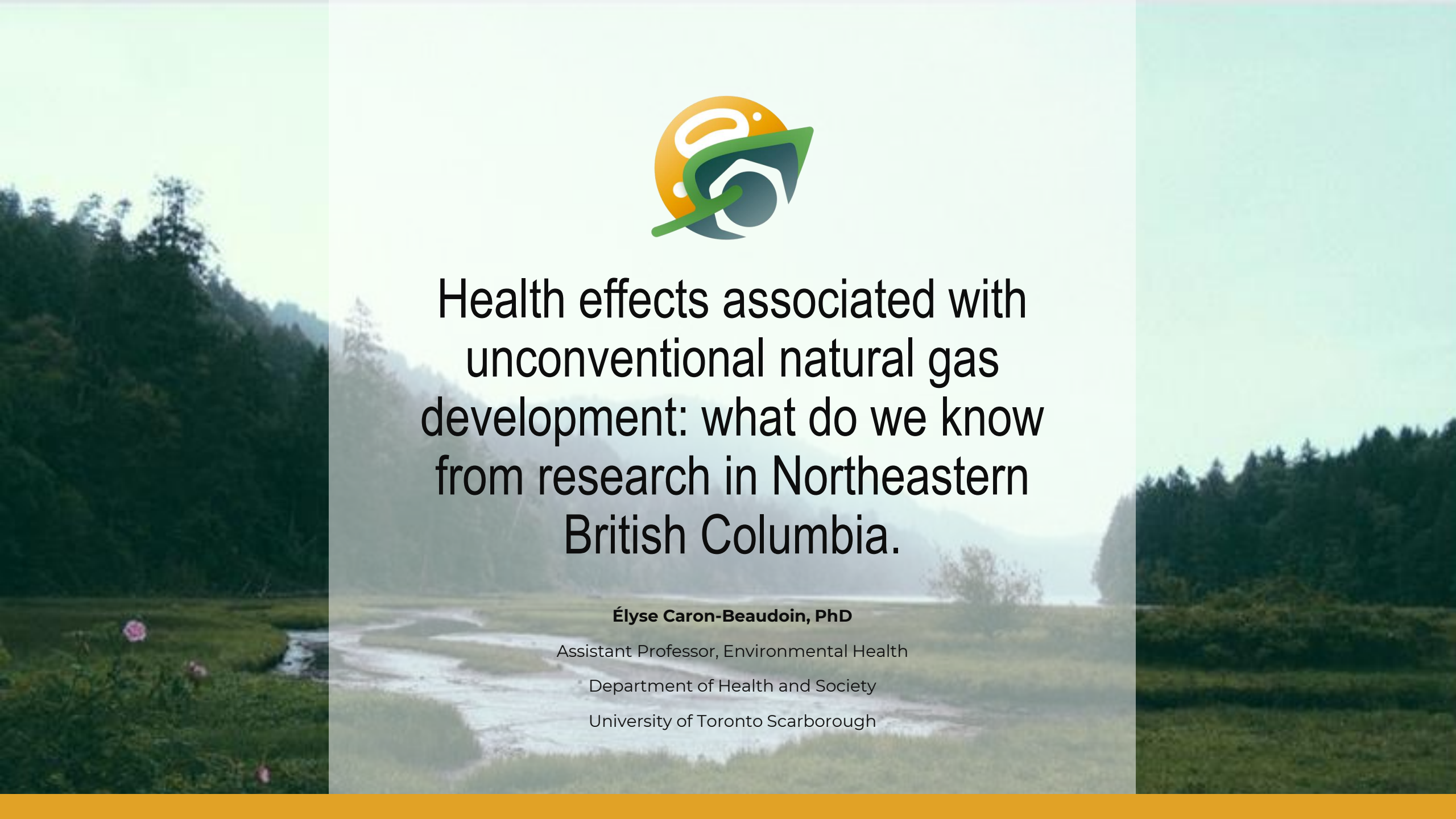

Health effects associated with unconventional natural gas development: what do we know from research in Northeastern British Columbia.

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University of Toronto Scarborough

DISCLOSURE

I have no actual or potential conflict of interest
in relation to this presentation.

FROM BENCH TO COMMUNITIES LAB

Develop customized research strategies to identify potential environmental factors associated with health issues observed by community partners

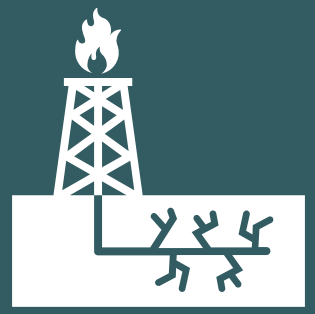
Investigate the prevalence and incidence of health issues identified by community partners

Develop and / or use cellular bioassays to study the biological mechanisms involved in the development/progression of health issues identified by community partners

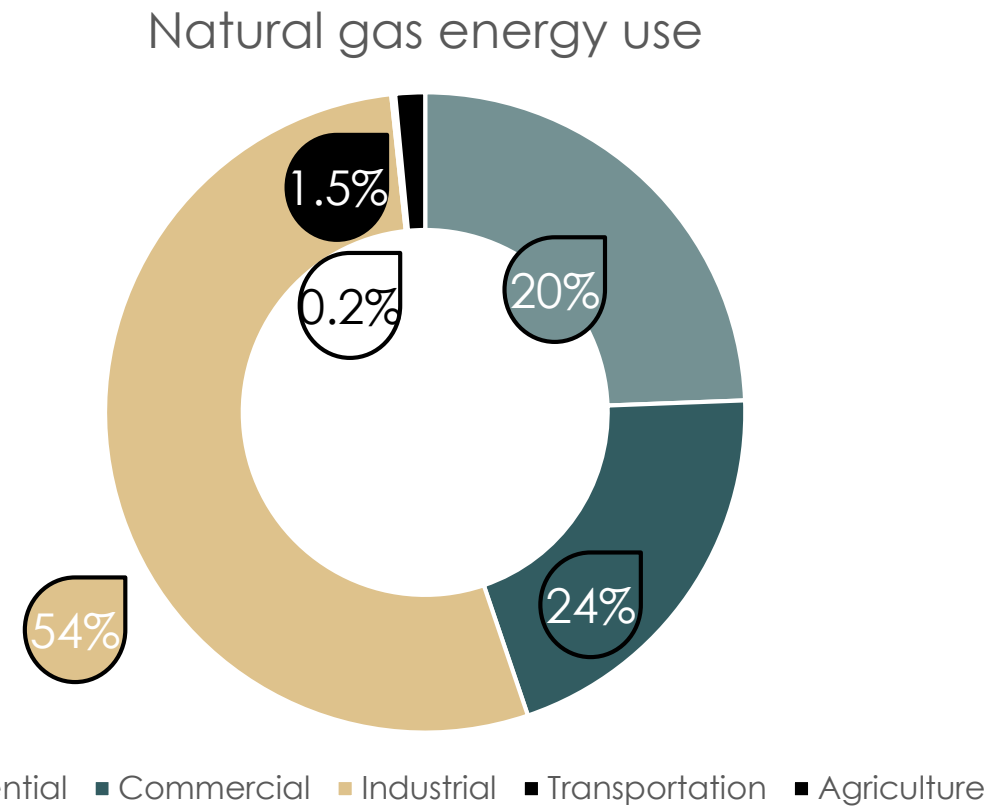
Contribute to adequate environmental & public health policies by collaborating with regulatory agencies

FROM BENCH TO COMMUNITIES LAB: RESEARCH AXES

UNCONVENTIONAL NATURAL GAS (UNG)



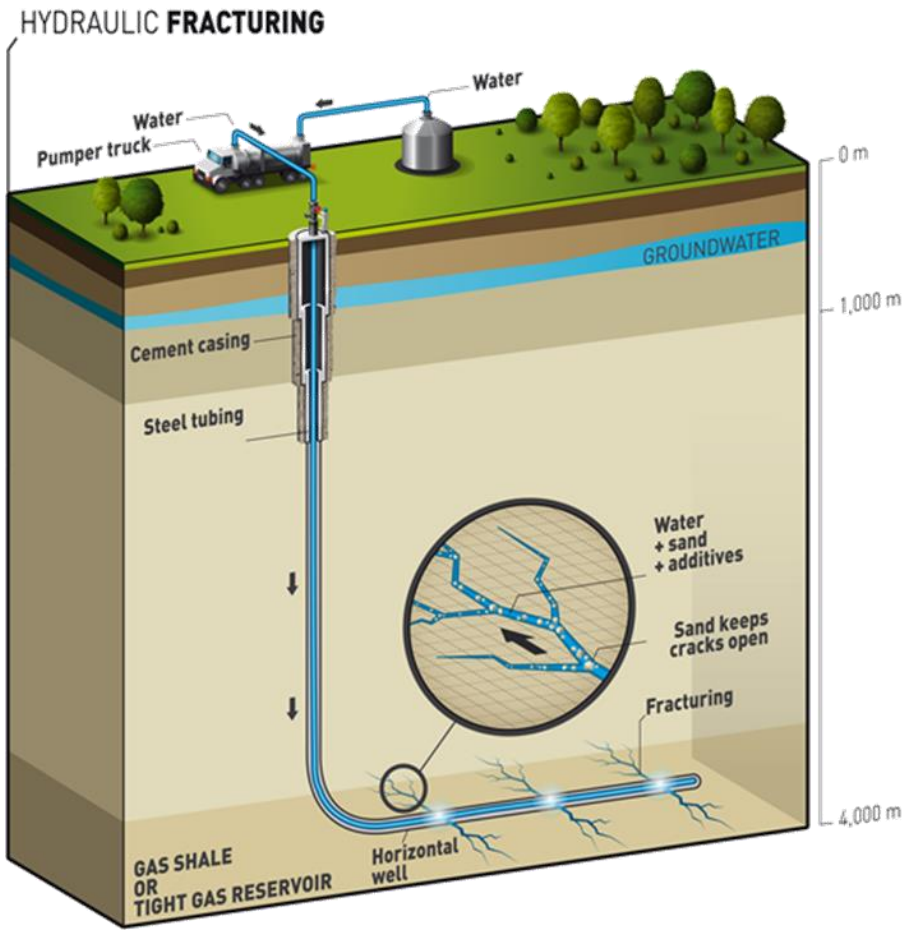
NATURAL GAS IN CANADA



- **Composed primarily of methane**
- **Canada = 4th largest producer**

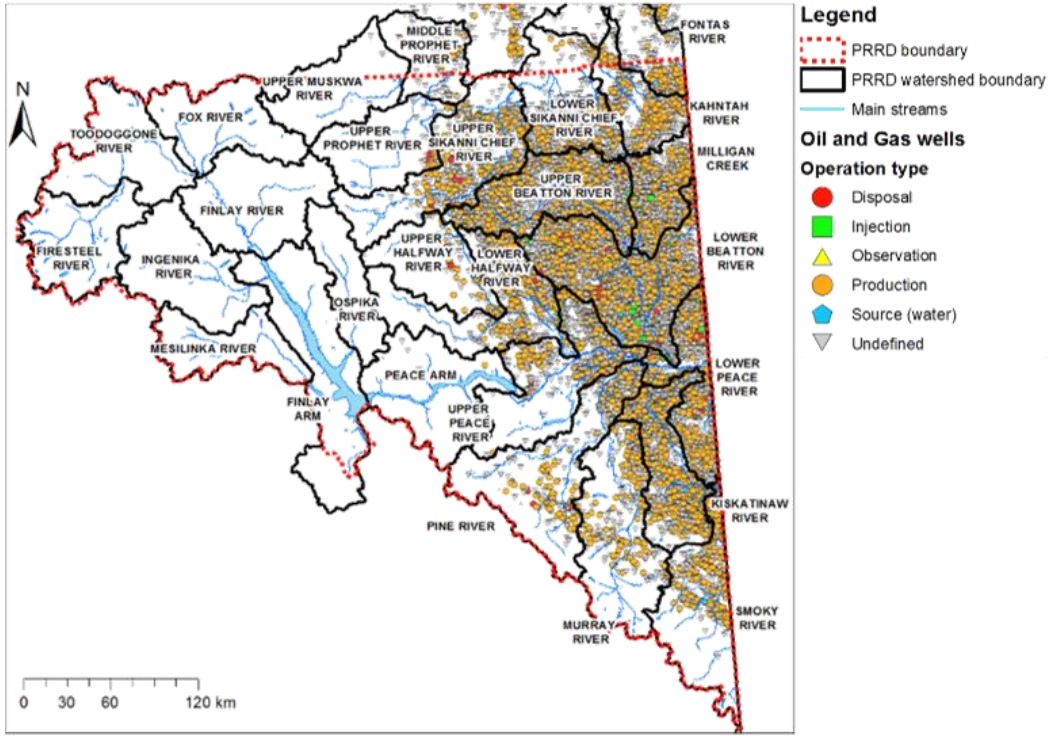
Data from Natural Resources Canada: https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/electricity-facts/200687

UNG & HYDRAULIC FRACTURING



- **Drilling phase:** wells are drilled vertically and then horizontally deep down in the rock formation
- **Completion phase:** perforating gun loaded with explosives charges punctures holes in the horizontal section of the casing
- **Fracking phase:** injecting large volumes of fracking fluid (water, sand, chemicals) in rock formation to create fractures, freeing the trapped natural gas
- **Flowback phase:** fracking fluid flows back out of the well and is taken for disposal or treatment
- **Production phase:** natural gas flow free from the shale layers. It is transferrred to storage tanks and delivered by pipelines

UNG



Map from GW Solutions 2016

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

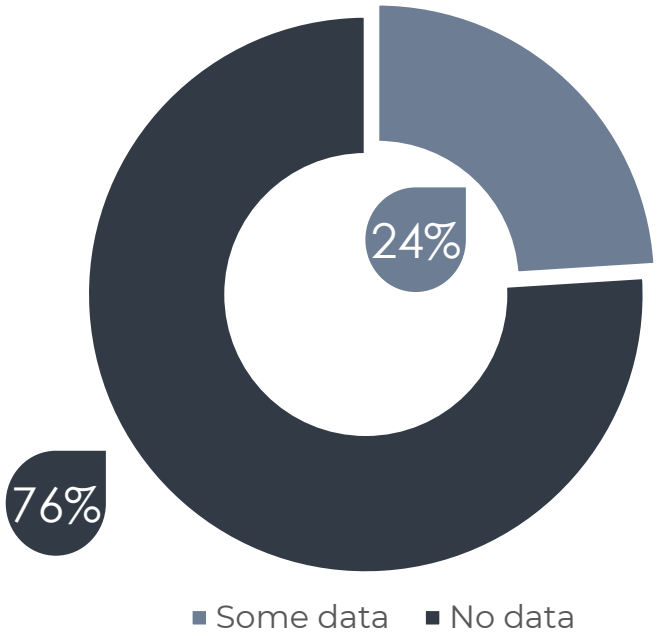
Lester *et al.* 2015; Pichtel 2016, Wisen *et al.* 2019a,b

In British Columbia (BC)

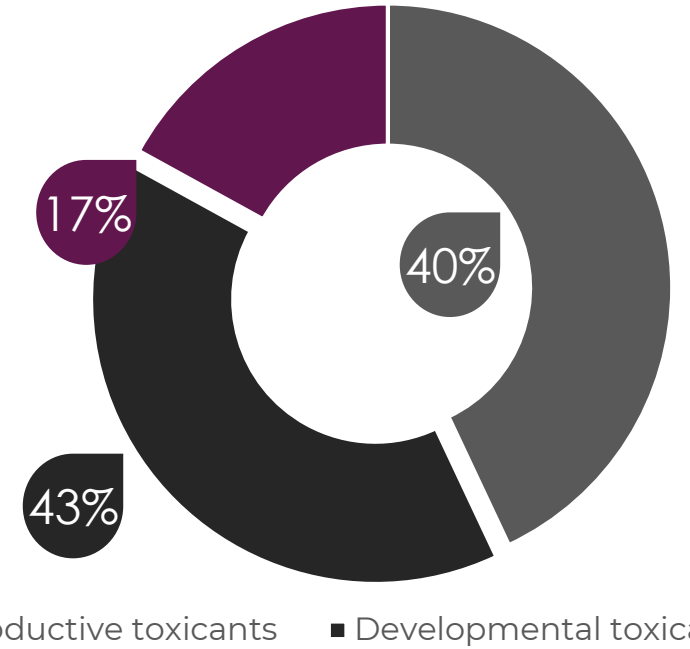
- Montney Formation ≈ 67% of the province's production

SCIENTIFIC LITERATURE: TOXICOLOGY

Toxicological data on chemicals in hydraulic fracturing fluids



Chemicals with toxicological data



Data from Elliott et al. 2016

SCIENTIFIC LITERATURE: BIRTH OUTCOMES

Literature is inconsistent

Birthweight

Study	Description	Effect
Casey et al. 2016	Mean difference in birthweight (95% CI) for highest vs lowest exposed group	-31 grams (-57; -5)
McKenzie et al. 2014	Mean difference in birthweight (95% CI) for highest vs lowest exposed group	+ 22 grams (15; 29)
Stacy et al. 2015	Mean difference in birthweight for highest vs lowest exposed group	- 21 grams

Bold: reached statistical significance

PILOT STUDY

Gestational exposure to environmental contaminants associated with UNG in Northeastern British Columbia

Publications

Caron-Beaudoin et al., 2019 JESSE (1)

Caron-Beaudoin et al., 2017 Environment International. 110:131-138

FUNDING AND SUPPORT

- PI: Marc-André Verner
- Universite de Montreal – Public Health Research Institute($15,000) & West Moberly First Nations ($5,000)
- 2 medical clinics

IRSPUM

Research team

Treaty 8 Tribal Association – Living in Harmony with Nature

West Moberly First Nations

ESPUM – L'école de santé publique de l'Université de Montréal

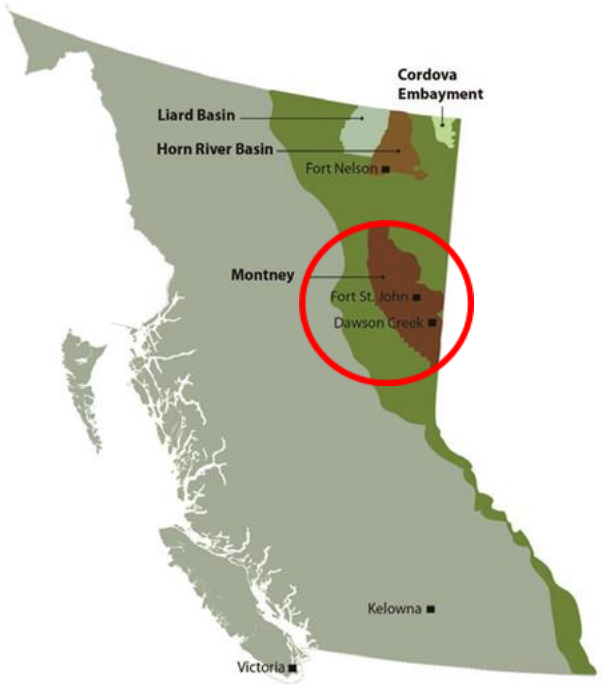
McGill University

Saulteau First Nations

Université Laval

OBJECTIVE

To evaluate gestational exposure to volatile organic compounds (VOCs) and trace elements in Northeastern British Columbia

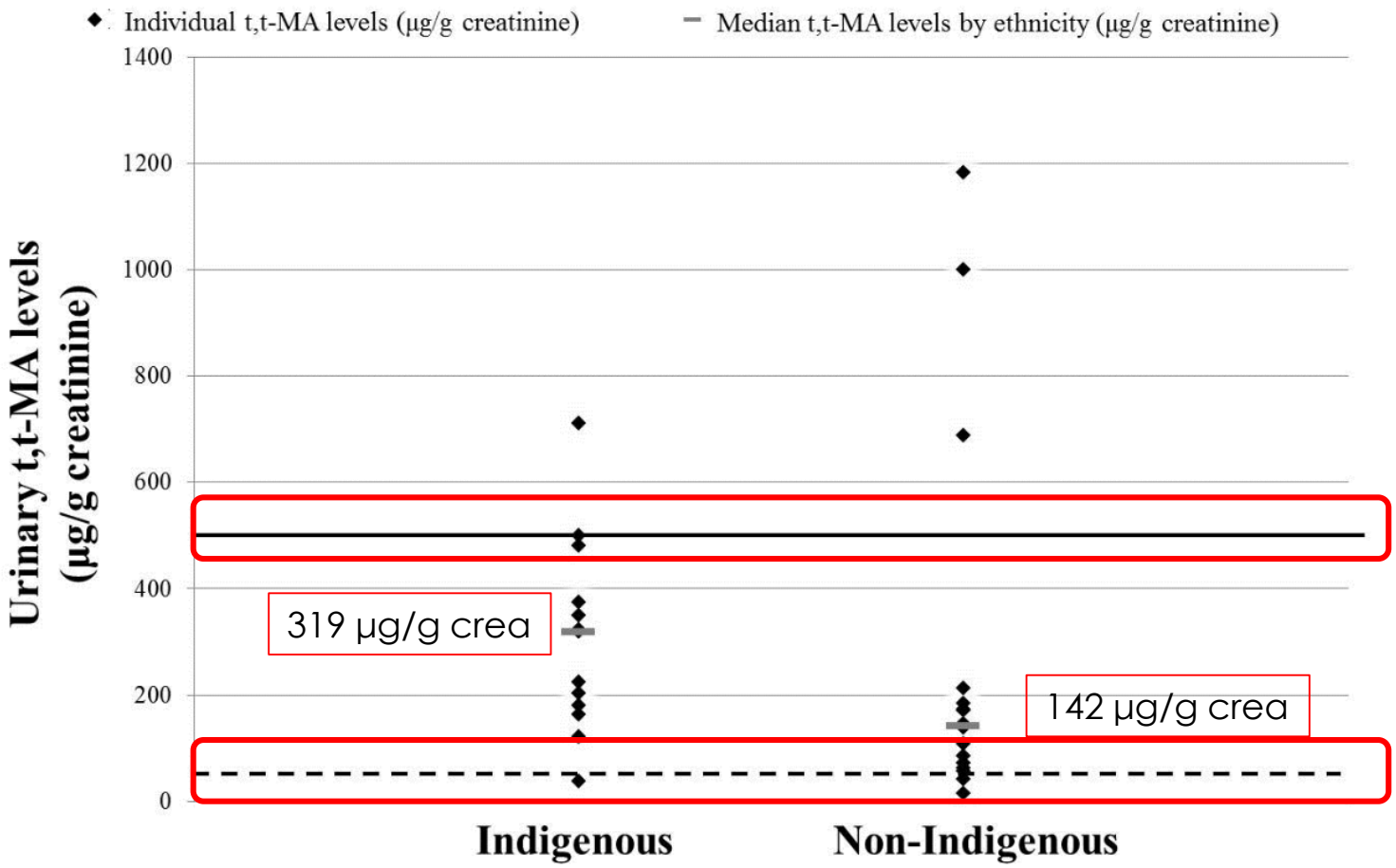


RESULTS: VOC METABOLITES

	Benzene metabolites	
	S-PMA (µg/g creatinine)	t,t-MA (µg/g creatinine)
Dawson Creek and Chetwynd, BC (this study)	Median: 0.18 10th percentile: 0.09 95th percentile: 0.74 n=29	Median: 180 10th percentile: 53.3 95th percentile: 899 n=29
CHMS cycle 3[a]	Median: 0.14 10th percentile: <LOD 95th percentile: 5.10 n=1248	Median: 51.0 10th percentile: 19.0 95th percentile: 460 n=1260

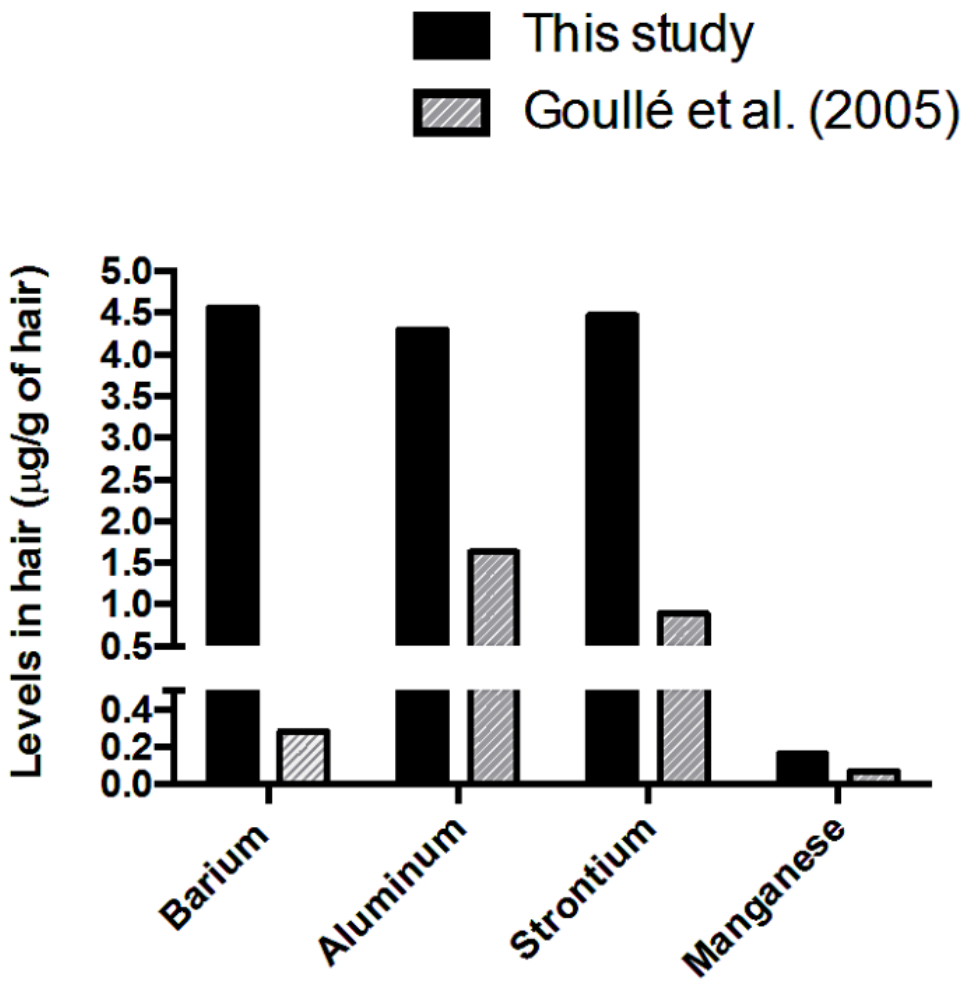
[a]Measured levels in women aged from 3 to 79 years old (Health Canada, 2015)

RESULTS: VOC METABOLITES



Caron-Beaudoin *et al.* 2018. *Environment International*

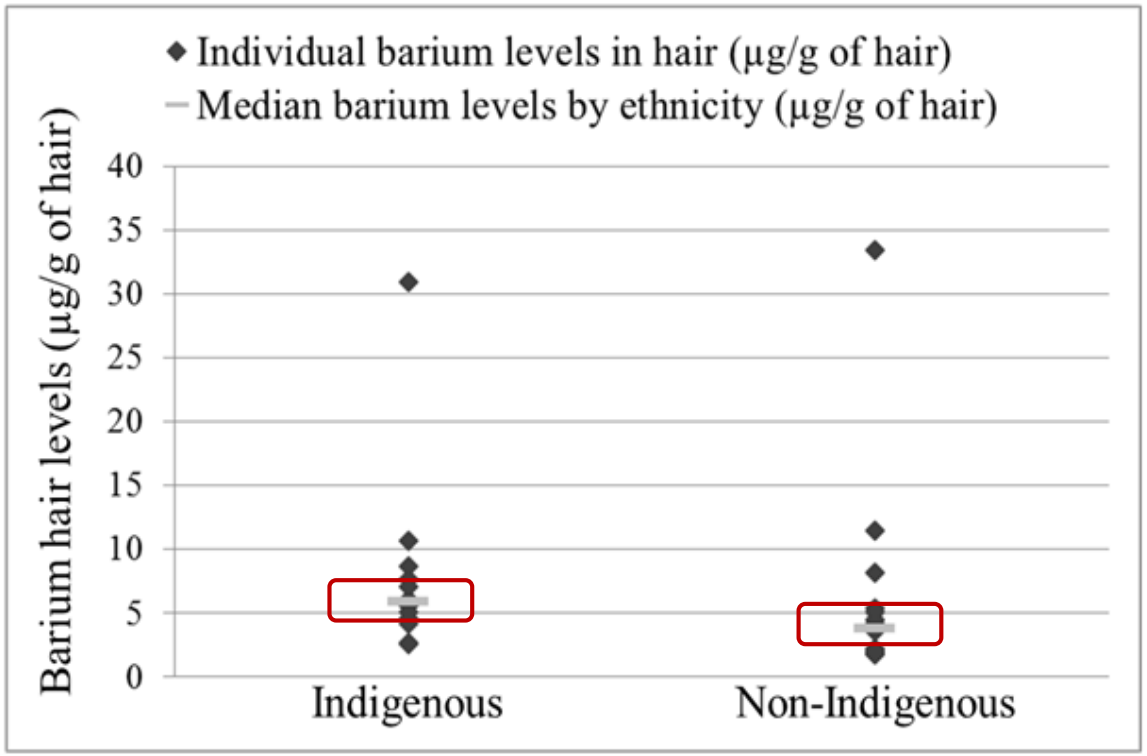
RESULTS: TRACE ELEMENTS



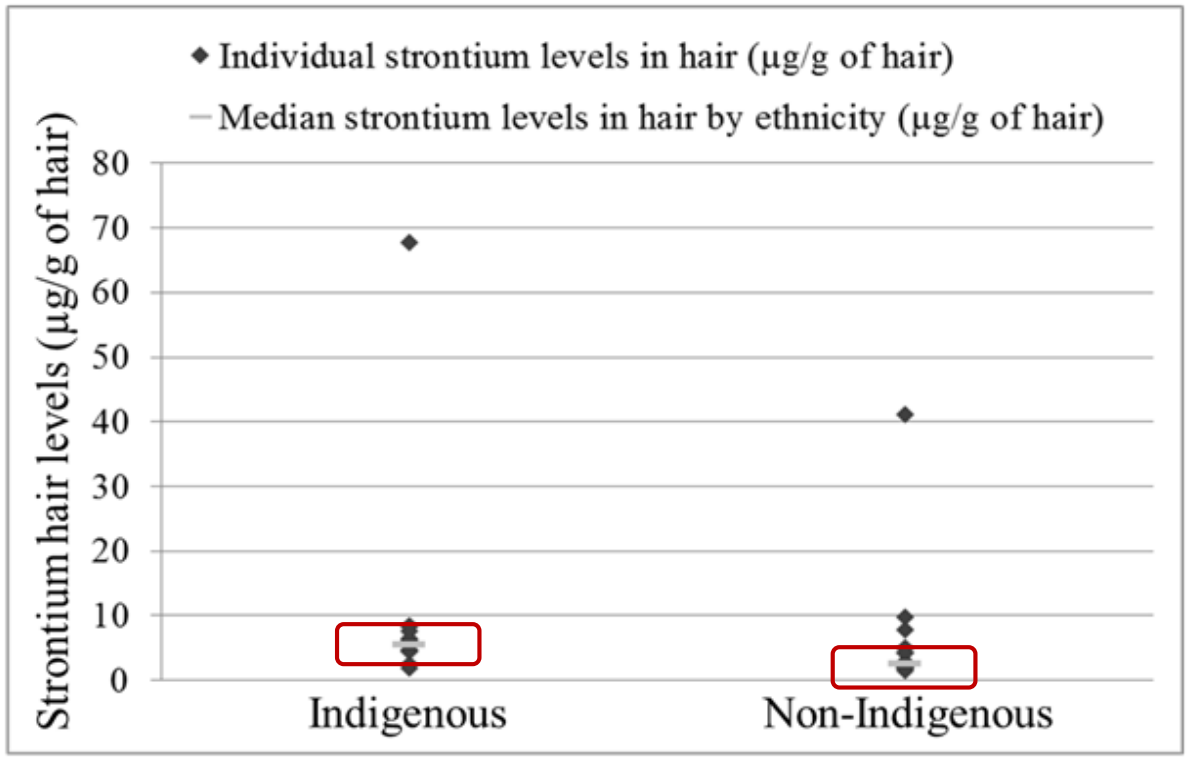
Caron-Beaudoin *et al.* 2019. *JESEE*

RESULTS: TRACE ELEMENTS

Barium



Strontium



Caron-Beaudoin *et al.* 2019. *JESEE*

LIMITATIONS

- Small number of participants
- Urinary t,t-MA not specific to benzene: transformed food containing sorbic acid
- No VOCs and trace elements data in participants' environment
- Reference population for trace elements = different baseline exposure

CONCLUSIONS

- Median level of **t,t-MA**: higher in this pilot study compared to the Canadian general population
- Median level of **t,t-MA**: 6 times higher in Indigenous participants, compared to the Canadian general population
- Median hair levels of **barium**, **aluminum**, **strontium** and **manganese:** higher in this pilot study compared to reference medians reported by Goullé et al. (2005)
- Median hair levels of **barium** and **strontium:** higher in Indigenous participants compared to non-Indigenous participants

EPIDEMIOLOGICAL STUDY

Proximity and density of UNG wells
and birth outcomes in Northeastern British Columbia

Publications

Caron-Beaudoin *et al.*, 2020 JESSE

Aker et al., submitted in Int J Hyg Environ Health

FUNDING AND SUPPORT

FRQS and CIHR postdoctoral training fellowships

Fonds de recherche Santé Québec

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

Research team

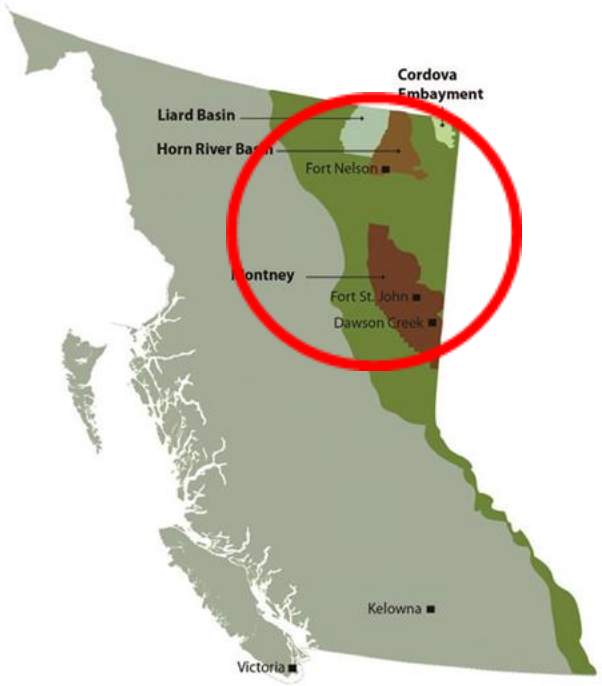
Treaty 8 Tribal Association — Living in Harmony with Nature

ESPUM
L'ÉCOLE DE SANTÉ PUBLIQUE DE L'UNIVERSITÉ DE MONTRÉAL

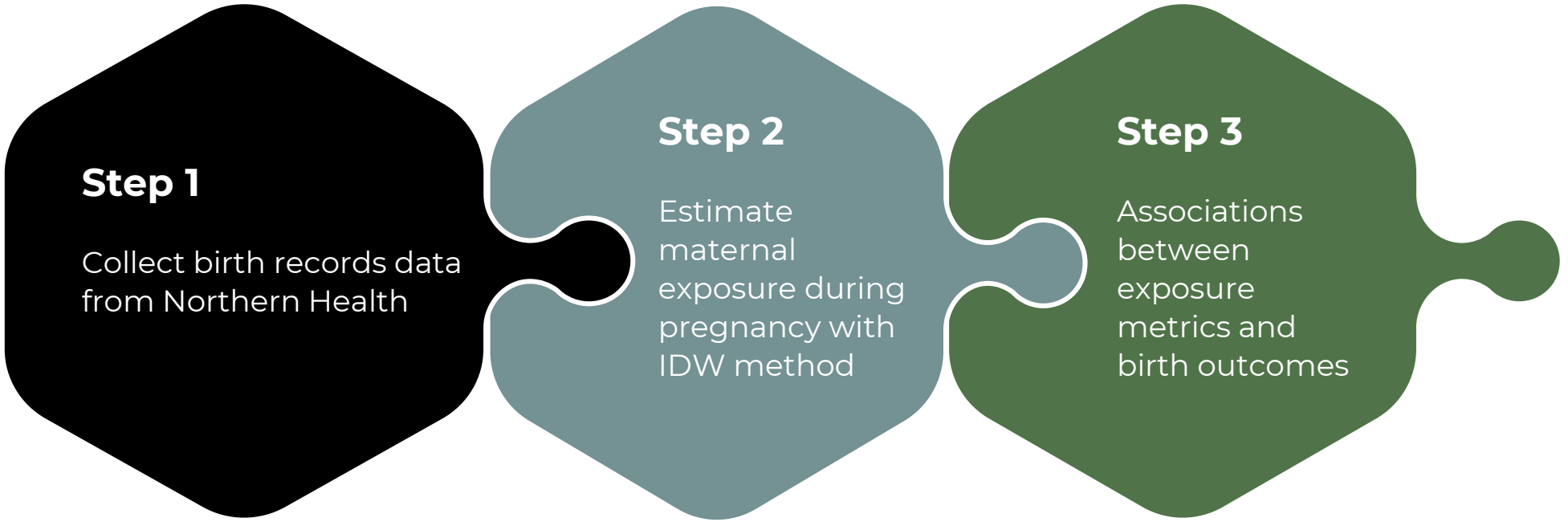
UTHealth | School of Public Health
The University of Texas Health Science Center at Houston

OBJECTIVE

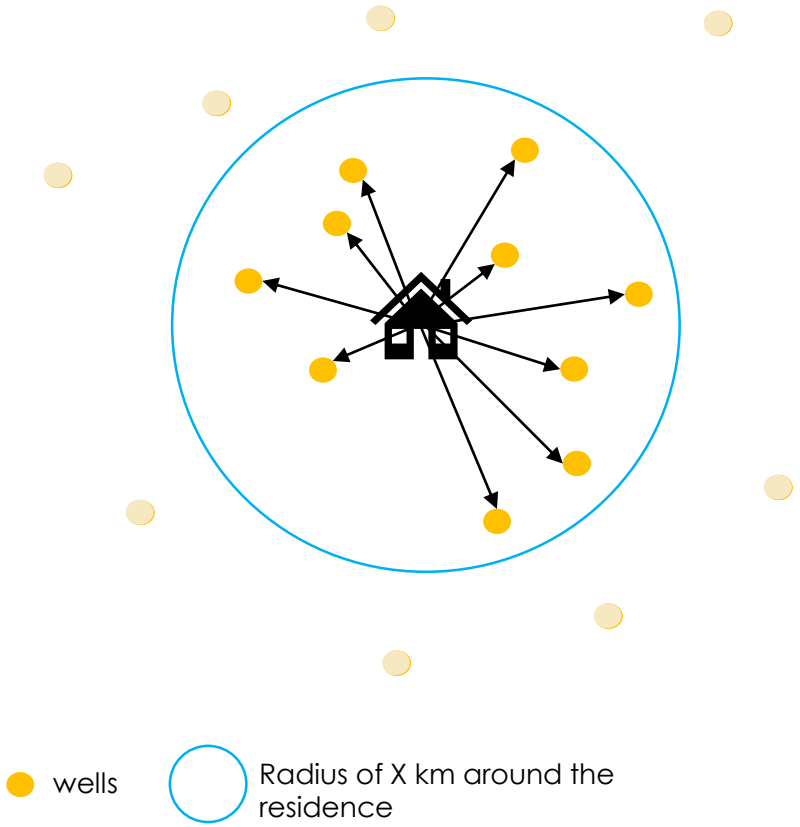
To evaluate associations between maternal residential proximity to UNG wells and birth outcomes using birth records from the Fort St John hospital between January 1 2007 to December 31 2016



METHODS


Step 1
Collect birth records data from Northern Health
Step 2
Estimate maternal exposure during pregnancy with IDW method
Step 3
Associations between exposure metrics and birth outcomes

METHODS: ESTIMATION OF EXPOSURE TO FRACKING



- IDW method: based on the density and proximity of hydraulic fracturing wells to postal codes centroids associated with each birth

IDWx = $\Sigma^{n}_{i=1}$ * (1/di)
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

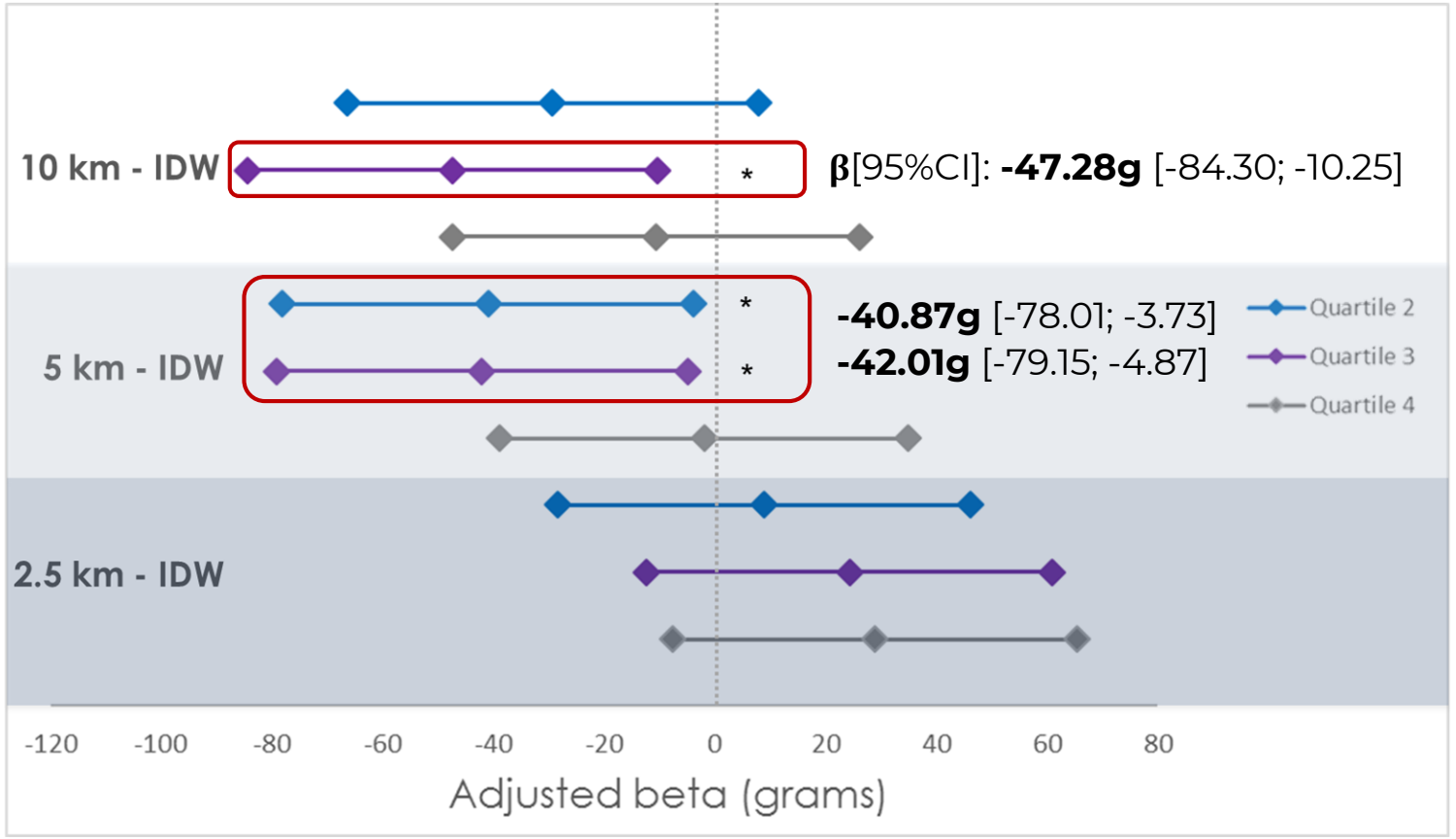
- For each birth: three IDW using a 2.5, 5 and 10 km buffer zone around the postal code centroid
- IDW metrics were categorized into quartiles

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**

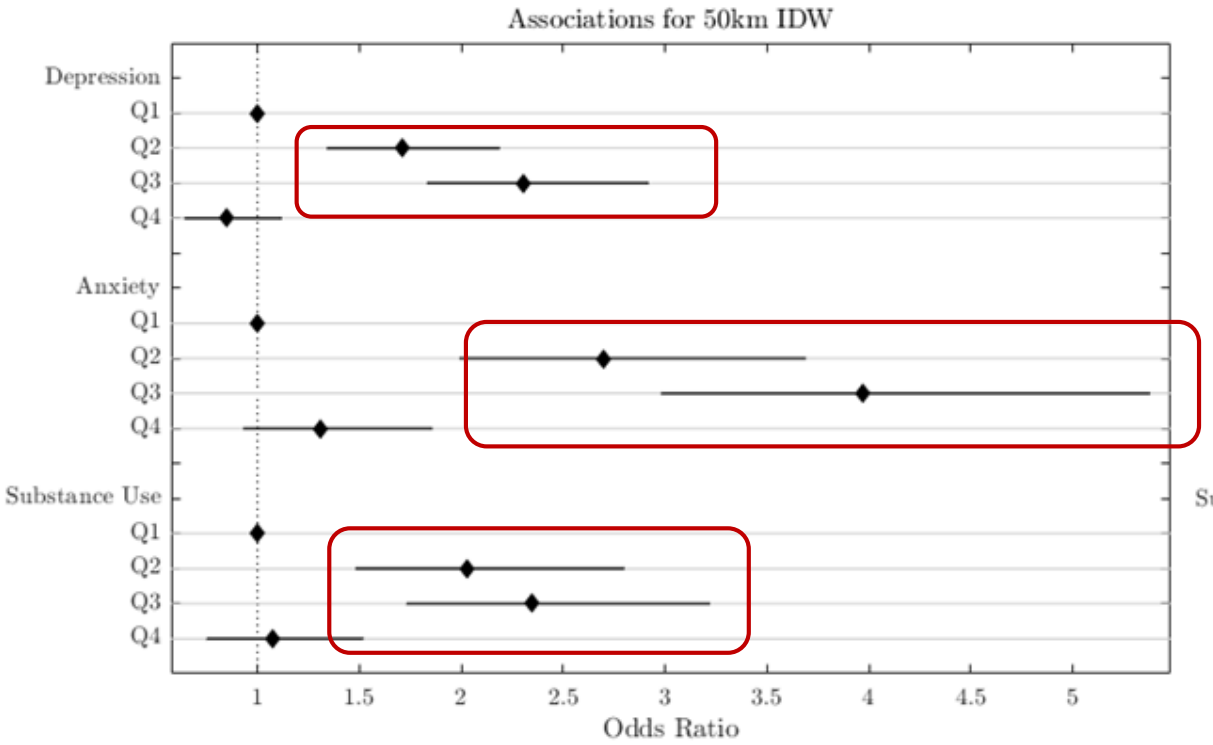


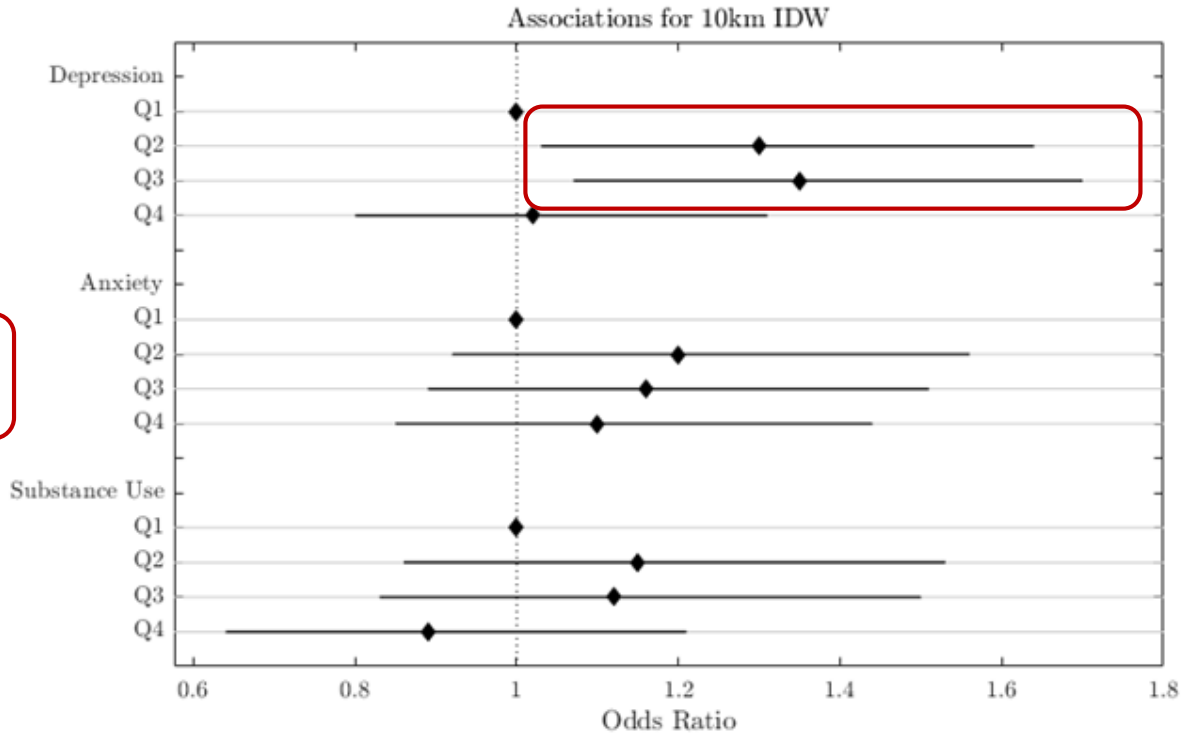
Adjusted for parity, infant's sex assigned at birth, mother's age and smoking
Full-term singleton birth in the Fort St John hospital, BC, Canada, from January 1 2007 to December 31 2016 (n=5018)
* p-value < 0.05

Caron-Beaudoin *et al. 2020. JESEE*

RESULTS: MATERNAL MENTAL HEALTH AND SUBSTANCE USE

Adjusted beta coefficients 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., submitted

LIMITATIONS

- IDW: based on postal codes centroids, not considering the different production phases
- No access to potentially important covariables (e.g., socioeconomic status, maternal education, family income, ethnicity)
- Mental illness data did not allow us to determine when a woman was first diagnosed (e.g. prior to or during her index pregnancy)

CONCLUSIONS

- First epidemiological studies in Canada on UNG and health outcomes
- Potential association with increased odds of preterm birth and reduced birthweight
- No association with SGA or head circumference
- Mechanisms potentially explaining dose-response relationships (e.g endocrine disruption) should be investigated
- Greater odds of mental illness prior to or during pregnancy, and substance use during pregnancy in pregnant women living in postal codes with increased UNG

EXPERIVA

Exposures in the Peace River Valley

Gestational exposure to chemicals related to UNG and their endocrine disrupting potential in Northeastern British Columbia

Publications

Caron-Beaudoin *et al.*, 2021 STOTEN

Caron-Beaudoin and Armstrong., 2019 J. Ethnobiol.

FUNDING AND SUPPORT

- PIs: Élyse Caron-Beaudoin and Marc-André Verner
- Oversight committee

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

Research team

OBJECTIVE

Transdisciplinary project combining exposure assessment, toxicological and sociological approaches:

1. Assess exposure to VOCs and trace elements in 85 pregnant women from northeastern BC
2. Assess endocrine disruption of environmentally-relevant concentrations of VOCs and trace elements → *in vitro* models of fetal development
3. Measure urinary oxidative stress biomarkers and investigate associations with natural gas wells density/proximity metrics and exposure to VOCs and trace elements

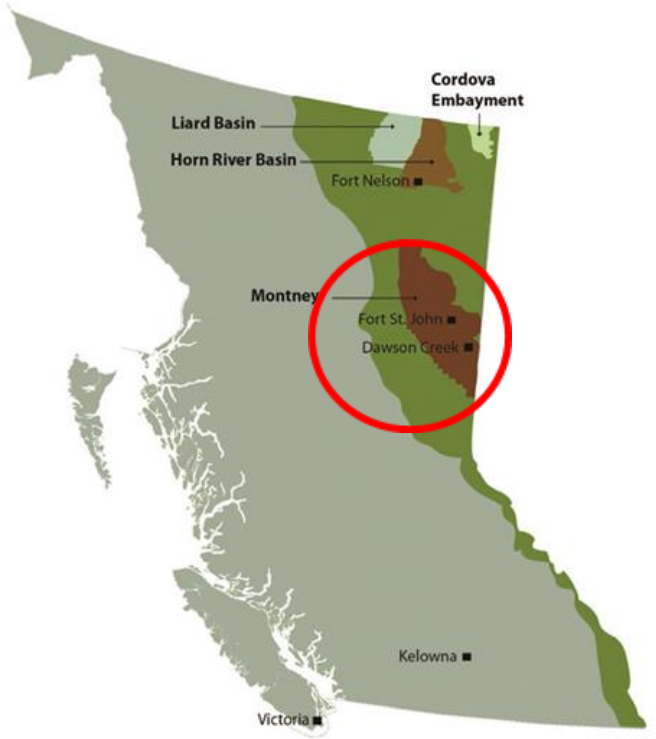
OBJECTIVE

4. Explore associations between density/proximity of hydraulic fracturing wells and exposure levels, and between exposure levels and birth outcomes
5. Explore social inequities related to exposure to contaminants associated with UNG

METHODS

Recruitment

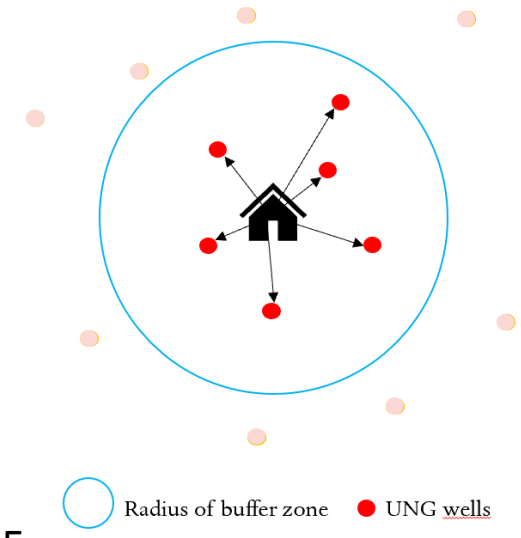
- From May to August 2019
- 3 medical clinics, 1 midwifery clinic
- Treaty 8 Tribal Association, West Moberly and Saulteau First Nations
- Recruited 85 participants ≈ 33% of pregnant women in region
- 90% of pregnant women that were met participated



METHODS

Recruitment (n = 85)

- Questionnaire (physiological, sociodemographic, housing and diet characteristics)
- Urine Sampling (7 consecutive days) → Biomarker Quantification (ELISA: 8-IP, 8-OHdG, MDA); Trace elements + VOCs metabolites
- Hair and nails (At recruitment) → Trace elements + VOCs metabolites; Trace elements
- Water sampling (At recruitment) → Trace elements + VOCs metabolites; Trace elements
- Indoor Air Sampling (7 days) → VOCs
- Natural gas well Density and Proximity Metrics → Well Density & IDW (2.5km, 5km, 10km, all wells)



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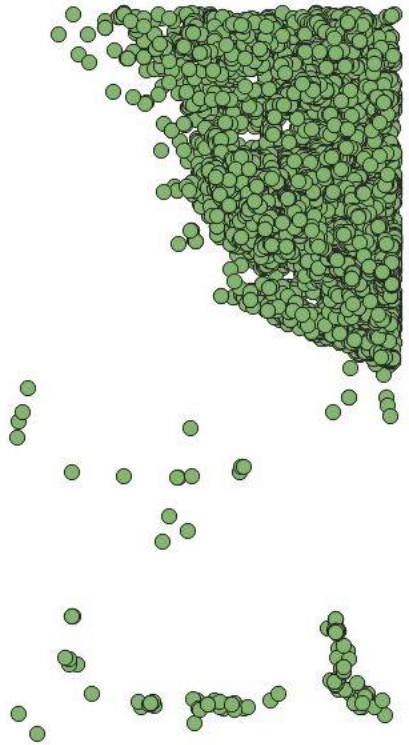
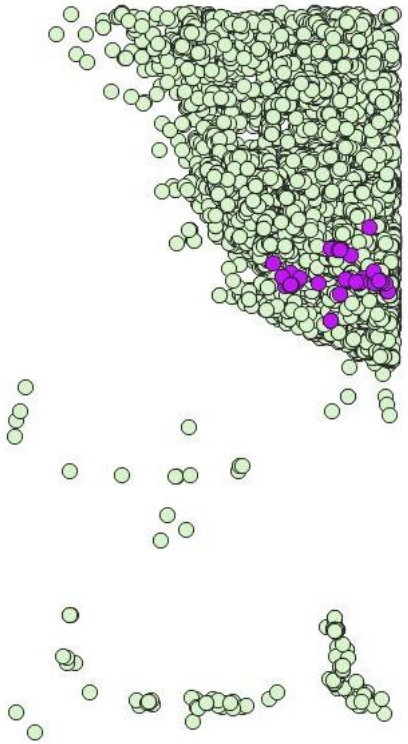
RESULTS: CHARACTERISTICS OF THE PARTICIPANTS

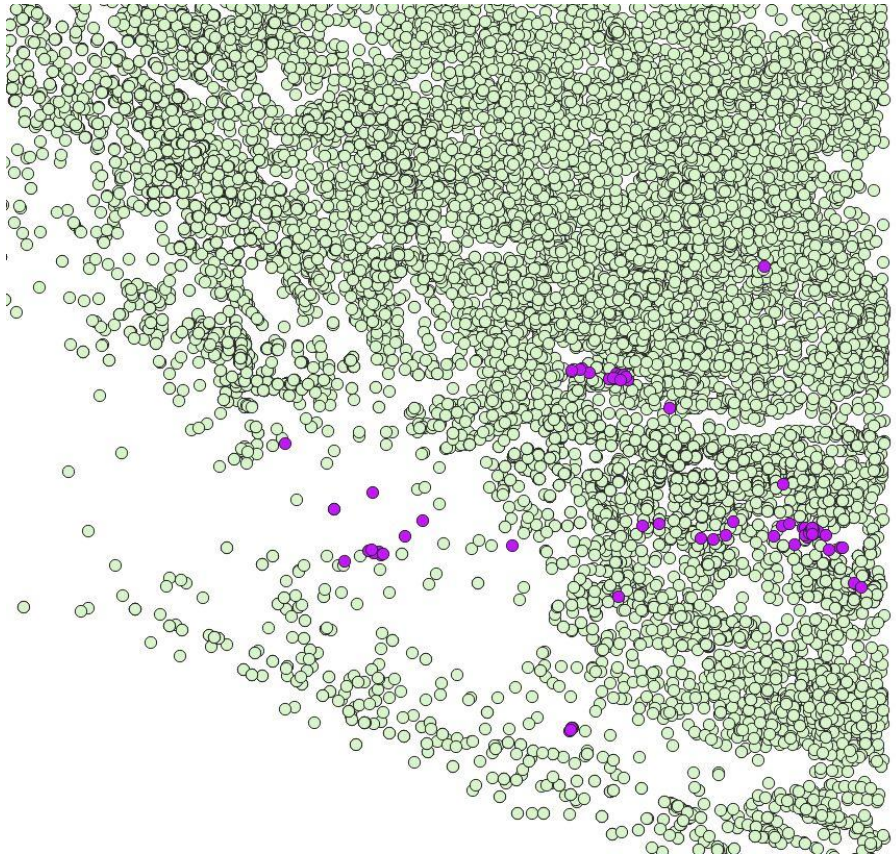
Median age	Indigenous	Median GA	Previous pregnancies
			
29 years old	20%	23 weeks	68%

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

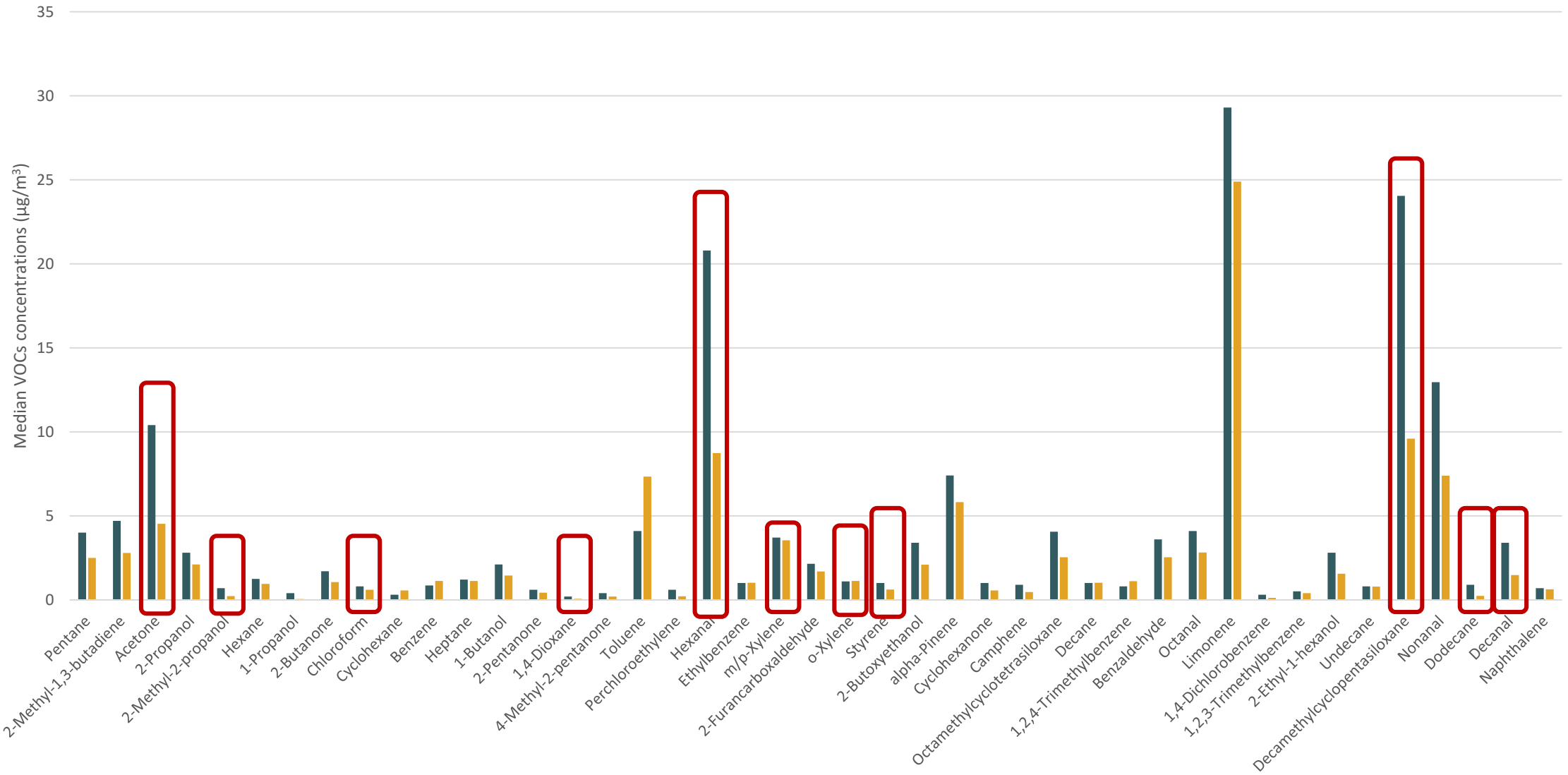
RESULTS: DENSITY/PROXIMITY OF WELLS





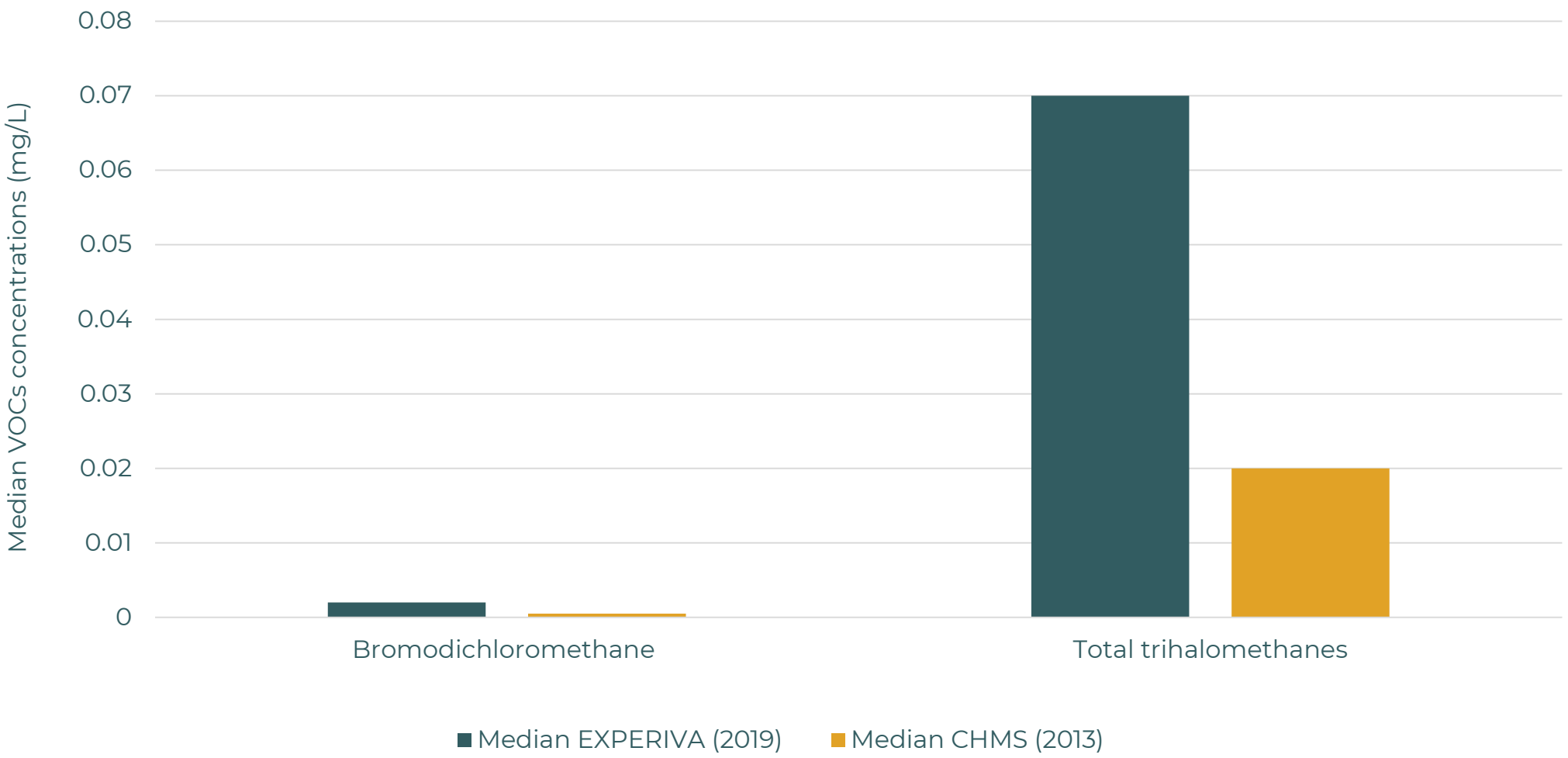


RESULTS: INDOOR AIR VOCs



Caron-Beaudoin *et al. 2021. STOTEN*

RESULTS: TAP WATER VOCs



Caron-Beaudoin *et al. 2021. STOTEN*

RESULTS: ASSOCIATIONS BETWEEN VOC AND UNG

Adjusted beta coefficients (µg/m^3) for the association of well density/proximity metrics and selected **indoor air VOCs**

VOC	Number of wells (10 km) Adjusted beta (95% CI)	Number of wells (5 km) Adjusted beta (95% CI)	IDW no buffer Adjusted beta (95% CI)	IDW 10 km Adjusted beta (95% CI)	IDW 5 km Adjusted beta (95% CI)
Acetone	**0.22** **(0.004; 0.448)***	0.104 (-0.126; 0.334)	**0.244** **(0.019; 0.466)***	0.151 (-0.08; 0.38)	0.093 (-0.139; 0326)
2-methyl-2-propanol	0.045 (-0.18; 0.263)	-0.063 (-0.294; 0.168)	0.084 (-0.15; 0.318)	0.006 (-0.197; 0.207)	-0.06 (-0.292; 0.173)
Chloroform	**0.178** **(0.06; 0.415)***	0.119 (-0.099; 0.337)	**0.15** **(-0.100; 0.400)** †	0.125 (-0.088; 0.338)	0.067 (-0.151; 0.285)

Model adjusted for smoking during pregnancy, exposure to second-hand smoke during pregnancy, attached garage and Indigenous status
† p ≤ 0.10; *p < 0.05

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RESULTS: ASSOCIATIONS BETWEEN VOC AND UNG

Adjusted beta coefficients (mg/L) for the association of well density/proximity metrics and **trihalomethanes** in tap water

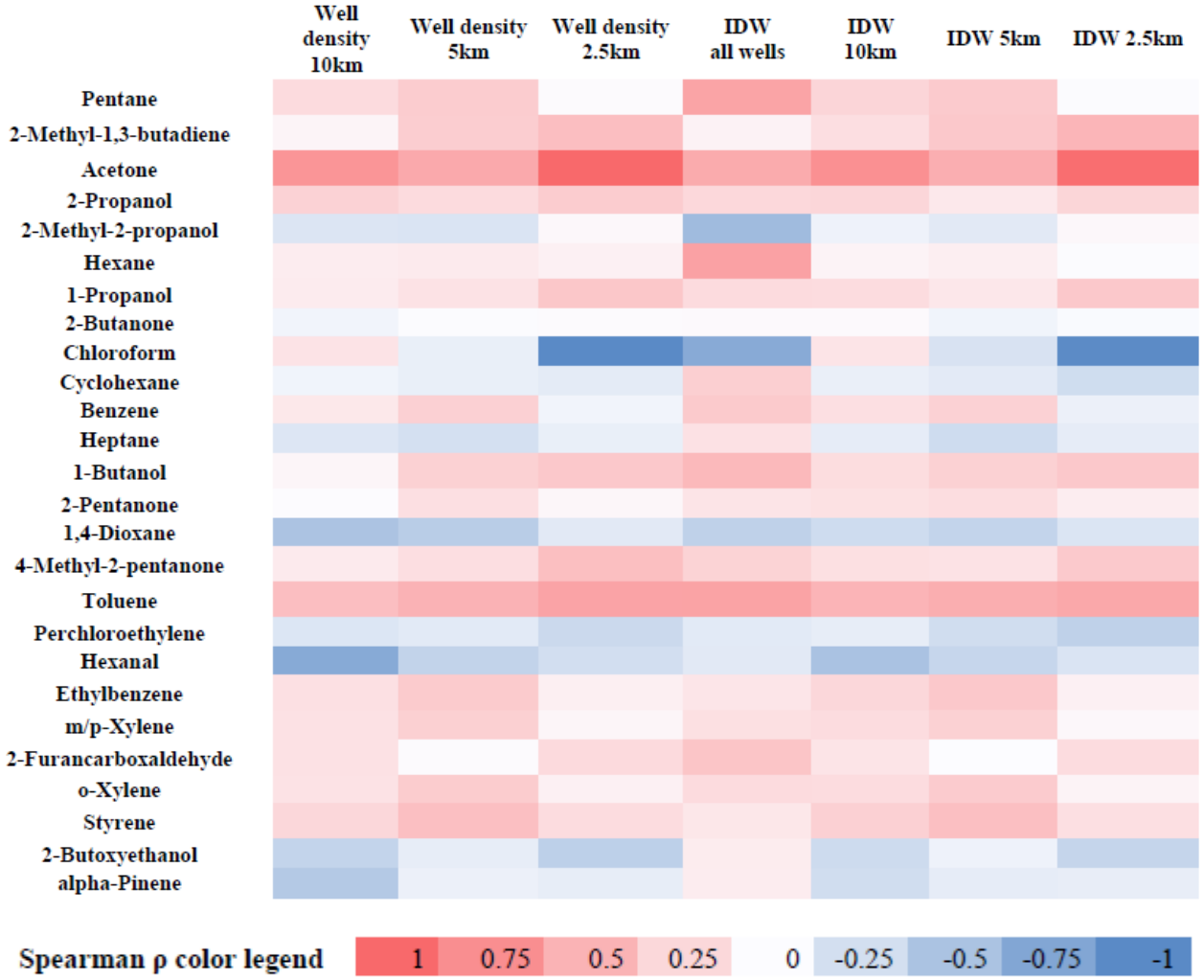
VOC	Number of wells (10 km) Adjusted beta (95% CI)	Number of wells (5 km) Adjusted beta (95% CI)	IDW no buffer Adjusted beta (95% CI)	IDW 10 km Adjusted beta (95% CI)	IDW 5 km Adjusted beta (95% CI)
Trihalomethanes	**0.143** **(-0.046; 0.333) †**	**0.233** **(0.028; 0.462)***	0.037 (-0.158; 0.232)	**0.183** **(-0.007; 0.180) †**	**0.227** **(0.023; 0.436)***

Model adjusted for main source of residential tap water and Indigenous status
† p ≤ 0.10; *p < 0.05

Caron-Beaudoin *et al. 2021. STOTEN*

RESULTS: ASSOCIATIONS BETWEEN VOC AND UNG

Heatmap correlation matrix between UNG well density/proximity metrics and VOCs in indoor air



Caron-Beaudoin *et al. 2021. STOTEN*

RESULTS: ASSOCIATIONS BETWEEN VOC AND UNG

Heatmap correlation matrix between UNG well density/proximity metrics and VOCs in indoor air

Caron-Beaudoin *et al. 2021. STOTEN*

WHAT'S NEXT?

- Compare levels of trace elements in tap water with nationally representative levels
- Analyze the exposure levels data of VOC metabolites and trace elements in biological samples

CONCLUSIONS

- Epidemiological literature suggests risk for poorer birth and maternal outcomes. Effects do not always reach statistical significance
- Important lack of data on exposure assessment and mechanisms of toxicity
- Preliminary evidence of higher exposure levels to VOC in the EXPERIVA study participants (especially Indigenous) compared to the general Canadian population
- Preliminary evidence that density and proximity of UNG wells contribute to the residential levels of VOC

To develop transdisciplinary research projects in partnership with communities living in a changing environment

To assess the impacts of anthropogenic pressures on health by combining information from multiple levels of biological organization

THANK YOU!

MERCI !

FROM BENCH
TO COMMUNITIES
LAB

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