Breastfeeding as a means to prevent infant morbidity and mortality in Aboriginal Canadians: A population prevented fraction analysis

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ABSTRACT

OBJECTIVES: Canadian Aboriginal infants experience poor health compared with other Canadian infants. Breastfeeding protects against many infant infections that Canadian Aboriginals disproportionately experience. The objective of our research was to estimate the proportion of select infant infection and mortality outcomes that could be prevented if all Canadian Aboriginal infants were breastfed.

METHODS: We used Levin's formula to estimate the proportion of three infectious outcomes and one mortality outcome that could be prevented in infancy by breastfeeding. Estimates were calculated for First Nations (both on- and off-reserve), Métis and Inuit as well as all Canadian infants for comparison. We extracted prevalence estimates of breastfeeding practices from national population-based surveys. We extracted relative risk estimates from published meta-analyses.

RESULTS: Between 5.1% and 10.6% of otitis media, 24.3% and 41.4% of gastrointestinal infection, 13.8% and 26.1% of hospitalizations from lower respiratory tract infections, and 12.9% and 24.6% of sudden infant death could be prevented in Aboriginal infants if they received any breastfeeding.

CONCLUSION: Interventions that promote, protect and support breastfeeding may prevent a substantial proportion of infection and mortality in Canadian Aboriginal infants.

KEY WORDS: Aboriginal; breast feeding; communicable diseases; sudden infant death; epidemiology

La traduction du résumé se trouve à la fin de l'article.

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Although infection and sudden infant death syndrome (SIDS) are common causes of morbidity and mortality in all infants,^{1,2} Aboriginal infants appear to be disproportionately burdened.³ This is true in indigenous populations worldwide.³ In Canada, such disparities exist in our three Aboriginal populations – First Nations, Inuit and Métis.⁴

Three infectious outcomes that Canadian Aboriginal infants experience in excess frequency are gastrointestinal infection, lower respiratory tract infection, and otitis media.^{5–9} Older Canadian data support a higher risk of gastrointestinal infection in Aboriginal groups compared to non-Aboriginal groups⁹ and there is similar evidence for American Indian and Alaska Native infants.⁸ Respiratory tract infections are not only more frequent among Aboriginal infants, they tend to result in more severe presentations requiring hospitalization.⁷ The same is true of otitis media. One study found that First Nations infants have a slightly elevated risk of any otitis media (10%) but a six times greater risk of hospitalization from otitis media compared with other Canadians.⁶ The substantial burden of otitis media has been well documented in Inuit Canadians.⁵ Canadian Aboriginal infants are also disproportionately affected by SIDS. First Nations infants are approximately five times more likely to die from SIDS compared with other Canadian infants; Inuit infants are approximately 12 times more likely to die.¹⁰ Infant health indicators for Métis are not readily available, but those of which we are aware suggest similar health profiles to other Aboriginal Canadians.⁴

Interventions and programs to decrease health disparities early in the life-course may not only impact the immediate health of Aboriginal Canadian infants, but could improve their overall health trajectories. One potential intervention is to promote breastfeeding. The World Health Organization (WHO) recommends infants receive exclusive breastfeeding to six months and continued breastfeeding with the addition of complementary foods to two years of age and beyond.¹¹ Several Canadian organizations, including Health Canada, concur.¹² The recommendation is substantiated by many short- and long-term benefits, including protection against SIDS,¹³ gastrointestinal infection,¹⁴ respiratory tract infection¹⁵ and otitis media.¹⁶

In recent years, the majority of Canadian mothers have initiated breastfeeding (87.4%).¹⁷ Canadian Aboriginals are less likely to do

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so (77.8%)¹⁷ and, accordingly, proportionally fewer Aboriginal children can reap the benefits of breastfeeding. Protecting, promoting and supporting breastfeeding could be a cost-effective means to improving population health outcomes in Canadian Aboriginal infants.

The objective of this research was to determine the proportion of excess cases of SIDS, gastrointestinal infection, respiratory tract infection, and otitis media that breastfeeding could potentially prevent in Aboriginal Canadian infants.

METHODS

The population attributable fraction (PAF) describes the proportion of disease in a population that can be attributed to a particular exposure. There are many approaches to calculating the PAF, but Levin's formula is the most frequently used.^{18,19} In its most basic form, Levin's formula includes the prevalence of exposure in the population (p_p) and a single relative risk – the risk of the outcome in the exposed relative to unexposed (RR).

$$\text{Levin's PAF} = \frac{p_p(RR - 1)}{1 + p_p(RR - 1)}$$

A corollary of the population attributable fraction (PAF) is the population prevented fraction (PPF): the fraction of cases that could be *prevented* in the population if everyone were exposed to the preventive behaviour. The PPF reframes the PAF formula in one important way: the prevalence of exposure in the population (p_p) is defined as the proportion of the population that *does not engage* in the preventive behaviour.²⁰ In other words, if we were interested in the PPF attributable to any breastfeeding and 90% of the population was breastfed for some duration, the prevalence of exposure (i.e., not receiving breastfeeding) would be 10%. Accordingly, all relative measures of association should be expressed in relation to the protective factor.

Our research used Levin's formula to estimate the PPF of select health outcomes attributable to breastfeeding in Aboriginal infants. Relative risks (RR) were extracted from previously published meta-analyses and the prevalence of exposure (p_p) from publicly available population-based surveys.^{21,22}

Data sources: prevalence of breastfeeding

Breastfeeding prevalence was abstracted from two national surveys: the Canadian Community Health Survey (CCHS)^{21,23} and the First Nations Regional Health Survey (RHS).²² We were specifically interested in breastfeeding initiation: all infants for whom breastfeeding was initiated were considered breastfed as infants.

Estimates of breastfeeding in Inuit, Métis and First Nations living off-reserve were abstracted from the CCHS (2007–2010) using the Government of Canada's Open Data.²¹ We also abstracted estimates for non-Aboriginal Canadians for comparison. Survey methodology for the CCHS is described in detail elsewhere.²³ Briefly, the CCHS is an annual population-based cross-sectional survey. Approximately 65,000 Canadians aged 12 years and older from each of the provinces ($n = 10$) and territories ($n = 3$) are sampled each year.²³

Estimates of breastfeeding of First Nations living on-reserve were abstracted from the *First Nations RHS, 2008/2010*.²² This was a cross-sectional national survey of First Nations communities conducted between June 2008 and November 2010. Participants in the RHS were recruited from 216 First Nations communities in Canada, covering all of the nation's provinces and territories except Nunavut: there are no reserves in this territory. The child component of the RHS contained the relevant questions on breastfeeding and was distributed to approximately 6,000 primary caregivers. More detailed methodology for the RHS is found elsewhere.²²

The CCHS asked all females aged 15 to 55 years of age who gave birth in the last five years if their child was ever breastfed. A similar question was asked of caregivers of children aged 11 years or younger in the RHS and our estimates were restricted to reports from biological mothers. Biological mothers generally have accurate recall of breastfeeding initiation: the sensitivity and specificity are 82% and 93% respectively up to 15 years after birth.²⁴ Table 1 presents the proportion of Aboriginal and other Canadian infants who were breastfed, as reported by the CCHS (2007–2010) and the RHS (2008/2010). Between 60% and 82% of Aboriginal Canadian infants were breastfed, compared to 88% of non-Aboriginal Canadian infants.

Data sources: relative risk of failing to breastfeed

The relative risks of not being breastfed on four separate health outcomes – SIDS, gastrointestinal infection, respiratory tract infection and otitis media – were abstracted from published meta-analyses.^{13–16} These outcomes were selected because Aboriginal Canadians are disproportionately affected by these conditions^{6–8,10} and breastfeeding reduces their incidence.^{13–16} Meta-analyses were identified from a Medline search, exploding the terms 'meta-analysis' and 'breastfeeding' separately and then combining with an 'and' statement. This search generated 152 potential articles; of these, we identified 9 potential meta-analyses through a title screen. For the current analyses, we selected the 4 most recently published meta-analyses of studies in healthy, term infants living in developed countries.^{13–16} The comparator of interest was receiving any vs. no breastfeeding,²⁵ which was not reported for respiratory tract infection.¹⁵ Instead we used a risk estimate comparing at least *four months of any breastfeeding* with no breastfeeding.¹⁵ We also preferred adjusted risk estimates, where available. A summary of the abstracted results is presented in Table 2.

Table 1. Prevalence of breastfeeding practices in Canada, by Aboriginal identity, 2007–2010

Aboriginal identity	Breastfeeding practice	
	Any breastfeeding*	No breastfeeding
First Nations – on-reserve ²²	60.2	39.8
First Nations – off-reserve ²¹	81.9	18.1
Inuit ²¹	76.8	23.2
Métis ²¹	78.2	21.8
Non-Aboriginal Canadians ²¹	87.8	12.2

* Also referred to as initiated breastfeeding.

Table 2. Relative risk estimates of breastfeeding on select infant health outcomes, abstracted from meta-analyses

Health outcome	Source of risk estimate	Comparator	RR (95% CI)	1/RR* (95% CI)
Sudden infant death	Hauck et al. (2011) ¹³	Any vs. none	0.55 (0.44–0.69)	1.82 (1.45–2.27)
Gastrointestinal infection	Chien et al. (2001) ¹⁴	Any vs. none	0.36 (0.32–0.41)	2.78 (2.44–3.12)
Hospitalization, lower respiratory tract infection	Bachrach et al. (2003) ¹⁵	At least 4 months vs. none	0.53 (0.30–0.93)	1.89 (1.08–3.33)
Otitis media	Ip et al. (2009) ¹⁶	Any vs. none	0.77 (0.64–0.91)	1.30 (1.10–1.56)

* 1/RR = Inverted risk estimate.

Table 3. Population prevented fraction (PPF) of infant health outcomes attributed to breastfeeding, by Aboriginal identity, 2007–2010

Health outcome	Aboriginal Canadians				Non-Aboriginal Canadians
	First Nations: on-reserve	First Nations: off-reserve	Inuit	Métis	
	PPF (95% CI)	PPF (95% CI)	PPF (95% CI)	PPF (95% CI)	
Sudden infant death	24.6 (15.2, 33.6)	12.9 (7.5, 18.7)	16.0 (9.4, 22.8)	15.1 (8.9, 21.7)	9.1 (5.2, 13.4)
Gastrointestinal infection	41.4 (36.4, 45.8)	24.4 (20.7, 27.7)	29.2 (25.0, 33.0)	27.9 (23.9, 31.6)	17.8 (14.9, 20.6)
Hospitalization, lower respiratory tract infection	26.1 (2.9, 48.2)	13.9 (1.4, 29.7)	17.1 (1.7, 35.1)	16.2 (1.6, 33.7)	9.7 (1.0, 22.2)
Otitis media	10.6 (3.8, 18.3)	5.2 (1.8, 9.2)	6.5 (2.2, 11.5)	6.1 (2.1, 10.9)	3.5 (1.2, 6.4)

Sudden Infant Death

The relative odds of SIDS in infants receiving any relative to no breastfeeding was abstracted from a meta-analysis of 18 case-control studies.¹³ Because SIDS is a rare outcome, the odds ratios from these studies will approximate risk ratios and can be substituted in Levin's formula to produce unbiased PPF estimates.¹⁹ Included studies used an "appropriate definition" of SIDS, which generally meant a sudden and unexpected infant death with competing causes ruled out by autopsy.¹³ The relative effect of any compared with no breastfeeding on SIDS was based on the pooling of 7 studies. All relative risks in this pooled estimate were adjusted for at least one of 19 covariates, including but not limited to maternal age, parity and social class.¹³

Gastrointestinal Infection

The relative risk of developing a gastrointestinal infection among infants receiving any compared with no breastfeeding was extracted from a meta-analysis of 14 cohort studies.¹⁴ The maximum follow-up was 12 months. Gastrointestinal infection was defined as any illness that resulted in vomiting or diarrhea or that was caused by a bacterial or viral agent known to result in enteric infection. The pooled relative risk was based on unadjusted measures of effect.¹⁴

Lower Respiratory Tract Infection

The effect of breastfeeding on developing a lower respiratory tract infection in infancy was taken from a meta-analysis pooling 4 prospective cohort studies.¹⁵ Follow-up in individual studies ranged from 6 to 24 months. The specific outcome of interest was hospitalization from lower respiratory tract infection, defined as bronchiolitis, asthma, bronchitis, pneumonia, empyema and other infections of the lower respiratory tract. The comparison of interest was breastfeeding for at least four

months relative to no breastfeeding. The pooled relative risk estimate was adjusted for social class.¹⁵

Acute Otitis Media

Relative risk estimates for developing acute otitis media in infants who received any breastfeeding relative to no breastfeeding were obtained from a meta-analysis of 2 cohort studies.¹⁶ Follow-up was up to 12 months. Acute otitis media was defined by the presenting clinical symptoms and was physician-diagnosed. The pooled relative risk was adjusted for confounding factors, which could have included maternal age, number of siblings or maternal smoking, among other variables.¹⁶

Statistical analysis

We estimated the PPF of four selected health outcomes that could be attributed to breastfeeding for Inuit, Métis and First Nations. First Nations may live on- or off-reserve and PPFs were estimated for both. We also estimated the PPF in the Canadian non-Aboriginal identity population. The exposure of interest was the prevalence of those who did not receive any breastfeeding (i.e., 1-prevalence_{initiation}). All abstracted risk estimates were inverted (i.e., 1/RR). Confidence limits were estimated using the substitution method.²⁶

RESULTS

PPF calculations used prevalence estimates of breastfeeding for Aboriginal and non-Aboriginal Canadians (Table 1) and relative risks from previously published meta-analyses (Table 2). The results of PPF calculations are presented in Table 3.

Inuit

We estimated that 6.5% of otitis media, 29.2% of gastrointestinal infection and 17.1% of hospitalizations from lower respiratory tract infections could potentially be prevented if Inuit Canadian

infants were breastfed. We also found that 16.0% of cases of SIDS in Inuit infants may be preventable.

First Nations

Among First Nations infants living off-reserve, we estimated that breastfeeding could potentially prevent 5.1% of otitis media, 24.3% of gastrointestinal infection, 13.8% of hospitalizations from lower respiratory tract infections, and 12.9% of SIDS. It is possible that breastfeeding could prevent even more of such outcomes in First Nations infants living on-reserve: 10.6% of otitis media, 41.4% of gastrointestinal infection, 26.1% of hospitalizations from lower respiratory tract infections, and 24.6% of SIDS.

Métis

We estimated that breastfeeding could potentially prevent 6.1% of otitis media, 27.9% of gastrointestinal infection, 16.2% of hospitalizations from lower respiratory tract infections, and 15.1% of instances of SIDS in Métis infants.

Non-Aboriginal

Non-Aboriginal Canadian infants would also benefit from breastfeeding, although we estimated that proportionately fewer instances of otitis media (3.5%), gastrointestinal infection (17.8%), hospitalizations from lower respiratory tract infection (9.7%), and SIDS (9.1%) were preventable.

DISCUSSION

This study estimated the proportion of excess cases of SIDS, gastrointestinal infection, respiratory tract infection and otitis media that potentially could be prevented if all Aboriginal infants were breastfed. We found that a substantial proportion of select infant health indicators may be prevented: between 13% and 25% of SIDS, 24% and 40% of gastrointestinal infection, 14% and 26% of hospitalizations from respiratory tract infections and 5% and 11% of otitis media. This proportion was between 1.5 to 2 times greater among Aboriginal as opposed to non-Aboriginal Canadian infants.

It has been suggested the PPF should be estimated only when the exposed group – in this case, those who do not receive any breastfeeding – can realistically become unexposed.¹⁸ There are very few contraindications to breastfeeding.¹² Exceptions include mothers with HIV, with concurrent substance use, or on certain medications and therapies (e.g., radiotherapy with iodine);²⁷ breastfeeding is also contraindicated for infants with galactosemia – a rare genetic disorder affecting lactose metabolism.¹² Aboriginal Canadians are disproportionately burdened by HIV²⁸ and accordingly, infants of affected mothers should not be breastfed. However, we do not expect the latter to constitute a large proportion of infants: a study in British Columbia estimated that 30 of 10,000 pregnant First Nations mothers tested positive for HIV between 2000 and 2003 – representing a rate three times higher than among other mothers, but still relatively rare.²⁸

The PPF also has utility when public health programs can be realistically developed and administered.¹⁸ Programs across the globe have been implemented to protect, promote and support breastfeeding. Our finding that a high proportion of infection

and SIDS in Aboriginal Canadians could be prevented if they were breastfed underscores the importance of targeting this population for focused intervention. One approach may be to promote breastfeeding to the women themselves. However, we agree with the recent recommendation to shift the bulk of responsibility for failure to breastfeed away from the woman and on to the health care system.²⁹

Measures such as implementing the Baby Friendly Hospital Initiative (BFHI) – an internationally embraced 10-item program put forward by WHO – may improve breastfeeding in Aboriginals and other Canadians and in turn reduce infant infection and mortality. Previous research suggests that adhering to BFHI recommendations improves breastfeeding initiation and duration.^{30,31} Prioritizing the adoption of the BFHI in hospitals where Aboriginal women give birth could be one potential approach. Another strategy that has shown some success is providing access to community-based programs, such as the Canadian Prenatal Nutrition Program (CPNP), which aims to improve the well-being of vulnerable infants through a variety of public health measures, including education, support and counselling. Women who accessed this program the most intensely were more likely to initiate and continue breastfeeding, and Aboriginal women who participated were more likely to initiate breastfeeding compared with non-Aboriginal participants.³² Any and all programs that are implemented to promote Aboriginal breastfeeding should be developed in consultation with Aboriginal women and, where possible, delivered by Aboriginal Canadians.

It is not surprising that the proportion of preventable illness and mortality was greater in Aboriginal compared with non-Aboriginal Canadians: the prevalence of breastfeeding was the only factor to vary across PPF calculations and Aboriginal Canadians were less likely to breastfeed. That said, the *overall number* of preventable infections and sudden infant deaths attributable to breastfeeding would almost certainly be greater in non-Aboriginal Canadians. Fewer than 10% of Canadian children aged 0 to 4 years report Aboriginal identity.³³ Even though the relative risk for each of this study's outcomes was greater in Aboriginal infants,^{6–9} Aboriginal Canadians would likely constitute a small fraction of the overall number of cases. We did not have access to the appropriate data to confirm, but this has been found elsewhere; for example, Aboriginal Canadians have a substantially higher incidence of TB but non-Aboriginal Canadians report the greatest number of TB cases.³⁴ As such, we also encourage mass population-based strategies that target breastfeeding in *all* new mothers. This approach will have the greatest impact on reducing the *overall number* of cases of infant infection and mortality.

There are several limitations which should be considered. Our PPF calculations were based on estimates abstracted from other sources. Prevalence estimates were from recent Canada-wide population-based surveys, and arguably provide some of the best estimates of breastfeeding practices in Aboriginal Canadians. Relative risks were from meta-analyses conducted in healthy, term infants in developed countries. Meta-analyses allow for more robust conclusions about the true magnitude of effects compared to individual studies, yet using relative risks from a variety of populations, the underlying assumption is that the

risk of endpoints – infection or mortality from SIDS – would be the same for Canadian Aboriginal infants. We do not expect this to be a concern since there is an established biological relationship between breast milk and immune function in infancy, existing irrespective of race and ethnicity.³⁵

The final abstracted relative risk estimates may have been biased as a result of a) residual confounding or b) heterogeneity in the unexposed group (i.e., those receiving breastfeeding). In regards to the former, risk estimates for gastrointestinal infection were unadjusted while risk estimates for respiratory tract infection were adjusted only for social class. In regards to the latter, the unexposed group may have included infants who were breastfed exclusively for 6 months as well as infants who were breastfed for less than one week. In either case, the magnitude of these abstracted relative effects may be exaggerated, resulting in an over-estimation of the PPF.

Finally, estimates of the PPF were generated using Levin's formula, which produces biased estimates with adjusted relative risks.²⁵ Alternative approaches that have the capacity to estimate an unbiased PPF using an adjusted relative risk require raw data that we do not have: we need to know the proportion of cases of disease (e.g., respiratory tract infection) where there was no breastfeeding.^{18,19} It is not uncommon to use Levin's formula in these circumstances,³⁶ and a recent article studied the anticipated direction of bias from adjusted estimates.²⁵ Most relevant to the current study, using Levin's formula when adjusted estimates are positively confounded results in an underestimation of the PPF. Positive confounding occurs when an exposure (e.g., not breastfeeding) is positively associated with the outcome, and a confounder is negatively associated with both the exposure and outcome.³⁷ Our adjusted risk estimates were likely positively confounded, resulting in a more conservative PPF. Consider how social class would affect the relationship between breastfeeding and respiratory tract infection. Not breastfeeding is positively associated with risk of lower respiratory tract infection,¹⁵ and higher social class is negatively associated with both a) not breastfeeding¹⁷ and b) respiratory tract infection.¹⁵ Thus, the anticipated direction of bias from failing to adjust for social class would be further from the null, i.e., a positive confounder.³⁷

In spite of these limitations, this research provides quantitative support for prioritizing breastfeeding promotion in Aboriginal Canadians. Combining effective breastfeeding programs with interventions and measures to improve social conditions in Aboriginal communities is an important step toward eliminating health disparities in Aboriginal and other Canadian infants.

CONCLUSION

Respiratory tract infection, gastrointestinal infection, otitis media and SIDS are important causes of infant morbidity and mortality that disproportionately affect Aboriginal Canadians. Interventions and programs to protect, promote and support breastfeeding may prevent a substantial proportion of these. These interventions should be developed in consultation and collaboration with indigenous populations to enhance cultural acceptability.

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RÉSUMÉ

OBJECTIFS : La santé des nourrissons autochtones canadiens est mauvaise par rapport à celle des autres nourrissons canadiens. L'allaitement maternel protège contre plusieurs infections infantiles que les Autochtones canadiens contractent de façon disproportionnée. L'objectif de notre recherche était d'estimer la proportion d'infections infantiles sélectionnées et la mortalité qui en résulte qui pourraient être évitées si tous les nourrissons autochtones canadiens étaient nourris au sein.

MÉTHODES : Nous avons utilisé la formule de Levin pour estimer la proportion de trois infections contractées et d'une mortalité qui aurait pu être évitées grâce à l'allaitement maternel. On a fait des estimations pour les Premières Nations (à l'intérieur comme à l'extérieur des réserves), les Métis et les Inuits, de même que pour tous les nourrissons canadiens à titre de comparaison. Nous avons extrait l'estimation de la prévalence des pratiques d'allaitement maternel à partir d'études nationales fondées sur la population. Nous avons extrait l'estimation du risque relatif des méta-analyses publiées.

RÉSULTATS : De 5,1 % à 10,6 % des otites moyennes, de 24,3 % à 41,4 % des infections gastro-intestinales, de 13,8 % à 26,1 % des hospitalisations dues aux infections des voies respiratoires inférieures et de 12,9 % à 24,6 % des morts subites de nourrissons auraient pu être évitées chez les nourrissons autochtones s'ils avaient été nourris au sein.

CONCLUSION : Les interventions qui favorisent, protègent et appuient l'allaitement maternel pourraient éviter une forte proportion des infections et des décès chez les nourrissons autochtones canadiens.

MOTS CLÉS : Autochtone; allaitement maternel; maladies transmissibles; mort subite du nourrisson; épidémiologie