

# Preterm birth in the Inuit and First Nations populations of Québec, Canada, 1981–2008

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**Objectives:** To evaluate preterm birth (PTB) for Inuit and First Nations vs. non-Indigenous populations in the province of Québec, Canada.

**Study design:** Retrospective cohort study.

**Methods:** We evaluated singleton live births for Québec residents, 1981–2008 (n = 2,310,466). Municipality of residence (Inuit-inhabited, First Nations-inhabited, rest of Québec) and language (Inuit, First Nations, French/English) were used to identify Inuit and First Nations births. The outcome was PTB (< 37 completed weeks). Cox proportional hazards regression was employed to estimate hazard ratios (HR) and 95% confidence intervals (CI) of PTB, adjusting for maternal age, education, marital status, parity and birth year.

**Results:** PTB rates were higher for Inuit language speakers in Inuit-inhabited areas and the rest of Québec compared with French/English speakers in the rest of Québec, and disparities persisted over time. Relative to French/English speakers in the rest of Québec, Inuit language speakers in the rest of Québec had the highest risk of PTB (HR 1.98, 95% CI: 1.62–2.41). The risk was also elevated for Inuit language speakers in Inuit-inhabited areas, though to a lesser extent (HR 1.29, 95% CI: 1.18–1.41). In contrast, First Nations language speakers in First Nations-inhabited areas and the rest of Québec had similar or lower risks of PTB relative to French/English speakers in the rest of Québec.

**Conclusions:** Inuit populations, especially those outside Inuit-inhabited areas, have persistently elevated risks of PTB, indicating a need for strategies to prevent PTB in this population.

**Keywords:** *First Nations; Indigenous populations; Inuits; premature birth; residence characteristics.*

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Indigenous peoples are at higher risk of preterm birth (PTB) even in developed countries such as Canada, Australia and the United States (1). In Québec, PTB rates are higher for Inuit language speakers and Inuit-inhabited areas (2,3). However, the most recent data are for births before 2000, and little is known on recent trends in Inuit populations. This is concerning because PTB is a leading cause of perinatal morbidity and mortality in developed countries (4). PTB accounts for 75% of perinatal mortality (4,5) and is associated with long-term sequelae later in life including developmental problems and neurocognitive dysfunction (6). Furthermore, PTB rates in many countries have risen over recent

decades (4,5), including Canada where rates increased from 7.0% in 1995 to 8.2% in 2008 (7).

Another issue is that the PTB status of Inuit populations living outside of predominantly Inuit-inhabited areas is largely unknown. A recent study suggested that birth outcomes in Inuit-inhabited areas were unfavourable compared with the rest of Canada (3), but Inuit populations living in other areas were not identified. The few remaining studies of PTB in the Canadian Inuit tended to use a marker of Inuit ethnicity reported on birth certificates or by health care providers (2,8,9), without capturing area-based differences. This is also the case for First Nations populations whose PTB rates

may vary depending on if they live in First Nations-inhabited areas or not. A clearer understanding of patterns in PTB rates for Inuit and First Nations populations not living in Inuit- and First Nations-inhabited areas is needed for targeted interventions to improve perinatal health in Indigenous populations.

The objective of this study was, therefore, to evaluate patterns in PTB for the Inuit and First Nations populations of the province of Québec, Canada, using a marker of Indigenous status based on language and area of residence. Trends over time and across areas were examined.

## Materials and methods

### Study design and setting

We performed a retrospective cohort study of the population of births in the province of Québec, Canada, from 1981 to 2008. According to the 2006 census, Québec had a population of over 7.4 million, of which approximately 0.1% was Inuit and 0.9% First Nations (10). Inuit communities are located in the Nunavik region of northern Québec, including the Ungava Bay and Hudson Bay areas (11). First Nations communities, in contrast, are more numerous and dispersed throughout Québec. Publicly funded universal health care covers obstetric services and is available to all Quebecers, including Indigenous populations, although health care delivery varies by community. In Ungava Bay, care is typically provided by physicians, whereas in Hudson Bay midwives predominate (11).

### Data and variables

We extracted singleton infants from the Québec live birth file from 1981 to 2008 ( $n = 2,310,466$ ). We excluded 18,229 births missing gestational age (0.8%), and an additional 176 births missing maternal age (0.01%). The birth file is compiled from birth certificates and provides complete coverage of births of residents of Québec (12,13).

Gestational age based on dating ultrasounds was available in complete weeks. Births at less than 37 completed gestational weeks were defined as preterm. PTB categories were also examined according to severity of gestational age at birth: (a) extreme PTB ( $\leq 27$  weeks); (b) very PTB (28–31 weeks); and (c) moderate PTB (32–36 weeks) (14). Ultrasound estimates of gestational age are typically more accurate than estimates based on menstruation (15–17), however, ultrasound examinations may not have been fully implemented in the 1980s.

Indigenous populations were identified using 2 indicators: municipality of residence and self-reported parental language. In Québec, municipalities can be used to identify Inuit- ( $n = 14$ ) and First Nations- ( $n = 45$ ) inhabited areas (also known as reserves or territories),

defined as such by Statistics Canada for census purposes. All remaining municipalities not coded as Indigenous were grouped in a separate category hereafter denoted “rest of Québec”. Hence, 3 types of areas were available for analyses (Inuit-inhabited, First Nations-inhabited, rest of Québec).

Language was expressed categorically (Inuit, First Nations, French/English, other, unknown). Inuit languages included Inuktituk, Eskimo and Syllabic. First Nations languages included all dialects of remaining Indigenous populations of North America. According to the 2006 census, 89% of self-identified Inuit and 46% of self-identified First Nations reported an Indigenous mother tongue in Québec (10). Maternal mother tongue was used to identify language, but language spoken at home and paternal mother tongue were also used to capture an additional 428 Inuit and 2,040 First Nations infants.

Language and type of area were analysed as a joint variable to identify Inuit and First Nations language births by area. Categories for the joint language-by-area type indicator of Indigenous status included (a) Inuit language speakers in Inuit-inhabited areas, (b) French/English speakers in Inuit-inhabited areas, (c) First Nations language speakers in First Nations-inhabited areas, (d) French/English speakers in First Nations-inhabited areas, (e) Inuit language speakers in the rest of Québec, (f) First Nations language speakers in the rest of Québec, (g) French/English speakers in the rest of Québec (referent), (h) other. It is important to note that French/English speakers in Inuit-inhabited areas represent individuals of Inuit ethnicity who reported French/English language on birth certificates, or non-Inuit migrants working temporarily in Inuit-inhabited areas (11). French/English speakers in First Nations-inhabited areas most likely represent a mix of First Nations and non-Indigenous individuals.

Available covariates included maternal age ( $< 20$ , 20–34 and  $\geq 35$  years), parity (0, 1 and  $\geq 2$  previous deliveries), education (no high school diploma, high school diploma, some post-secondary, some university or more, unknown) and marital status (legally married, not legally married). Several studies have identified these variables as potential confounders of the relation between Indigenous ethnicity and adverse birth outcomes (2,18). Due to the lack of variability in Indigenous populations, immigration status was not included as a covariate. Birth year was assessed in 3 intervals (1981–1989, 1990–1999 and 2000–2008).

### Statistical analysis

PTB rates were computed according to Indigenous status, maternal age, education, marital status, parity and birth year. Fisher’s exact 95% confidence intervals (CIs), or Wald 95% CIs for large samples, were computed for proportions (<http://www.openepi.com/OE2.3/Proportion/>

Proportion.htm). Cox proportional hazard regression was employed to estimate hazard ratios (HR) and 95% CIs of PTB for Indigenous status in models that were unadjusted and adjusted for maternal age, education, marital status, parity and birth year. Adjusted models were also run for each birth year category separately. The proportional hazard assumption was verified with  $\log(-\log(\text{survival}))$  curves for all variables. Cox regression is increasingly used to examine perinatal outcomes such as PTB, because pregnancy is a dynamic process that evolves over time and results in a specific event, birth (19,20). As the data were hierarchical with births nested in municipalities, clustering was accounted for with the robust sandwich estimator (21).

Statistical Package for Social Sciences (SPSS, [www.spss.com](http://www.spss.com), version 17.0 for Windows) software was used for descriptive statistics, and SAS software (Statistical Analysis System, <http://www.sas.com>, version 9.2) for regression models. This study was based on denormalised administrative birth data. Individual consent was thus not sought, and formal ethical approval was waived by the research ethics committee of the University of Montréal Hospital Centre.

## Results

In Inuit-inhabited areas, 4,851 infants (0.2%) were born to Inuit language speakers and 680 infants (0.03%) to French/English speakers (Table I). In contrast, 11,678 infants (0.5%) were born to First Nations language speakers and 8,962 infants (0.4%) to French/English speakers in First Nations-inhabited areas. There were 513 births (0.02%) to Inuit language speakers and 3,836 births to First Nations language speakers (0.2%) in the rest of Québec.

The overall rate of PTB was 5.9%. Compared with French/English speakers in the rest of Québec (5.8%), PTB rates were elevated for Inuit and French/English speakers in Inuit-inhabited areas (9.5 and 12.7%, respectively), and for Inuit language speakers in the rest of Québec (12.7%). In contrast, rates for First Nations (5.9%) and French/English speakers (6.7%) in First Nations-inhabited areas and First Nations language speakers in the rest of Québec (6.0%) were only slightly higher compared with French/English speakers in the rest of Québec.

Similar patterns were observed when PTB was examined by severity according to gestational age (Table II). Compared with French/English speakers in the rest of Québec, Inuit language speakers in the rest of Québec and French/English speakers in Inuit-inhabited areas had the highest rates of moderate (10.3 and 11.0% vs. 5.1%, respectively) and very PTB (1.95 and 1.32% vs. 0.44%, respectively). Rates of extreme PTB were higher for Inuit language speakers in Inuit-inhabited areas (0.49%) and the rest of Québec (0.39%), as well as for French/English

speakers in First Nations-inhabited areas (0.42%), compared with French/English speakers in the rest of Québec (0.27%).

Whereas PTB rates increased over time for French/English language speakers in the rest of Québec, rates tended to decrease slightly for Inuit language and French/English speakers in Inuit-inhabited areas, and were generally stable for Inuit language speakers in the rest of Québec (Table III). The PTB rate increased for all other groups, especially First Nations language speakers in First Nations-inhabited areas and the rest of Québec.

Relative to French/English speakers in the rest of Québec, the hazard of PTB was greatest for Inuit language speakers in the rest of Québec (adjusted HR 1.98, 95% CI: 1.55–2.53) and French/English speakers in Inuit-inhabited areas (adjusted HR 1.97, 95% CI: 1.59–2.43, Table IV). The hazard of PTB for Inuit language speakers in Inuit-inhabited areas was also elevated, but slightly weaker (adjusted HR 1.28, 95% CI: 1.17–1.41). Adjustment for maternal characteristics attenuated the associations, but did not change the direction of findings. This was not the case for First Nations language speakers in First Nations-inhabited areas and the rest of Québec, who upon adjustment had a lower hazard of PTB relative to French/English speakers in the rest of Québec (HR <0.9).

Analyses stratified by birth year showed a persistently elevated hazard of PTB for Inuit language speakers in the rest of Québec, and decreasing disparities for Inuit language and French/English speakers in Inuit-inhabited areas relative to French/English speakers in the rest of Québec (Table V). In contrast, HRs increased over calendar time for First Nations language speakers. While the hazard was initially protective against PTB for First Nations language speakers in the rest of Québec relative to French/English speakers in the rest of Québec (HR 0.83), the hazard was higher in the most recent period (HR 1.32). For First Nations language speakers in First Nations-inhabited areas, the initial protective association in 1981–1989 (HR 0.71) disappeared by 2000–2008 (HR 0.99).

## Discussion

We observed higher rates of PTB in Inuit-inhabited areas compared with French/English speakers in the rest of Québec. Rates were also elevated for Inuit language speakers in the rest of Québec. Disparities for Inuit groups persisted or decreased slightly over time relative to French/English speakers in the rest of Québec, but increased for First Nations populations, although disparities generally remained greater for Inuit groups. Interestingly, Inuit language speakers had a lower risk of PTB relative to French/English in Inuit-inhabited areas, though their risk was nonetheless higher relative to French/English speakers in the rest of Québec. Overall,

**Table 1.** Rates of preterm birth according to maternal characteristics, singleton live births, Québec, 1981–2008<sup>a</sup>

	Preterm birth (<37 weeks)		Total births N
	% (95% CI)	n	
<b>Language by type of area</b>			
Rest of Québec			
French/English	5.8 (5.8–5.9)	115,346	1,982,761
Inuit	12.7 (9.8–15.6)	65	513
First Nations	6.0 (5.3–6.8)	231	3,836
Inuit–inhabited			
French/English	12.7 (10.2–15.2)	86	680
Inuit	9.5 (8.6–10.3)	459	4,851
First Nations–Inhabited			
French/English	6.7 (6.2–7.3)	604	8,962
First Nations	5.9 (5.5–6.4)	694	11,678
<b>Age (years)</b>			
< 20	8.1 (7.9–8.2)	7,700	95,563
20–34	5.6 (5.6–5.7)	110,915	1,965,560
≥ 35	6.7 (6.6–6.8)	15,562	230,938
<b>Education</b>			
No high school diploma	7.1 (7.0–7.2)	24,113	338,134
High school diploma	6.5 (6.4–6.5)	18,966	294,013
Some post–secondary	5.6 (5.6–5.7)	33,384	592,704
Some university or more	5.1 (5.0–5.1)	47,299	934,745
<b>Marital status</b>			
Legally married	5.2 (5.1–5.2)	66,022	1,282,983
Not legally married	6.8 (6.7–6.8)	68,155	1,009,078
<b>Parity (previous deliveries)</b>			
0	6.6 (6.5–6.6)	68,283	1,043,221
1	5.0 (5.0–5.1)	40,715	808,606
≥2	5.7 (5.7–5.8)	25,179	440,234
<b>Birth year<sup>b</sup></b>			
1981–1989	5.3 (5.3–5.4)	40,808	768,400
1990–1999	6.0 (6.0–6.1)	51,004	846,203
2000–2008	6.3 (6.2–6.3)	42,365	677,458
<b>Total</b>	<b>5.9 (5.8–5.9)</b>	<b>134,177</b>	<b>2,292,061</b>

CI, confidence interval.

<sup>a</sup>May not sum to total as “unknown” or “other” language categories are not shown. All  $\chi^2$  tests for differences in proportions had  $p < 0.0001$ .<sup>b</sup>Cochran-Armitage test for trend  $p < 0.0001$ .

the highest risks of PTB were observed for French/English speakers in Inuit-inhabited areas, and Inuit language speakers in the rest of Québec, relative to French/English speakers in the rest of Québec. These findings indicate a need for effective interventions to improve perinatal health in Inuit-inhabited areas and for Inuit language speakers in the rest of Québec.

In general, our findings were consistent with previous reports of higher odds of PTB in Inuit-inhabited areas

compared with other areas (1,3,9), as well as for Inuit language compared with French/English speakers (8,22). The lower rates of PTB for First Nations language speakers in First Nations-inhabited areas and the rest of Québec were consistent with those noted in other studies (1,2,8). However, these studies grouped Inuit individuals in the rest of Québec with the referent. Previous studies also did not distinguish between the different linguistic groups living in Inuit-inhabited areas.

**Table II.** Preterm birth rates according to severity by gestational age and Indigenous status, singleton live births, Québec, 1981–2008<sup>a</sup>

	Preterm birth			
	Extreme ( $\leq 27$ weeks)	Very (28–31 weeks)	Moderate (32–36 weeks)	All births
	% (95% CI)	% (95% CI)	% (95% CI)	N
Language by type of area				
Rest of Québec				
French/English	0.27 (0.27–0.28)	0.44 (0.43–0.45)	5.1 (5.1–5.1)	1,982,761
Inuit	0.39 (0.05–1.40)	1.95 (0.94–3.56)	10.3 (7.8–13.3)	513
First Nations	0.13 (0.04–0.30)	0.55 (0.34–0.84)	5.3 (4.7–6.1)	3,836
Inuit–inhabited				
French/English	0.29 (0.04–1.06)	1.32 (0.61–2.50)	11.0 (8.8–13.6)	680
Inuit	0.49 (0.32–0.72)	0.72 (0.50–1.00)	8.3 (7.5–9.1)	4,851
First Nations–inhabited				
French/English	0.42 (0.30–0.58)	0.66 (0.50–0.85)	5.7 (5.2–6.2)	8,962
First Nations	0.25 (0.17–0.36)	0.32 (0.22–0.44)	5.4 (5.0–5.8)	11,678

CI, confidence interval.

<sup>a</sup>May not sum to total as the “other” language category is not shown. All  $\chi^2$  tests for differences in proportions had  $p < 0.0001$ .

In fact, we found that in Inuit-inhabited areas, Inuit language speakers had a lower risk of PTB relative to French/English speakers. Why this happens is unclear, but Inuit people who report French/English as their language may be more acculturated to Western society, and less protected by traditional lifestyle factors. Behavioural risk factors for PTB such as smoking, substance use and poor nutritional habits (23–26), as well as psychosocial problems such as domestic violence, emotional stress, depression and anxiety (23,27–29) may potentially be greater in acculturated Inuit women with weaker ties to traditional culture and language (30). It is important to note that a substantial proportion of

French/English speakers in Inuit-inhabited areas likely represent Inuit individuals, but may also include some non-Inuit individuals (e.g. non-Indigenous residents of Québec employed in Inuit-inhabited areas). Our data did not permit distinction between the 2 groups.

The higher risk of PTB in all Inuit categories may be related to environmental, cultural and lifestyle factors that potentially differ from French/English speakers in the rest of Québec (27,31). Inuits prefer Indigenous midwives and traditional ceremonies during delivery (32). There is, however, little evidence that midwife care is a risk factor for PTB for Inuit women (11). Furthermore, midwife care is typically provided by Inuit language

**Table III.** Preterm birth rates according to birth year and Indigenous status, singleton live births, Québec, 1981–2008<sup>a</sup>

	1981–1989			1990–1999			2000–2008		
	% (95% CI)	n	N	% (95% CI)	n	N	% (95% CI)	n	N
Language by type of area									
Rest of Québec									
French/English <sup>b</sup>	5.3 (5.2–5.4)	36,974	698,310	6.0 (6.0–6.1)	43,664	727,649	6.2 (6.2–6.3)	34,708	556,802
Inuit	12.8 (8.8–16.9)	34	265	12.1 (7.1–17.1)	20	165	13.3 (6.0–20.6)	11	83
First Nations <sup>b</sup>	5.3 (4.3–6.4)	92	1,723	5.3 (4.2–6.4)	79	1,488	9.6 (7.3–11.9)	60	625
Inuit-inhabited									
French/English	14.7 (8.2–21.1)	17	116	12.6 (8.0–17.2)	25	199	12.1 (8.7–15.4)	44	365
Inuit	10.2 (7.9–12.9)	59	578	9.5 (8.3–10.7)	213	2,243	9.2 (8.0–10.5)	187	2,030
First Nations-inhabited									
French/English	6.0 (5.0–7.0)	124	2,063	7.4 (6.4–8.3)	211	2,871	6.7 (5.9–7.4)	269	4,028
First Nations <sup>b</sup>	4.6 (3.9–5.3)	153	3,348	5.7 (5.0–6.3)	252	4,455	7.5 (6.6–8.3)	289	3,875

CI, confidence interval.

<sup>a</sup>Results for “other” language category available upon request.

<sup>b</sup>Cochran-Armitage test for trend over time,  $p < 0.0001$ .

**Table IV.** Association between Indigenous status and preterm birth, singleton live births, Québec, 1981–2008

	Unadjusted HR	Adjusted HR <sup>a</sup>
	(95% CI)	(95% CI)
Language by type of area <sup>b</sup>		
Rest of Québec		
French/English	Referent	Referent
Inuit	2.29 (1.79–2.92)	1.98 (1.55–2.53)
First Nations	1.04 (0.91–1.18)	0.89 (0.78–1.01)
Inuit-inhabited		
French/English	2.28 (1.85–2.82)	1.97 (1.59–2.43)
Inuit	1.66 (1.51–1.82)	1.28 (1.17–1.41)
First Nations-inhabited		
French/English	1.17 (1.08–1.26)	1.00 (0.92–1.08)
First Nations	1.02 (0.95–1.10)	0.85 (0.79–0.92)

<sup>a</sup>Hazard ratio (HR) and 95% confidence interval (CI), adjusted for maternal age, education, marital status, parity and birth year.

<sup>b</sup>Results for “other” language category available upon request.

speakers, whereas physician-led care is provided in French or English (11), suggesting that cultural differences in communication or language barriers (27,31,33) are unlikely to explain the associations. Indigenous mothers prefer to give birth in their community, and may be reticent to hospitalisation for treatment of preterm labour (27,34). Women with risk factors for preterm labour and high-risk pregnancies are nonetheless recommended for evacuation to larger facilities prior to term (35), although the majority of transfers for preterm labour without ruptured membranes succeed in delivering at term (36). Thus, the potential role of obstetric interventions in driving PTB rates among the Inuit is unclear. It is possible that rural isolation is related to the

higher risks in Inuit-inhabited areas, as challenges accessing medical care may be greater due to remoteness and limited resources (22,37). Another challenge faced by rural populations is socioeconomic disadvantage (31,38,39). PTB rates in remote rural Indigenous populations of Australia and the US are also high compared with non-Indigenous populations, and it has been speculated that this may be due to differences in access to health care, socio-demographic, behavioural, cultural and environmental factors (40–43).

Results suggested that disparities between Inuit populations and French/English speakers in the rest of Québec were stable over time, though there tended to be a decrease in Inuit-inhabited areas. The decrease in inequalities, however, was most likely caused by a relative increase in PTB rates among French/English speakers in the rest of Québec, coupled with a slight improvement in rates in Inuit-inhabited areas. Wider use of ultrasound dating over time may explain some of the rate increase among French/English speakers in the rest of Canada (as menstrual dating tends to overestimate gestational age) (16). In Inuit-inhabited areas, access to ultrasound is more limited and may have been adopted more gradually over time (36), which suggests that PTB rates in the Inuit are likely underestimated in all periods, and that disparities are likely greater in more recent periods. Data on other potentially time-varying covariates such as obstetric interventions were, however, not available, which precludes a more detailed interpretation of time trends (44). Another important issue is that the initially protective association against PTB for First Nations populations relative to French/English speakers in the rest of Québec has gradually disappeared over time, likely because PTB rates in First Nations have caught up to the general population. Nonetheless, disparities in PTB

**Table V.** Association between Indigenous status and preterm birth by birth year, singleton live births, Québec, 1981–2008

	HR (95% CI) <sup>a</sup>		
	1981–1989	1990–1999	2000–2008
Language by type of area <sup>b</sup>			
Rest of Québec			
French/English	Referent	Referent	Referent
Inuit	2.00 (1.43–2.81)	1.77 (1.14–2.75)	1.94 (1.08–3.51)
First Nations	0.83 (0.68–1.02)	0.75 (0.60–0.94)	1.32 (1.03–1.70)
Inuit-inhabited			
French/English	2.56 (1.59–4.12)	2.04 (1.38–3.01)	1.73 (1.29–2.32)
Inuit	1.39 (1.07–1.79)	1.25 (1.09–1.43)	1.22 (1.06–1.41)
First Nations-inhabited			
French/English	0.99 (0.83–1.18)	1.09 (0.95–1.24)	0.92 (0.82–1.04)
First Nations	0.71 (0.61–0.84)	0.80 (0.70–0.90)	0.99 (0.88–1.11)

<sup>a</sup>Hazard ratio (HR) and 95% confidence interval (CI), adjusted for type of area, maternal age, education, marital status, and parity.

<sup>b</sup>Results for “other” language category available upon request.

continue to be greater for Inuit populations than for First Nations.

### Limitations

This study was limited by lack of data on several maternal risk factors such as smoking, substance use and obesity that could have influenced the observed associations (5,45–47). The extent to which our findings may be related to obesity, however, is unclear, because First Nations populations also have high obesity rates (23), but lower PTB rates. Though we accounted for education, we may not have captured other aspects of socioeconomic status including income and occupation. Misclassification of Indigenous status through the use of language may have occurred and potentially attenuated the associations, as such individuals would have been grouped with French/English or other language categories. Specifically, we could not capture Inuit and First Nations births in the rest of Québec among mothers who had reported French/English language, or Métis Indigenous groups not identifiable through language or area indicators (0.4% of Quebecers are Métis) (10). Results for Inuit language speakers in the rest of Québec and French/English speakers in Inuit-inhabited areas should be interpreted with caution in light of small numbers. Last, our findings may not generalise to other settings, especially places without universal health insurance.

In summary, we found persistently elevated risks of PTB in Inuit-inhabited areas and for Inuit language speakers in the rest of Québec. The underlying pathways leading to these perinatal health disparities require further investigation to target prevention of PTB in Inuit and Northern populations.

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