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Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

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Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

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Abstract

Objectives: Immigrants are thought to be healthier than their native-born counterparts, but less is known about the health of refugees or forced migrants. Previous studies often equate refugee status with immigration status or country of birth (COB) and none have matched refugees to non-refugee immigrants on COB. Herein, we examined whether: i) refugee status, irrespective of immigration status and COB, is a risk indicator for adverse maternal and perinatal health outcomes, and ii) refugee and non-refugee immigrants differ from Canadian-born mothers for maternal and perinatal outcomes.

Design: This is a retrospective population-based database study. We implemented two designs: i) 1:1 matching of refugees to non-refugee immigrants on COB and ii) an unmatched design using all data.

Setting and participants: Refugee immigrants (N=52,360), non-refugee immigrants (N=360,007) and Canadian-born mothers (N=977,045) eligible for universal health care insurance who had a hospital birth in Ontario, Canada between 2002 and 2014.

Primary outcomes: Numerous adverse maternal and perinatal health outcomes.

Results: Refugees did not differ from non-refugee immigrants for most adverse maternal and perinatal outcomes, except for HIV, with respective rates of 0.36% and 0.17% and an ARR of 1.67 (95% CI 1.17-2.37). Other elevated outcomes included gestational diabetes mellitus (ARR 1.10, 95% CI 1.04-1.17), moderate preterm birth (ARR 1.10, 95% CI 1.03-1.19) and very preterm birth (ARR 1.18, 95% CI 0.99-1.42). Separately comparing refugee and non-refugee immigrants to Canadian-born mothers, the ARRs for each immigrant group were generally in the same direction and of a similar magnitude, with refugee and non-refugee immigrant mothers faring worse for one third of outcomes.

Conclusions: Refugee status was not strongly associated with adverse maternal and perinatal health outcomes. The definition of refugee status used herein may not sensitively identify refugees at highest risk. Future research would benefit from further refining refugee status based on migration experiences.

Strengths and limitations of this study

- This is a retrospective population-based cohort study from Ontario, Canada linking official permanent resident immigration, hospital and physician billing data to compare deliveries between 2002 and 2014 from refugee mothers (N=52,360) to both non-refugee immigrant mothers (N=360,007) and Canadian-born mothers (N=977,045).
- This is the first study to match refugee immigrant to non-refugee immigrant mothers on country of birth, making it possible to explicitly determine whether excess risk among refugees is independent of a woman's country of birth.
- This is the largest study of refugee maternal and perinatal health in the literature.
- The administrative definition of refugee status used in this study may not be sensitive enough to identify refugees with greater health risks or greater health care needs.

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Introduction

Refugees are considered an extremely vulnerable group for adverse health outcomes.[1] Canada, and other signatories to the United Nations (UN) Convention Relating to the Status of Refugees, define refugees as persons who fear persecution or violence because of their race, religion, nationality or political views and are forced to flee their home countries.[2] In Canada 10% of the 250,000 immigrants who become permanent residents each year are admitted as refugees.[3] Most non-refugee permanent residents are skilled workers or their family members. Skilled immigrants are selected based on high levels of education, official language fluency, and work experience. Family class immigrants must be related to a permanent resident or Canadian citizen able to provide financial support. This is in contrast to refugees who are either chosen based on vulnerability by the UN High Commissioner for Refugees (UNHCR) or, claim refugee status upon arrival and have the claim accepted by an independent tribunal.[4] Given differing exposures in: countries of origin (e.g., conflict), transition countries (e.g., poor access to health services), post-migration exposures (e.g., discrimination); and receiving country immigration policies, the maternal and perinatal health of refugees may differ from their non-refugee immigrant counterparts.[5,6]

To advance knowledge of the relationship between refugee status and health, we used population-based administrative health care and immigration data from Ontario, the province which receives about half of all refugees arriving to Canada [3]. First, we aimed to determine whether refugee immigrants experience greater risk of adverse maternal and perinatal health outcomes above and beyond that experienced by non-refugee immigrants from the same country of birth. Few refugee maternal and perinatal health studies in Canada [5–8] or in other countries [9] compare refugees to non-refugee immigrants. Many studies use a native-born comparator and attribute excess risk to refugee status even though a non-refugee immigrant comparator is absent [10–15]. In addition, many studies rely on country of birth as an indicator of refugee migration [11–18] rather than identifying refugees based on their legal status or migration history. These details are critical, since specialized maternal and perinatal health care tailored to refugees cannot be effectively justified if a "refugee effect" cannot be differentiated from an "immigrant effect" or "country effect". Second, we compared maternal and perinatal health outcomes among refugee and non-refugee immigrant mothers to Canadian-born mothers. Research often finds that immigrants are healthier than the native-born population, the so-called "healthy migrant effect"[19]. However, this may not apply to refugees given their differential exposure to health risks prior to arrival (as described above). Results from refugee maternal and perinatal health studies are mixed.[5,6,12] Secondary analyses focused on the top 5 refugee source countries (Sri Lanka, Somalia, Afghanistan, Iran, and China).

Methods

Study Design and Inclusion/Exclusion Criteria

This retrospective population-based database study included all Ontario hospital childbirth admissions occurring between April 1, 2002 and March 31, 2014. A matched cohort design was used to isolate the excess risk conferred by refugee status beyond that of immigration and country of birth, while a non-matched cohort design used all available data to compare outcomes of refugee and non-refugee immigrants to Canadian-born mothers. Deliveries to refugee and non-refugee immigrant mothers were identified retrospectively through linkage of hospital admissions to the Immigration and Refugees Citizenship Canada Permanent Resident Database (IRCC-PRD). The cost of health care services was not a barrier to accessing care since all mothers were eligible for universal, publicly funded health care insurance. Deliveries not linked to the IRCC PRD were attributed to *Canadian-born mothers*. We reduced the bias attributed to unlinked migrant mothers among Canadian-born mothers by further restricting to mothers who: i) became eligible for provincial health care insurance on or before 1990 (the

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first year insurance eligibility was recorded – those eligible prior to 1990 were given an eligibility start year of 1990) and less likely to be immigrants; ii) were born in an Ontario hospital after 1991 (the first year births were available in hospital data) or; iii) became eligible for provincial health care insurance within 1 year of their year of birth and therefore lived in Ontario from a very young age.

For maternal outcomes, the unit of analysis was the delivery episode, where multiple births were counted as a single delivery. For all perinatal outcomes, the unit of analysis was restricted to singletons. Since the outcomes are commonly used in epidemiologic surveillance, Canadian Perinatal Surveillance System [20] definitions were used where possible. Analysis of preterm birth (PTB) was restricted to live births between 22-41 weeks gestational age (GA) and a birth weight (BWT) of ≥500 grams (g); neonatal intensive care (NICU) admission - live births with GA ≥20 weeks or a BWT ≥500 g; neonatal mortality - live births with a BWT ≥500 g; any congenital anomaly - stillbirths and live births with a GA ≥20 weeks or a BWT ≥500 g; stillbirth - GA ≥20 weeks or a BWT ≥500 g; perinatal mortality - stillbirths and live births with a GA ≥20 weeks or a BWT ≥500 g.

Data Sources

We linked five administrative databases held at the Institute for Clinical and Evaluative Sciences (ICES) in Toronto, Ontario. These datasets were linked using unique encoded identifiers and analyzed at ICES.

The IRCC-PRD is administered by the Canadian government. The Ontario portion of this dataset contains information on all international migrants successful in obtaining permanent residency between 1985 and 2012. The IRCC-PRD contained <1% of missing values for all variables. Eighty-six percent of IRCC-PRD individuals (91.6% of all refugees) were linked to Ontario's health care registry, consisting of all persons eligible for publicly funded health care insurance in the province of Ontario between April 1, 1990 and March 31, 2014. Little bias in the linkage was detected.[21] The health care registry also contains date of health care eligibility, neighborhood income quintile and date of death.

Childbirth records were obtained from the Discharge Abstract Database originating from the Canadian Institute of Health Information. Diagnosis and procedure codes using the 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI) identified women with all maternal or perinatal outcomes except early neonatal and neonatal mortality. A validation study supported the use of this database for perinatal research.[22] This dataset also contains information on maternal age at the time of delivery, self-reported parity and birth plurality.

The Office of the Registrar General's Vital Statistics-Death registry was used to identify early neonatal mortality (0-7 days of life) and neonatal mortality (0-28 days of life) between 2002 and 2012. 96.2% of records in the Vital Statistics Registry were successfully linked to the health care registry and little bias in the linkage was detected.[21] However, individuals between the ages of 0 and 14 years were more likely to be unlinked. Vital Statistics data were supplemented by mortality recorded in the health care registry and other administrative health care databases, however early neonatal deaths may also be missing in the health care registry because health care numbers may not have been issued.[21]

The Ontario HIV Database (1992-2014) uses an algorithm consisting of at least three physician HIV diagnoses in a 3-year period to identify HIV positive persons. The algorithm demonstrated 96.2% sensitivity and 99.6% specificity when compared to patient charts.[23] HIV diagnoses were restricted to women diagnosed prior to child birth.

Variables

Refugee status was defined using the IRCC-PRD. Refugees included government assisted refugees, privately sponsored refugees, successful refugee claimants and refugee dependents (i.e., family members listed on the primary applicant's permanent residency application for refugee status). Non-

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refugee immigrants included economic and family class immigrants. Canadian-born women are described above (under "Study Design and Inclusion/Exclusion Criteria").

We examined several maternal and perinatal health outcomes (see Supplementary Table S1 for codes). Severe maternal morbidity (SMM), was evaluated using a composite surveillance indicator [24,25] developed by the Canadian Perinatal Health Surveillance System. A woman had SMM if she had one or more of forty-five ICD-10-CA/CCI diagnoses or procedures reported during hospital admission for labour or delivery.[24] Other maternal health outcomes, documented at the time of delivery, were: complicated urinary tract infection (UTI), pre-existing hypertension, gestational hypertension, preeclampsia, eclampsia, pre-pregnancy diabetes, gestational diabetes mellitus (GDM), caesarean section, post-partum hemorrhage (PPH) and maternal intensive care unit (ICU) admission. Perinatal outcomes, documented at birth, included: any congenital anomaly, moderate preterm birth (MPTB) (32-36 weeks gestation), very preterm birth (VPTB) (< 32 weeks gestation), neonatal ICU (NICU) admission and stillbirth. Measurement of early neonatal mortality (0-7 days of life) and neonatal mortality (0-28 days of life) were not restricted to the hospital delivery admission. Information from both the ORGD and the RPDB were combined to identify early neonatal and neonatal mortality. Early neonatal mortality was combined with information on stillbirth to identify perinatal mortality.

Potential confounders were identified *a priori*. Some control variables were available for all deliveries, including maternal age at delivery (15-19, 20-24, 25-29, 30-34, 35-39, 40+ years), neighborhood income quintile, parity (0, 1, 2 or ≥ 3 previous births) and plurality. Other control variables were only available for refugees and non-refugee immigrants since this information was collected in the IRCC-PRD. These included: maternal country of birth (COB), COBs categorized into world sub-regions according to the UN classification system with a modification to the developed countries classification [26]; maternal education at arrival (0-9 years, 10-12 years, 13+ years, trade certificate/non-university diploma, University degree); knowledge of official Canadian languages at arrival (English and/or French or neither); and duration of residence in Canada, defined as the time (in years) elapsed between the date of becoming a permanent resident and the date of delivery.

Analysis

Multivariable log-binomial regression was used for all analyses. Deliveries with missing data for any control variable were excluded. To estimate an independent association with refugee status, we considered the potential heterogeneity in countries represented among refugees and non-refugees and the potential for this to bias the frequency of the outcome by 1:1 matching of first deliveries in Canada among refugees to non-refugee immigrants. Analyses were restricted to the first delivery in the hospitalization database to prevent matching several deliveries from a single refugee mother to deliveries to more than one non-refugee immigrant mother. Generalized estimating equations (GEE) with an exchangeable correlation matrix were used to take into account paired cohort data.[27] Models were adjusted for maternal age at delivery, parity, neighborhood income, education at arrival, knowledge of official languages at arrival and duration of residence in Canada. In secondary analyses focusing on refugee and non-refugee immigrants from the top 5 refugee source countries of birth, all deliveries were included and non-independence of the outcome among deliveries to the same mother was accounted for with GEE.

To compare refugee and non-refugee mothers to Canadian-born mothers all deliveries were included and GEE was used to account for non-independence of the outcome among deliveries from the same mother. Fewer variables were available for Canadian-born women so models could only be adjusted for maternal age at delivery, parity and neighborhood income.

Research Ethics

This study was approved by the institutional review board at Sunnybrook Health Sciences

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Centre, and the ethics review board of St. Michael's Hospital, Toronto, Canada.

Results

Table 1 summarizes the characteristics of deliveries to refugee immigrant (N=52,360), non-refugee immigrant (N=360,007) and Canadian-born mothers (N=977,045). More refugee mothers (13.9%) had high parity (≥ 3 previous births) compared to both non-refugee immigrant (5.8%) and Canadian-born mothers (5.5%). A greater proportion of refugees had less than 13 years of education at arrival (74.5%) compared to non-refugee immigrants (45.4%). South Asia and Sub-Saharan Africa contributed the most refugees (27.4% and 24.0%, respectively).

For most outcomes, differences between refugees and non-refugees matched on COB were non-significant (see Figures 1 and 2). GDM (ARR=1.10 95% CI 1.04-1.17), HIV (ARR=1.67 95% CI 1.17-2.37 and MPTB (ARR=1.10 95% CI 1.03-1.19) were significantly higher among refugees. VPTB approached statistical significance (ARR=1.18, 95% CI 0.99-1.42).

Supplementary Figures (S1a/b through S5a/5b) disaggregate results according to the top 5 refugee source countries to Ontario– Sri Lanka, Somalia, Afghanistan, Iraq and China. Afghan and Iraqi refugees had higher risk of caesarean section while Sri Lankan and Somali refugees experienced higher risk of MPTB compared to their same-country non-refugee counterparts.

Figures 3 and 4 compare both refugees to Canadian-born mothers and non-refugee immigrants to Canadian-born mothers. Other than severe maternal morbidity (SMM) and HIV, the two sets of ARRs comparing refugees to Canadian-born mothers and non-refugees to Canadian-born mothers were in the same direction and of a similar magnitude. With respect to SMM (Figure 3), refugees had a significantly higher rate compared to Canadian-born mothers while non-refugee immigrant mothers had a significantly lower rate. However, after HIV was removed from the SMM index refugees experienced a similar rate of SMM to Canadian-born mothers. For other maternal outcomes (Figure 3), both refugees and non-refugees compared to Canadian-born mothers had: *significantly lower risk* of complicated UTI, pre-existing hypertension, gestational hypertension, preeclampsia, eclampsia, pre-pregnancy diabetes, and PPH; and *significantly higher risk* of caesarean section, GDM, maternal ICU admission and HIV. In terms of perinatal outcomes (Figure 4), both refugees and non-refugees compared to Canadian-born mothers had: *significantly lower risk* of any congenital anomaly and MPTB; similar risk of VPTB and neonatal mortality; and *significantly higher risk* of NICU admission, perinatal mortality and stillbirth.

Discussion

We found modest increased risks of GDM, MPTB and VPTB among refugee compared to non-refugee mothers from the same COB. HIV was the exception with a much greater prevalence. Overall, our findings suggest that refugee status, measured with an administrative definition, is not a strong risk indicator for poor maternal and perinatal health. In addition, we found that refugee and non-refugee mothers experienced the same direction and a similar magnitude of relative risk for almost all outcomes when each group was separately compared to Canadian-born mothers. About one third of outcomes were significantly worse among refugee and non-refugee immigrant mothers when compared to Canadian-born mothers.

The findings on SMM and HIV are explained in detail in a previous report of ours [5] (although unmatched on COB). Our current results are consistent with the previous study however with smaller HIV prevalence ratios. The smaller prevalence ratio can likely be explained by the different method used to capture HIV diagnoses (hospital discharge data in the previous study and HIV physician diagnoses data in the current study) but also because 1:1 matching of refugee to non-refugee immigrants on COB in the current study accounted for some of the difference between refugee and non-refugee immigrants. In our previous work we found that refugee mothers with HIV did not have any greater maternal morbidity compared to non-refugee immigrant or Canadian-born mothers with HIV, suggesting

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that HIV during pregnancy is well-managed in Ontario regardless of refugee status (with permanent residency). In contrast, a Dutch study [9] describes HIV as a risk indicator for severe acute maternal morbidity among asylum-seekers (refugees without permanent residency); suggesting that a lack of appropriate HIV care may be contributing to SAMM.

Afghan and Iraqi refugee mothers were ~20% more likely to experience caesarean section than their non-refugee counterparts. A study involving 10 Canadian hospitals [28] found a significant difference between refugee, asylum-seeker and non-refugee immigrants from South-East and Central Asia (56.7%, 28.6%, 26.0%, respectively). Reasons for the higher caesarean rate among refugees were: higher parity, medical complications, low socio-economic status, socio-cultural factors and sub-optimal perinatal care.[28]

Refugee status was also positively associated with GDM, MPTB and VPTB. Sri Lankan and Somali refugees had a greater risk of MPTB. The relationship between refugee status and GDM may be explained by a study which found stressful events were associated with 2.5 times greater risk of GDM.[29] Other research suggests maternal chronic stress is an important risk factor for PTB,[30] particularly among socially disadvantaged populations.[31] Previously published research of ours found that the effect of refugee status on PTB was stronger among refugee mothers who resided in a transition country prior to arriving in Canada [7] with potentially greater exposure to psychosocial stress. The hypothesized physiological mechanism connecting psychosocial stress to both GDM and PTB involves dysfunction of regulatory hormones in the body - insulin resistance or impaired insulin metabolism leading to GDM [29] and early release of hormones required for the initiation of labour leading to PTB.[30]

The extent to which refugee and non-refugee immigrants experienced the "healthy migrant effect" (HME) (relative to Canadian-born mothers) for all maternal and perinatal health outcomes was identical. We found that both refugee and non-refugee immigrants experienced higher risk of the same adverse maternal and perinatal health outcomes (1/3 of all outcomes examined) compared to Canadian-born mothers. This suggests that refugee status, using an administrative definition of refugees, is not an important factor in the HME for these outcomes. These findings are also consistent with others who have stated that the HME is not evident for all health outcomes.[32]

Strengths and Limitations

Among studies examining refugee maternal and perinatal health [5–18,33–44], our study has several unique and important strengths. Firstly, our study used official government immigration data to identify women who met the UNHCR definition of a refugee rather than relying on COB as an indicator of refugee status, as many previous studies have done.[11–18] Secondly, we matched refugee and non-refugee immigrant women on COB (see Supplementary Figures S6 & S7 for unmatched results). By matching on COB, ours is the first study to effectively address the question of whether refugee status, independent of COB, is a risk indicator for adverse maternal and perinatal outcomes. Thirdly, to our knowledge our study includes the largest sample of mothers legally classified as refugees reported in the literature contributing to adequate statistical power for our main analyses (objectives 1 and 2).

This study is not without limitations. Firstly, the "refugee experience" as it pertains to health risks may not be consistent with the legally applied definition of "refugee". Risk factors for adverse outcomes (i.e., exposure to violence, forced family separation) are context dependent, such as the length of time in the migration phase and access to health and other supportive services before and during migration - factors for which we did not have data. We addressed context by matching refugees to non-refugees on COB a well as restricting analyses to the top 5 refugee-source countries; however even within these COBs there is likely important heterogeneity which we could not examine. Sponsorship status (government assisted and privately sponsored refugees vs. successful refugee claimants) was examined in secondary analyses but other than gestational diabetes, no significant

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effects were found. A second limitation is the inability to categorize family class non-refugee immigrants according to the permanent residency status of the sponsoring family member (i.e., economic or refugee). This may have caused some refugees to be misclassified as non-refugee immigrants and contributed to biasing estimates in Figures 1 and 2 towards the null. However, given that refugees make up ~10% of all permanent residents to Canada and are less likely to have the financial means necessary for sponsorship, the number of family class members who may be refugees is not likely to substantially affect risk estimates. A third limitation may be that estimates in Figures 1 and 2 were over-adjusted given that the majority of non-refugee permanent residents are selected based on their education and official language ability. However, unadjusted estimates (see Supplementary Table S2) demonstrate that adjusting for these variables does not affect our conclusions. Finally, our findings are not generalizable to *unsuccessful* refugee claimants being that our study is limited to permanent residents, including *successful* refugee claimants, who have access to universal comprehensive health care.

Implications

To help understand modest differences in GDM, MPTB and VPTB between refugee and non-refugee immigrant women, further research into stressors refugee mothers experience in their countries of origin, in transition countries and in countries of re-settlement may help support development of preconception and pregnancy stress prevention and management strategies.

Overall, based on an administrative definition of refugee, we do not find a strong need to enhance health care for refugee mothers and their infants in Canada. There are a few important caveats to this interpretation. Firstly, and perhaps most importantly, the administrative definition of refugees is broad and is perhaps unable to sensitively identify refugees at highest health risk. Secondly, non-refugee immigrants from refugee-source countries may be just as likely to experience pre-departure health risks as their refugee counterparts, reducing specificity and minimizing any differences between the groups. Thirdly, community resources targeting the unique health and resettlement needs of refugees [45,46] as well as efforts focusing on equity and migrant friendly maternity care [47] may be helping to minimize disparities. Lastly, despite official immigration admission policies [5,48] which appear to select for vulnerable refugees, it may be possible that unofficial processes may favour selection of healthy refugees, similar to official processes that select for non-refugee immigrants.

Future Research

Refugees should be compared to non-refugee immigrants, preferably from the same country of birth, as this more effectively addresses the question of whether refugees, among all migrants, are at increased risk for poor health. Further refining refugee status based on detailed migration experiences would also be beneficial. Finally, to help facilitate international comparisons, refugee health researchers may find it useful to state if and how immigration policies shape the health of refugees relative to other immigrants within their borders.

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References

1 Gagnon AJ, Merry L, Robinson C. A systematic review of refugee women's reproductive health. *Refuge* 2002.

2 Citizenship and Immigration Canada. Guide 6000 - Convention Refugees Abroad and Humanitarian-Protected Persons Abroad. 2017.http://www.cic.gc.ca/English/information/applications/guides/E16000TOC.asp (accessed 1 May 2017).

3 Immigration, Refugees & Citizenship Canada. Facts & Figures 2015: Immigration Overview - Permanent Residents – Annual IRCC Updates. Canada - Permanent residents by province or territory and category. 2015. http://www.cic.gc.ca/opendata-donneesouvertes/data/IRCC_FFPR_17_F.xls (accessed 11 May 2017).

4 Settlement.org. How does Canada's refugee system work? 2017.http://settlement.org/ontario/immigration-citizenship/refugees/basic-information-for-refugees/how-does-canada-s-refugee-system-work/ (accessed 1 May 2017).

5 Wanigaratne S, Cole DC, Bassil K, *et al.* Contribution of HIV to Maternal Morbidity Among Refugee Women in Canada. *Am J Public Health* 2015;**105**:2449–56. doi:10.2105/AJPH.2015.302886

6 Wanigaratne S, Cole DC, Bassil K, *et al.* Severe Neonatal Morbidity Among Births to Refugee Women. *Matern Child Health J* 2016;**20**:2189–98. doi:10.1007/s10995-016-2047-4

7 Wanigaratne S, Cole DC, Bassil K, *et al.* The influence of refugee status and secondary migration on preterm birth. *J Epidemiol Community Health* 2016;**70**:622–8. doi:10.1136/jech-2015-206529

8 Vigod SN, Bagadia AJ, Hussain-Shamsy N, *et al.* Postpartum mental health of immigrant mothers by region of origin, time since immigration, and refugee status: a population-based study. *Arch Womens Ment Health* Published Online First: 4 April 2017. doi:10.1007/s00737-017-0721-1

9 Van Hanegem N, Miltenburg AS, Zwart JJ, *et al.* Severe acute maternal morbidity in asylum seekers: a two-year nationwide cohort study in the Netherlands. *Acta Obstet Gynecol Scand* 2011;**90**:1010–6.

10 Gagnon AJ, Dougherty G, Wahoush O, *et al.* International migration to Canada: The post-birth health of mothers and infants by immigration class. *Soc Sci Med* 2012;**76**:197–207.

11 Vangen S, Stoltenberg C, Johansen REB, *et al.* Perinatal complications among ethnic Somalis in Norway. *Acta Obstet Gynecol Scand* 2002;**81**:317–22.

12 Essen B, Hanson BS, Ostergren PO, *et al.* Increased perinatal mortality among sub-Saharan immigrants in a city-population in Sweden. *Acta Obstet Gynecol Scand* 2000;**79**:737–43.

13 Belihu FB, Davey M-A, Small R. Perinatal health outcomes of East African immigrant populations in Victoria, Australia: a population based study. *BMC Pregnancy Childbirth* 2016;**16**. doi:10.1186/s12884-016-0886-z

9

14 Bakken KS, Skjeldal OH, Stray-Pedersen B. Immigrants from conflict-zone countries: an observational comparison study of obstetric outcomes in a low-risk maternity ward in Norway. *BMC Pregnancy Childbirth* 2015;**15**. doi:10.1186/s12884-015-0603-3

15 Miller LS, Robinson JA, Cibula DA. Healthy Immigrant Effect: Preterm Births Among Immigrants and Refugees in Syracuse, NY. *Matern Child Health J* 2016;**20**:484–93. doi:10.1007/s10995-015-1846-3

16 Gibson-Helm M, Teede H, Block A, *et al.* Maternal health and pregnancy outcomes among women of refugee background from African countries: a retrospective, observational study in Australia. *BMC Pregnancy Childbirth* 2014;**14**:392.

17 Gibson-Helm M, Boyle J, Cheng I-H, *et al.* Maternal health and pregnancy outcomes among women of refugee background from Asian countries. *Int J Gynecol Obstet* 2015;**129**:146–51. doi:10.1016/j.ijgo.2014.10.036

18 Gibson-Helm M, Teede H, Cheng I-H, *et al.* Maternal health and pregnancy outcomes comapring migrant women born in humanitarian and nonhumanitarian source courtries: a retrospective, observational study. *Birth* 2015;**42**:116–24.

19 Urquia ML, Gagnon AJ. Glossary: migration and health. *J Epidemiol Community Health* 2011;**65**:467–472.

20 Public Health Agency of Canada. Perinatal Health Indicators for Canada - 2011. 2011. http://www.phac-aspc.gc.ca/rhs-ssg/phi-isp-2011-eng.php (accessed 15 Aug 2013).

21 Chiu M, Lebenbaum M, Lam K, *et al.* Describing the linkages of the immigration, refugees and citizenship Canada permanent resident data and vital statistics death registry to Ontario's administrative health database. *BMC Med Inform Decis Mak* 2016;**16**. doi:10.1186/s12911-016-0375-3

22 Joseph KS, Fahey J. Validation of perinatal data in the Discharge Abstract Database of the Canadian Institute for Health Information. *Chronic Dis Can* 2009;**29**:96–100.

23 Antoniou T, Zagorski B, Loutfy MR, *et al.* Validation of Case-Finding Algorithms Derived from Administrative Data for Identifying Adults Living with Human Immunodeficiency Virus Infection. *PLoS ONE* 2011;**6**:e21748. doi:10.1371/journal.pone.0021748

24 Joseph KS, Liu S, Rouleau J, *et al.* Severe maternal morbidity in Canada, 2003 to 2007: surveillance using routine hospitalization data and ICD-10CA codes. *J Obstet Gynaecol Can* 2010;**32**:837–846.

25 Liu S, Joseph KS, Bartholomew S, *et al.* Temporal trends and regional variations in severe maternal morbidity in Canada, 2003 to 2007. *J Obstet Gynaecol Can* 2010;**32**:847–855.

26 United Nations Statistics Division. Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groups. 2013.http://unstats.un.org/unsd/methods/m49/m49regin.htm (accessed 13 Oct 2016).

27 Alexander MT, Kufera JA. Butting heads on matched cohort analysis using SAS software. 2007.

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28 Gagnon AJ, Van Hulst A, Merry L, *et al.* Cesarean section rate differences by migration indicators. *Arch Gynecol Obstet* 2013;**287**:633–9. doi:10.1007/s00404-012-2609-7

29 Hosler AS, Nayak SG, Radigan AM. Stressful events, smoking exposure and other maternal risk factors associated with gestational diabetes mellitus. *Paediatr Perinat Epidemiol* 2011;**25**:566–574.

30 Latendresse G. The interaction between chronic stress and pregnancy: preterm birth from a biobehavioral perspective. *J Midwifery Women's Health* 2009;**54**:8–17.

31 Wadhwa PD, Entringer S, Buss C, *et al.* The contribution of maternal stress to preterm birth: issues and considerations. *Clin Perinatol* 2011;**38**:351–84. doi:10.1016/j.clp.2011.06.007

32 Vang ZM, Sigouin J, Flenon A, *et al.* Are immigrants healthier than native-born Canadians? A systematic review of the healthy immigrant effect in Canada. *Ethn Health* 2017;**22**:209–41. doi:10.1080/13557858.2016.1246518

33 Goosen S, Hoebe CJ, Waldhober Q, *et al.* High HIV prevalence among asylum seekers who gave birth in the Netherlands: a nationwide study based on antenatal HIV tests. *PloS One* 2015;**10**:e0134724.

34 Dennis C-L, Merry L, Stewart D, *et al.* Prevalence, continuation, and identification of postpartum depressive symptomatology among refugee, asylum-seeking, non-refugee immigrant, and Canadian-born women: results from a prospective cohort study. *Arch Womens Ment Health* 2016;**19**:959–67. doi:10.1007/s00737-016-0633-5

35 Dennis C-L, Merry L, Gagnon AJ. Postpartum depression risk factors among recent refugee, asylum-seeking, non-refugee immigrant, and Canadian-born women: results from a prospective cohort study. *Soc Psychiatry Psychiatr Epidemiol* 2017;**52**:411–22. doi:10.1007/s00127-017-1353-5

36 Gann P, Nghiem L, Warner S. Pregnancy characteristics and outcomes of Cambodian refugees. *Am J Public Health* 1989;**79**:1251–7.

37 Flynn PM, Foster EM, Brost BC. Indicators of acculturation related to Somali refugee women's birth outcomes in Minnesota. *J Immigr Minor Health* 2011;**13**:224–231.

38 Kandasamy T, Berniak R, Shah R, *et al.* Obstetric Risks and Outcomes of Refugee Women at a Single Centre in Toronto. *J Obstet Gynaecol Can* 2014;**36**:296–302.

39 Davis JM, Goldenring J, McChesney M, *et al.* Pregnancy outcomes of Indochinese refugees, Santa Clara County, California. *Am J Public Health* 1982;**72**:742–4.

40 Lalchandani S, MacQuillan K, Sheil O. Obstetric profiles and pregnancy outcomes of immigrant women with refugee status. *Ir Med J* 2001;**94**:79–80.

41 King PA, Duthie SJ, Li DFH, *et al.* Obstetric outcome among Vietnamese refugees in Hong Kong: an age-matched case-controlled study. *Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet* 1990;**33**:203–10.

42 Malamitsi-Puchner A, Tzala L, Minaretzis D, *et al.* Preterm delivery and low birthweight among refugees in Greece. *Paediatr Perinat Epidemiol* 1994;**8**:384–390.

11

43 Kuvacic I, Skrablin S, Hodzic D, *et al.* Possible influence of expatriation on perinatal outcome. *Acta Obstet Gynecol Scand* 1996;**75**:367–71.

44 Liu C, Urquia M, Cnattingius S, *et al.* Migration and preterm birth in war refugees: a Swedish cohort study. *Eur J Epidemiol* 2014;**29**:141–3. doi:10.1007/s10654-013-9877-9

45 Women's College Hospital. Crossroads Clinic. http://www.womenscollegehospital.ca/programs-and-services/crossroads-clinic/ (accessed 21 Jul 2017).

46 Access Alliance Multicultural Health and Community Services. http://accessalliance.ca/ (accessed 21 Jul 2017).

47 Gagnon AJ, DeBruyn R, Essén B, *et al.* Development of the Migrant Friendly Maternity Care Questionnaire (MFMCQ) for migrants to Western societies: an international Delphi consensus process. *BMC Pregnancy Childbirth* 2014;**14**:200.

48 Immigration, Refugees & Citizenship Canada. Excessive demand on health and social services. 2016.http://www.cic.gc.ca/english/resources/tools/medic/admiss/excessive.asp (accessed 1 May 2017).

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Table 1: Characteristics of deliveries to refugee immigrant, non-refugee immigrant and Canadian-born mothers in Ontario, Canada 2002-2014.

	Refugee immigrant (N = 52,360)	Non-refugee immigrant (N = 360,007)	Canadian-born (N = 977,045)
Maternal age, years			
15-19	1086 (2.1)	3725 (1.0)	46,156 (4.7)
20-24	6,863 (13.1)	38,002 (10.6)	141,442 (14.5)
25-29	15,361 (29.3)	108,010 (30.0)	272,588 (27.9)
30-34	16,480 (31.5)	125,191 (34.8)	330,477 (33.8)
35-39	9762 (18.6)	68,930 (19.1)	155,966 (16.0)
≥ 40	2793 (5.3)	16,107 (4.5)	30,012 (3.1)
Missing	15 (0.0)	42 (0.0)	404 (0.0)
Parity at the index birth			
0	19,262 (36.8)	155,919 (43.3)	454,583 (46.5)
1	16,786 (32.1)	135,095 (37.5)	343,647 (35.2)
2	8956 (17.1)	47,971 (13.3)	123,575 (12.6)
≥3	7301 (13.9)	20,706 (5.8)	53,871 (5.5)
Missing	55 (0.1)	316 (0.1)	1369 (0.1)
Neighbourhood income quintile			
1 (lowest)	23,160 (44.2)	112,660 (31.3)	173,947 (17.8)
2,3,4 (middle)	25,884 (49.4)	211,787 (58.8)	609,707 (62.4)
5 (highest)	3183 (6.1)	34,487 (9.6)	187,167 (19.2)
Missing	133 (0.3)	1073 (0.3)	6224 (0.6)
Official language ability at immigration			
English and/or French	29,679 (56.7)	227,096 (63.1)	--
Neither English or French	22,681 (43.3)	132,903 (36.9)	--
Missing	0 (0)	8 (0)	--
Level of education at immigration			
0-9 years	23,800 (45.5)	88,850 (24.7)	--
10-12 years	15,204 (29)	74,455 (20.7)	--
≥ 13 years	4463 (8.5)	33,550 (9.3)	--
Trade, Diplomas	5170 (9.9)	43,855 (12.2)	--
Bachelors, Masters, Doctorate	3723 (7.1)	119,297 (33.1)	--
Duration of residence, years			
< 10	30,450 (58.2)	257,345 (71.5)	--
≥ 10	21,910 (41.8)	102,662 (28.5)	--
World region of birth			
South Asia	14,360 (27.4)	118,942 (33)	--
Sub Saharan Africa	13,052 (24.9)	19,547 (5.4)	--
Latin America & Caribbean	6974 (13.3)	48,575 (13.5)	--
Western & Central Asia, North Africa	5247 (10.0)	27,803 (7.7)	--
Eastern Europe	4535 (8.7)	25,948 (7.2)	--
Southeast Asia, Oceania Islands	2216 (4.2)	40,495 (11.2)	--
East Asia (excluding Japan)	2671 (5.1)	46,486 (12.9)	--
Southern Europe	2914 (6.0)	11,729 (3.0)	--
Developed Countries	381 (1.0)	20,371 (6.0)	--
Missing	10 (0.0)	111 (0.0)	--

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Figure 1: Adverse maternal outcomes comparing 30,747 deliveries to refugee immigrants (● circles) vs. 30,747 deliveries to non-refugee immigrants (○ circles), 1:1 matched on country of birth. Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	333 (1.08)		
	307 (1.00)		0.97 (0.83-1.14)
Pre-existing hypertension	123 (4.00)		
	152 (0.49)		1.11 (0.85-1.44)
Gestational hypertension	930 (3.02)		
	978 (3.18)		1.05 (0.96-1.15)
Preeclampsia	333 (1.08)		
	345 (1.12)		1.01 (0.86-1.18)
Eclampsia	33 (0.11)		
	20 (0.07)		0.58 (0.32-1.05)
Pre-pregnancy diabetes	132 (0.43)		
	160 (0.52)		1.02 (0.80-1.29)
Gestational diabetes	1906 (6.20)		
	2,204 (7.17)		1.10 (1.04-1.17)
Caesarean section	9,043 (29.41)		
	8,926 (29.03)		1.02 (0.99-1.04)
Postpartum hemorrhage	1,021 (3.32)		
	1,018 (3.31)		1.03 (0.94-1.12)
Maternal ICU admission	102 (0.33)		
	112 (0.36)		0.99 (0.75-1.30)
Severe maternal morbidity (SMM)	410 (1.33)		
	444 (1.44)		1.07 (0.93-1.24)
SMM excluding HIV	372 (1.21)		
	373 (1.21)		0.98 (0.84-1.14)
HIV	52 (0.17)		
	111 (0.36)		1.67 (1.17-2.37)

ARR (95% CI)

0.10   1.00   10.00

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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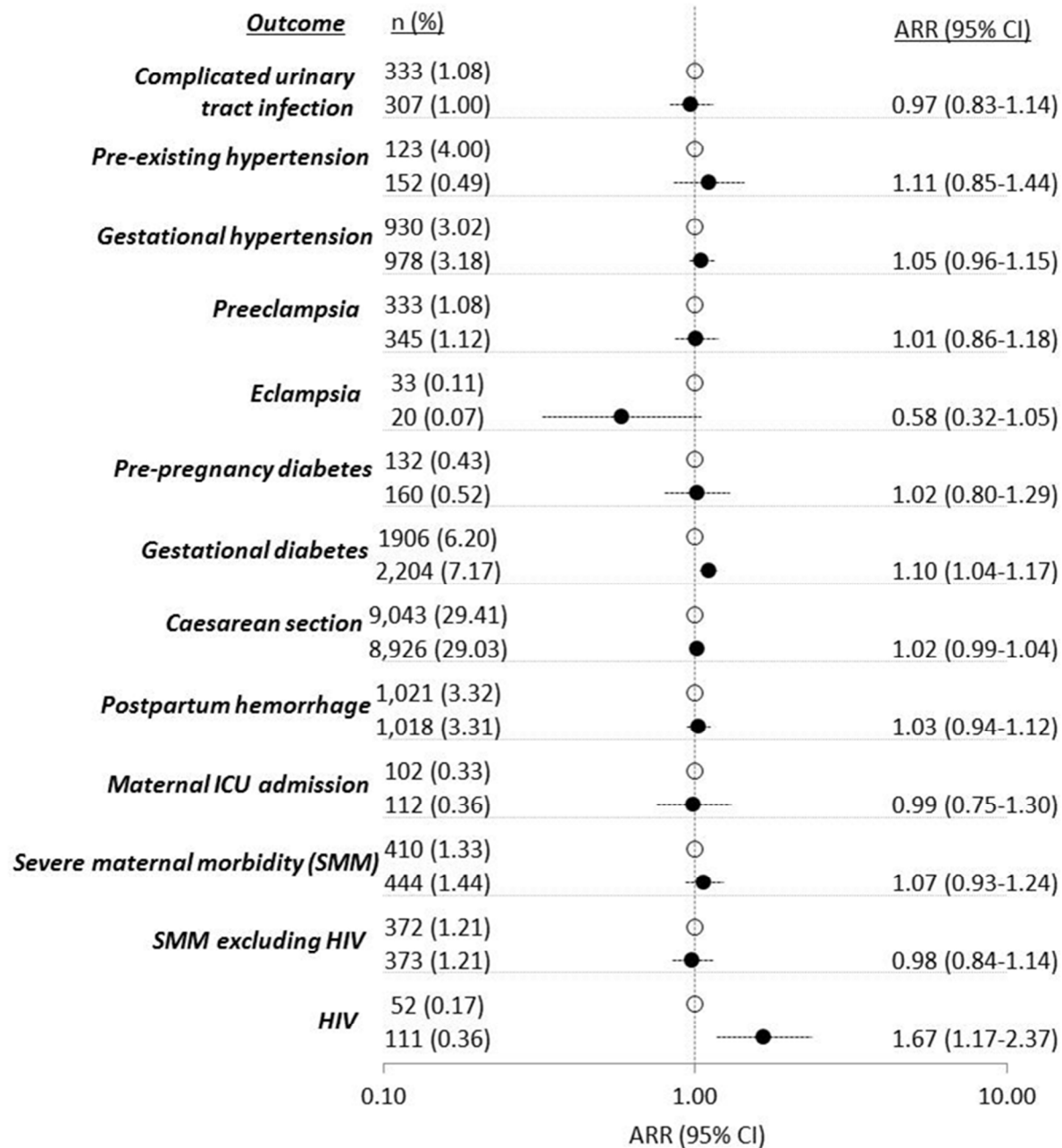
Figure 2: Adverse perinatal outcomes comparing births to refugee immigrants (●circles) vs. births to non-refugee immigrants (○circles), 1:1 matched on country of birth. Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
1,417/30,069 (4.71)		
1,327/30,069 (4.41)		0.94 (0.87-1.01)
Moderate preterm birth (32-36 wks)		
1,390/29,908 (4.65)		
1,566/29,908 (5.24)		1.10 (1.03-1.19)
Very preterm birth (<32 wks)		
233/29,908 (0.78)		
294/29,908 (0.98)		1.18 (0.99-1.42)
Neonatal mortality (<28 days)		
50/30,034 (0.17)		
53/30,034 (0.18)		0.95 (0.64-1.41)
NICU admission		
4,237/30,061 (14.09)		
4,340/30,061 (14.44)		1.00 (0.96-1.04)
Perinatal mortality		
265/30,343 (0.87)		
269/30,343 (0.89)		0.92 (0.77-1.10)
Stillbirth		
213/30,343 (0.70)		
214/30,343 (0.71)		0.91 (0.73-1.14)

0.50   1.00   2.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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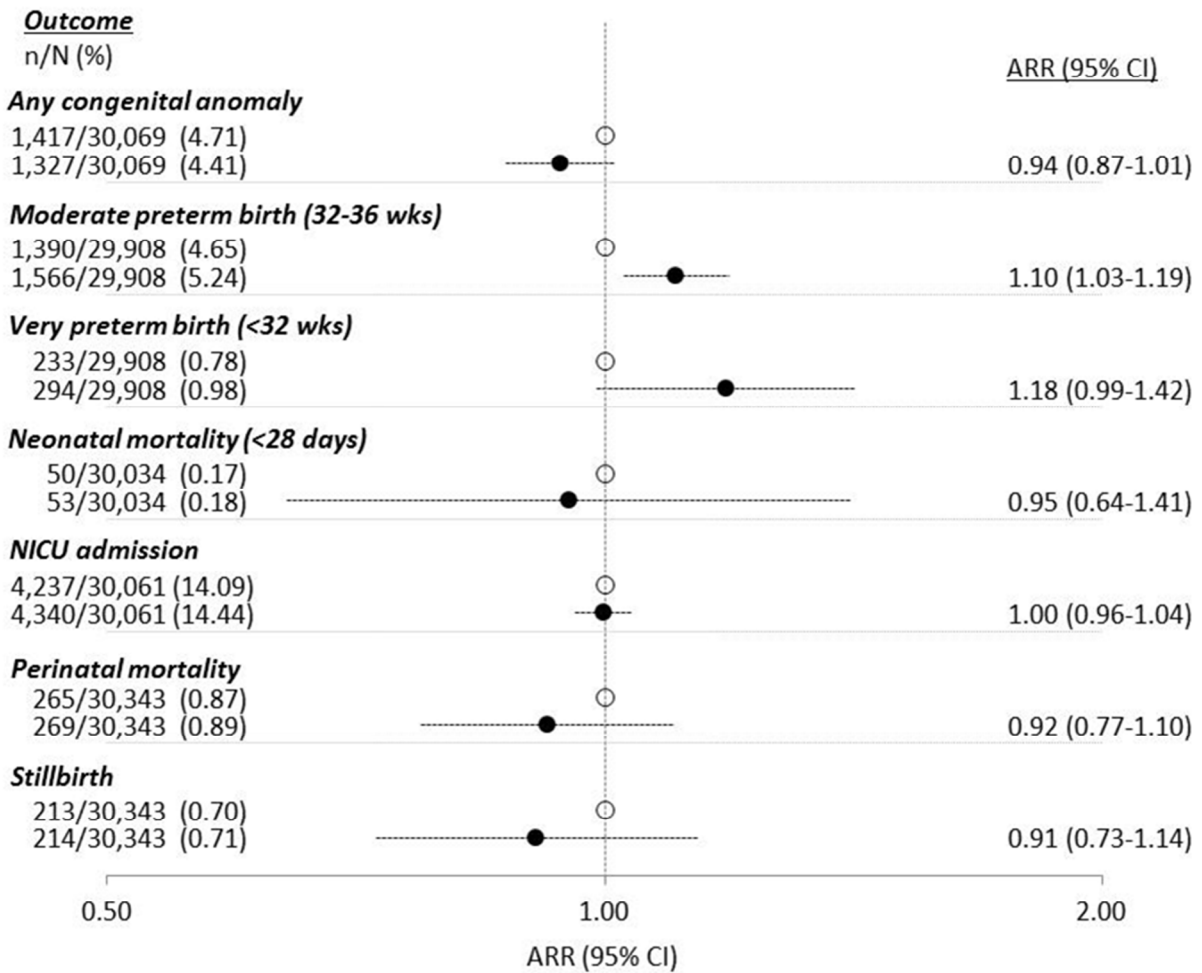
Figure 3: Adverse maternal outcomes comparing 52,360 deliveries to refugee immigrants (●circles) and 360,007 deliveries to non-refugee immigrants (●circles) vs. 977,045 deliveries to Canadian-born (○circles) mothers. Risk ratios adjusted for maternal age, parity and income quintile.

Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	11,852 (1.22)		
	3,335 (0.93)		0.79 (0.76-0.82)
	421 (0.81)		0.71 (0.64-0.78)
Pre-existing hypertension	5,386 (0.56)		
	1,734 (0.48)		0.72 (0.68-0.77)
	266 (0.51)		0.74 (0.65-0.85)
Gestational hypertension	42,146 (4.35)		
	10,615 (2.96)		0.65 (0.64-0.67)
	1,513 (2.90)		0.67 (0.63-0.71)
Preeclampsia	11,368 (1.17)		
	3,036 (0.85)		0.70 (0.67-0.73)
	511 (0.98)		0.87 (0.79-0.95)
Eclampsia	957 (0.10)		
	269 (0.08)		0.76 (0.66-0.87)
	30 (0.06)		0.76 (0.66-0.87)
Pre-pregnancy diabetes	6,301 (0.65)		
	1,706 (0.48)		0.63 (0.59-0.67)
	309 (0.59)		0.73 (0.65-0.83)
Gestational diabetes	30,901 (3.19)		
	26,559 (7.41)		1.98 (1.94-2.01)
	3,826 (7.34)		1.90 (1.83-1.97)
Caesarean section	265,859 (27.43)		
	101,863 (28.41)		1.01 (1.00-1.01)
	14,622 (28.03)		1.02 (1.00-1.03)
Postpartum hemorrhage	39,619 (4.09)		
	11,318 (3.16)		0.79 (0.78-0.81)
	1,688 (3.24)		0.83 (0.79-0.87)
Maternal ICU admission	2,317 (0.24)		
	1,060 (0.30)		1.14 (1.06-1.23)
	183 (0.35)		1.33 (1.14-1.55)
Severe maternal morbidity (SMM)	10,910 (1.13)		
	3,971 (1.11)		0.94 (0.90-0.97)
	759 (1.46)		1.20 (1.11-1.29)
SMM excluding HIV	10,758 (1.11)		
	3,811 (1.06)		0.92 (0.88-0.95)
	602 (1.15)		0.97 (0.90-1.06)
HIV	315 (0.03)		
	220 (0.06)		1.52 (1.23-1.87)
	229 (0.44)		10.09 (8.14-12.51)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure 4: Adverse perinatal outcomes comparing births to refugee immigrants (●circles) and births to non-refugee immigrants (●circles) vs. births to Canadian-born mothers (○circles). Risk ratios adjusted for maternal age, parity, and income quintile.

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
46,711/941,226 (4.96)		
15,341/350,136 (4.38)		0.87 (0.85-0.88)
2,239/50,884 (4.40)		0.87 (0.83-0.91)
Moderate preterm birth (32-36 wks)		
52,386/936,852 (5.59)		
17,678/348,924 (5.07)		0.88 (0.86-0.89)
2,600/50,575 (5.14)		0.87 (0.84-0.91)
Very preterm birth (<32 wks)		
7,301/936,852 (0.78)		
2,941/348,924 (0.84)		1.02 (0.98-1.07)
457/50,575 (0.90)		1.05 (0.95-1.16)
Neonatal mortality (<28 days)		
1,437/940,452 (0.15)		
588/349,771 (0.17)		1.06 (0.96-1.17)
84/50,830 (0.17)		0.96 (0.77-1.20)
NICU admission		
108,072/940,956 (11.49)		
44,248/350,058 (12.64)		1.05 (1.04-1.07)
6,642/50,877 (13.06)		1.07 (1.05-1.10)
Perinatal mortality		
6,169/949,807 (0.65)		
2,695/353,070 (0.76)		1.10 (1.05-1.15)
454/51,356 (0.88)		1.17 (1.06-1.29)
Stillbirth		
4,823/949,807 (0.51)		
2,116/353,070 (0.60)		1.10 (1.04-1.16)
366/51,356 (0.71)		1.20 (1.07-1.34)

0.50   1.00   2.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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SUPPLEMENTARY TABLES

Table S1: List of 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI) codes for maternal and perinatal outcomes

Maternal or Perinatal Outcome	Definition	Source Database	ICD-10-CA/CCI
Complicated urinary tract infection		CIHI-DAD	O23, O86, N39
Pre-existing hypertension		CIHI-DAD	O10, O11
Gestational hypertension		CIHI-DAD	O13
Preeclampsia			O14
Eclampsia		CIHI-DAD	O15
Pre-pregnancy diabetes mellitus		CIHI-DAD	O24.0-O24.3
Gestational diabetes mellitus (GDM)		CIHI-DAD	O24.4
Caesarean delivery		CIHI-DAD	5.MD.60.^^
Post-partum hemorrhage		CIHI-DAD	O72
Maternal intensive care unit (ICU) admission		CIHI-DAD	Special Care Unit 1-6
Severe maternal morbidity		CIHI-DAD	See Joseph et al, 2010*
HIV	Three physician diagnoses within three years.	Ontario HIV DB	
Congenital anomaly	An abnormality of structure or function present at birth	CIHI-DAD	ICD-10: Q00-Q99
Moderate preterm birth (PTB)	Live birth with gestational age 32-36 weeks	CIHI-DAD	32-36 weeks gestation recorded on CIHI-DAD birth record
Very preterm birth (VPTB)	Live birth with gestational age <32 weeks	CIHI-DAD	< 32 weeks gestation recorded on CIHI-DAD birth record
Neonatal mortality	Death <28 days of life	RPDB, ORG-VSD	
Neonatal intensive care unit (NICU) admission		CIHI-DAD	Special care unit admission, any level
Perinatal mortality	Stillbirth or death of live born infant < 7 days of life	RPDB, ORG-VSD	
Stillbirth	Intrauterine fetal death ≥ 20 weeks gestation and > 500 g birthweight	CIHI-DAD	Maternal record: Z371, Z373-7, O364. Infant record: P95

Abbreviations
ICD-10-CA/CCI - 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI)
CIHI-DAD – Canadian Institute for Health Information – Discharge Abstract Database
RPDB – Registered Persons Database (referred to as "Ontario Health Care Registry" in paper)
ORGD-VSD – Office of the Registrar General's Vital Statistics-Death Registry

* Joseph KS, Liu S, Rouleau J, Kirby RS, Kramer MS, Sauve R, et al. Severe maternal morbidity in Canada, 2003 to 2007: surveillance using routine hospitalization data and ICD-10CA codes. J Obstet Gynaecol Can. 2010;32(9):837

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Table S2: Unadjusted Risk Ratios (RR) (95% CI) for Figures 1 and 2

FIGURE 1	
OUTCOME	**UNADJUSTED RR (95% CI)**
Complicated urinary tract infection	0.92 (0.79-1.08)
Pre-existing hypertension	1.24 (0.97-1.57)
Gestational hypertension	1.05 (0.96-1.15)
Preeclampsia	1.04 (0.89-1.20)
Eclampsia	0.61 (0.35-1.06)
Pre-pregnancy diabetes mellitus	1.21 (0.96-1.52)
Gestational diabetes mellitus (GDM)	1.16 (1.09-1.23)
Caesarean delivery	0.99 (0.96-1.01)
Post-partum hemorrhage	1.00 (0.92-1.09)
Maternal intensive care unit admission	1.10 (0.84-1.44)
Severe maternal morbidity (SMM)	1.08 (0.95-1.24)
SMM excluding HIV	1.00 (0.87-1.16)
HIV	2.14 (1.54-2.96)
FIGURE 2	
OUTCOME	**UNADJUSTED RR (95% CI)**
Congenital anomaly	0.94 (0.89-0.99)
Moderate preterm birth (MPTB)	1.13 (1.05-1.21)
Very preterm birth (VPTB)	1.26 (1.06-1.50)
Neonatal mortality	1.06 (0.72-1.56)
Neonatal intensive care unit admission	1.02 (0.99-1.06)
Perinatal mortality	1.02 (0.86-1.20)
Stillbirth	1.00 (0.83-1.21)

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Table S3: Unadjusted Risk Ratios (RR) (95% CI) for Figures 3 and 4

FIGURE 3	UNADJUSTED RR (95% CI)	
OUTCOME	REFUGEES VS. CDN	NON-REFUGEES VS. CDN
Complicated urinary tract infection	0.66 (0.60-0.73)	0.76 (0.73-0.79)
Pre-existing hypertension	0.92 (0.81-1.05)	0.86 (0.81-0.91)
Gestational hypertension	0.67 (0.63-0.70)	0.68 (0.66-0.69)
Preeclampsia	0.83 (0.76-0.91)	0.72 (0.69-0.75)
Eclampsia	0.58 (0.40-0.84)	0.60 (0.42-0.86)
Pre-pregnancy diabetes mellitus	0.35 (0.30-0.39)	0.72 (0.68-0.76)
Gestational diabetes mellitus (GDM)	2.27 (2.19-2.36)	2.30 (2.26-2.34)
Caesarean delivery	1.03 (1.02-1.05)	1.05 (1.05-1.06)
Post-partum hemorrhage (PPH)	0.80 (0.76-0.84)	0.78 (0.77-0.80)
Maternal intensive care unit admission	1.46 (1.26-1.70)	1.23 (1.15-1.33)
Severe maternal morbidity (SMM)	1.29 (1.20-1.40)	0.98 (0.95-1.02)
SMM without HIV	1.04 (0.96-1.13)	0.96 (0.92-0.99)
HIV	13.84 (11.32-16.93)	1.85 (1.51-2.26)
FIGURE 4		
OUTCOME		
Congenital anomaly	0.89 (0.85-0.92)	0.88 (0.87-0.90)
Moderate preterm birth (MPTB)	0.92 (0.89-0.96)	0.91 (0.89-0.92)
Very preterm birth (VPTB)	1.08 (1.03-1.13)	1.16 (1.06-1.28)
Neonatal mortality	1.08 (0.87-1.35)	1.10 (1.00-1.21)
Neonatal intensive care unit (NICU) admission	1.13 (1.11-1.16)	1.10 (1.09-1.11)
Perinatal mortality	1.36 (1.24-1.50)	1.17 (1.12-1.23)
Stillbirth	1.40 (1.26-1.56)	1.18 (1.12-1.24)

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SUPPLEMENTARY FIGURES

Figure S1a: Adverse maternal outcomes comparing 5,724 deliveries to Sri Lankan refugee immigrants (▲triangles) vs. 17,373 deliveries to Sri Lankan non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	101 (0.58)	△	
	40 (0.70)	▲	1.11 (0.74-1.68)
Pre-existing hypertension	54 (0.31)	△	
	25 (0.44)	▲	0.90 (0.54-1.51)
Gestational hypertension	502 (2.89)	△	
	184 (3.21)	▲	1.20 (0.99-1.45)
Preeclampsia	136 (0.78)	△	
	52 (0.91)	▲	0.99 (0.69-1.41)
Eclampsia	10 (0.06)	△	
	*		
Pre-pregnancy diabetes	147 (0.85)	△	
	62 (1.08)	▲	0.95 (0.68-1.33)
Gestational diabetes	2,062 (11.87)	△	
	790 (13.80)	▲	1.08 (0.99-1.18)
Caesarean section	5,359 (30.85)	△	
	1,722 (30.08)	▲	0.97 (0.91-1.03)
Postpartum hemorrhage	465 (2.68)	△	
	132 (2.31)	▲	0.83 (0.67-1.03)
Maternal ICU admission	44 (0.25)	△	
	15 (0.26)	▲	0.81 (0.43-1.55)
Severe maternal morbidity	165 (0.95)	△	
	47 (0.82)	▲	0.83 (0.58-1.19)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S1b: Adverse perinatal outcomes comparing births to Sri Lankan refugee immigrants (▲triangles) vs. births to Sri Lankan non-refugee immigrants (△triangles). Risk ratios adjusted for maternal ae, parity, income quintile, official language ability, education and duration of residence.

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
689/16,984 (4.06)	△	
187/5,591 (3.34)	▲	0.85 (0.71-1.01)
Moderate preterm birth (32-36 wks)		
927/16,945 (5.47)	△	
346/5,573 (6.21)	▲	1.13 (1.01-1.28)
Very preterm birth (<32 wks)		
122/16,945 (0.72)	△	
58/5,573 (1.04)	▲	1.20 (0.85-1.70)
Neonatal mortality (<28 days)		
26/16,963 (0.15)	△	
8/5,583 (0.14)	▲	1.02 (0.42-2.47)
NICU admission		
3,496/16,977 (20.59)	△	
1,211/5,590 (21.66)	▲	1.12 (1.05-1.19)
Perinatal mortality		
137/17,128 (0.80)	△	
47/5,640 (0.83)	▲	1.01 (0.70-1.45)
Stillbirth		
112/17,128 (0.65)	△	
37/5,640 (0.66)	▲	1.00 (0.66-1.51)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S2a: Adverse maternal outcomes comparing 2,453 deliveries to Somali refugee immigrants (▲triangles) vs. 4,499 deliveries to Somali non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)	ARR (95% CI)
Complicated urinary tract infection	14 (0.57)	
	39 (0.87)	1.42 (0.73-2.75)
Pre-existing hypertension	9 (0.37)	
	18 (0.40)	0.98 (0.41-2.34)
Gestational hypertension	51 (2.08)	
	109 (2.42)	1.10 (0.76-1.59)
Preeclampsia	28 (1.14)	
	46 (1.02)	0.80 (0.47-1.37)
Eclampsia	*	
	*	
Pre-pregnancy diabetes	24 (0.98)	
	33 (0.73)	0.87 (0.48-1.56)
Gestational diabetes	183 (7.46)	
	379 (8.42)	1.18 (0.97-1.43)
Caesarean section	583 (23.77)	
	1,124 (24.98)	0.98 (0.88-1.09)
Postpartum hemorrhage	98 (4.00)	
	173 (3.85)	1.00 (0.76-1.31)
Maternal ICU admission	13 (0.53)	
	23 (0.51)	1.19 (0.55-2.54)
Severe maternal morbidity (SMM)	42 (1.71)	
	68 (1.51)	0.82 (0.54-1.26)
SMM excluding HIV	36 (1.47)	
	36 (0.80)	0.89 (0.57-1.41)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S2b: Adverse perinatal outcomes comparing births to Somali refugee immigrants (▲triangles) vs. births to Somali non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
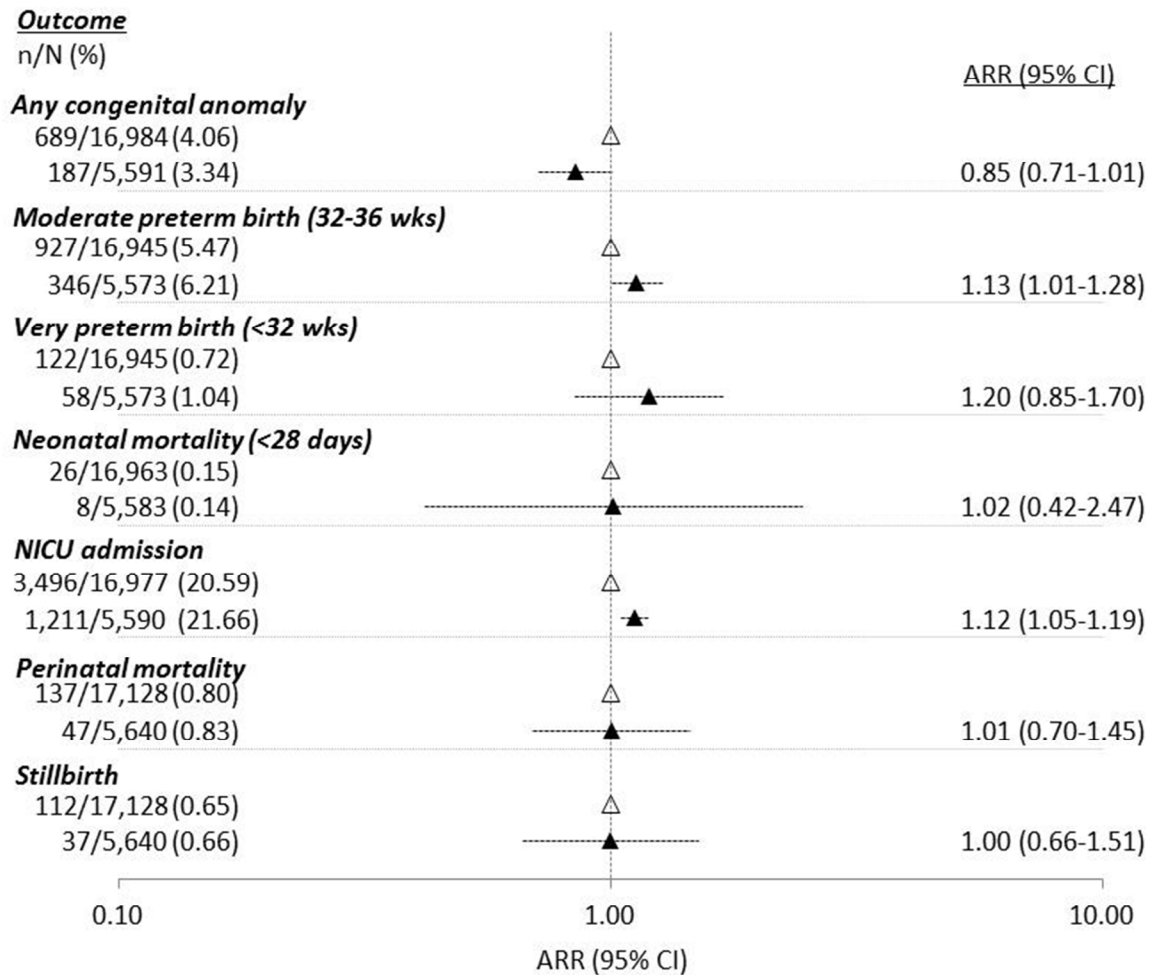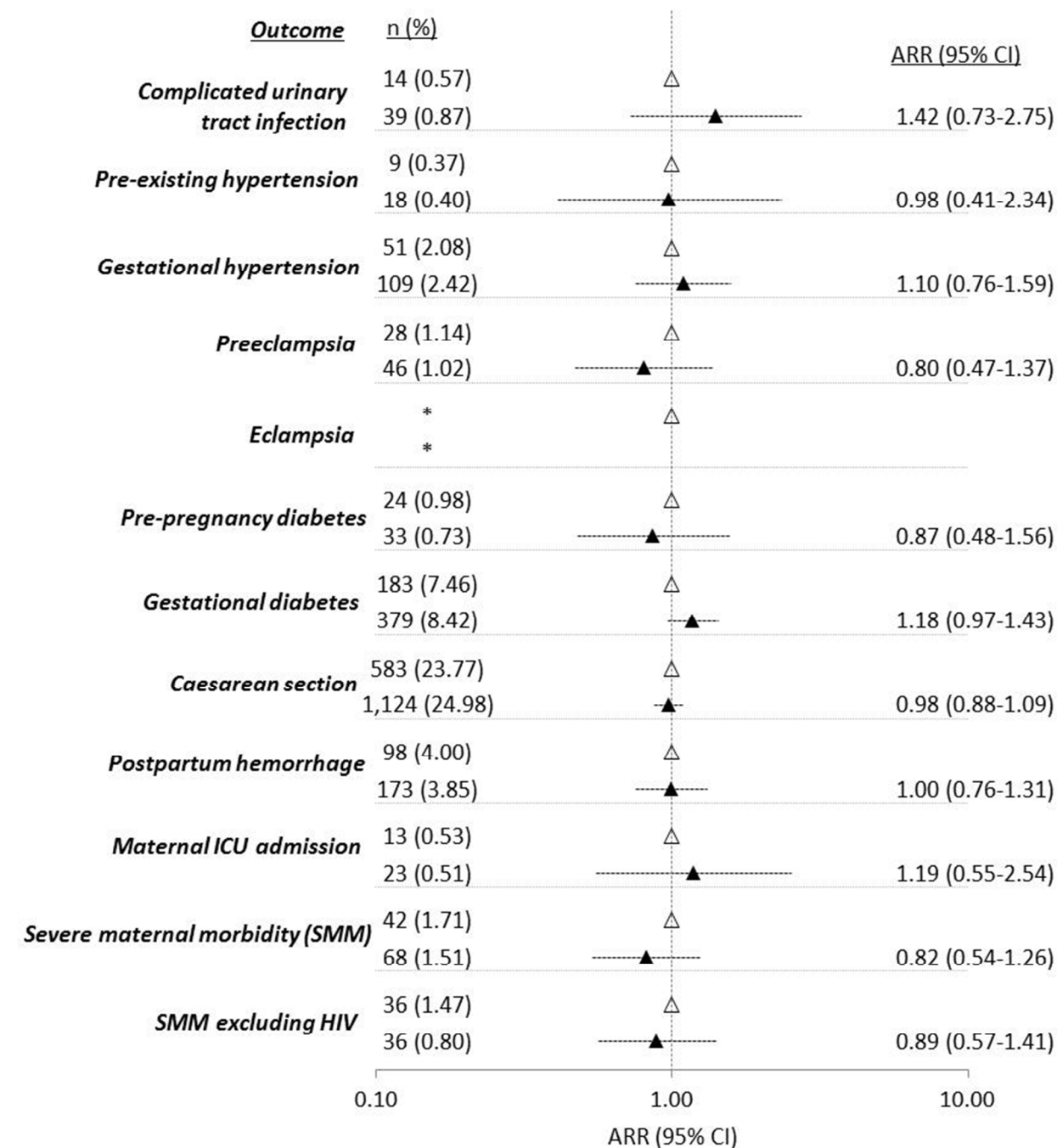

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S3a: Adverse maternal outcomes comparing 4,210 deliveries to Afghan refugee immigrants (▲triangles) vs. 3,905 deliveries to Afghan non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

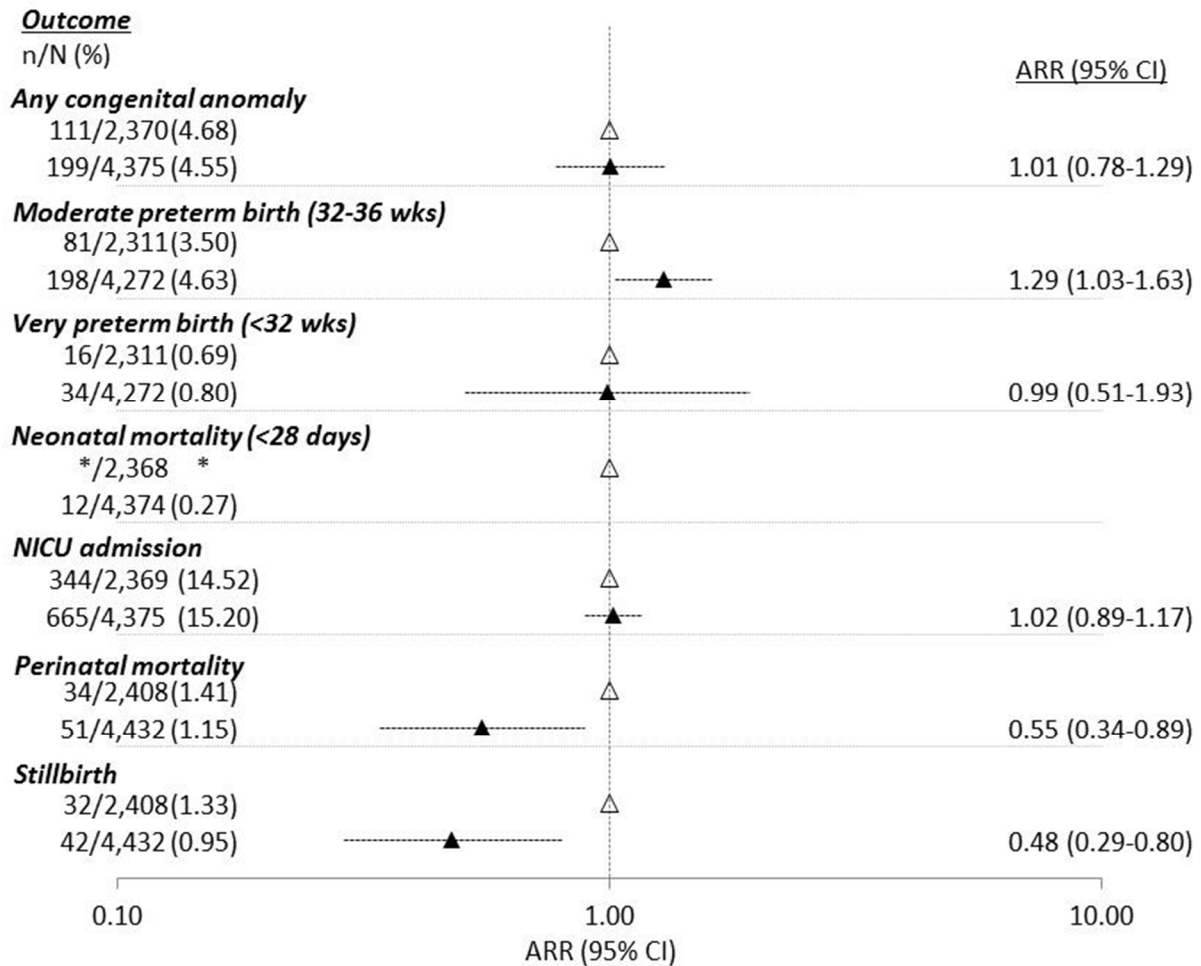| Outcome	n (%)	ARR (95% CI)
Complicated urinary tract infection	21 (0.54) / 12 (0.29)	0.60 (0.28-1.28)
Pre-existing hypertension	* / 10 (0.24)	
Gestational hypertension	61 (1.56) / 87 (2.07)	1.19 (0.82-1.71)
Preeclampsia	26 (0.67) / 38 (0.90)	1.25 (0.74-2.14)
Eclampsia	* / *	
Pre-pregnancy diabetes	11 (0.28) / 29 (0.69)	1.42 (0.70-2.90)
Gestational diabetes	248 (6.35) / 426 (10.12)	1.26 (1.07-1.49)
Caesarean section	788 (20.18) / 1,159 (27.53)	1.20 (1.09-1.33)
Postpartum hemorrhage	96 (2.46) / 123 (2.92)	1.13 (0.85-1.51)
Maternal ICU admission	9 (0.23) / 22 (0.52)	1.71 (0.75-3.89)
Severe maternal morbidity	41 (1.05) / 47 (1.12)	0.92 (0.59-1.45)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S3b: Adverse perinatal outcomes comparing births to Afghan refugee immigrants (▲triangles) vs. births to Afghan non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
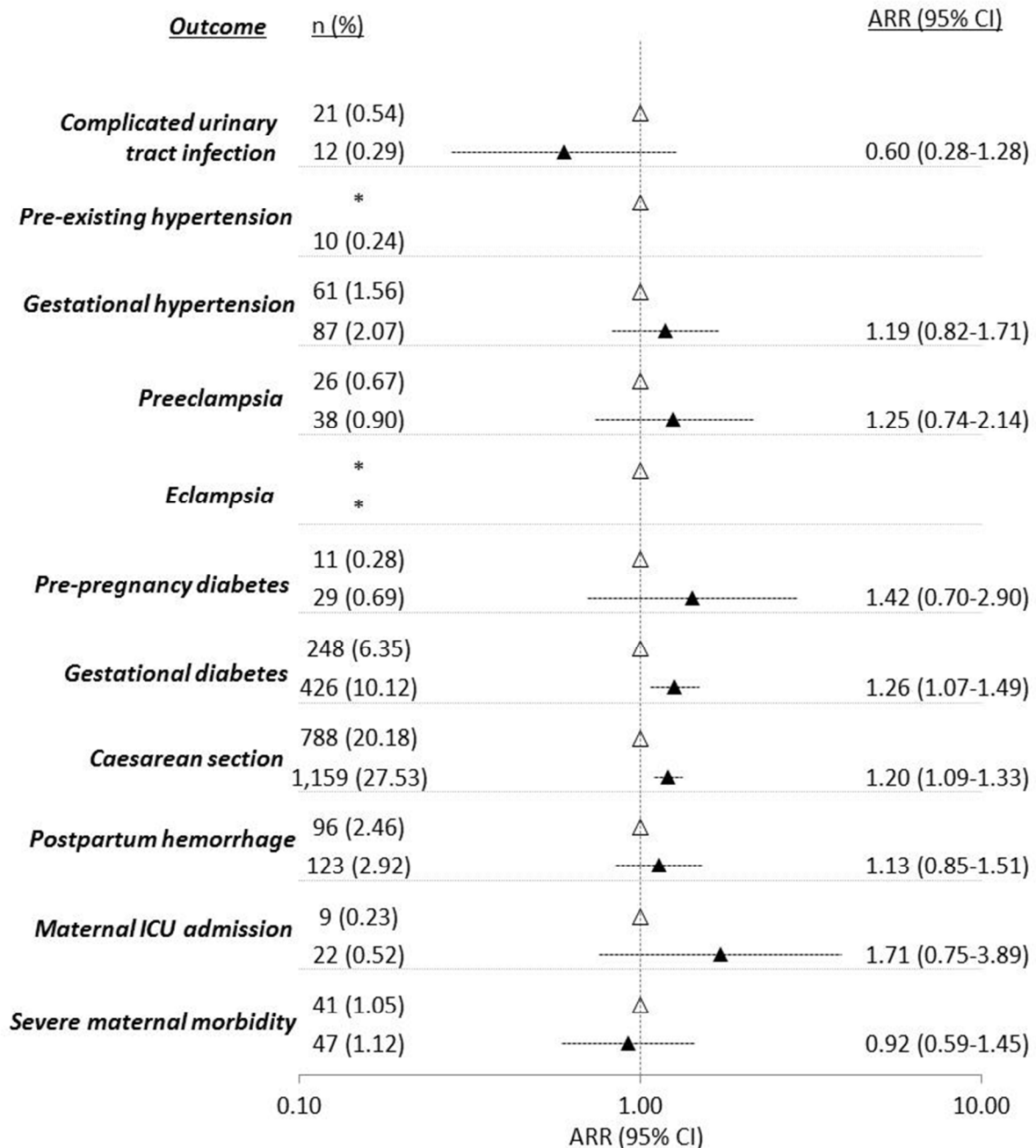
Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
183/3,824 (4.79)	△	
200/4,115 (4.86)	▲	1.03 (0.84-1.27)
Moderate preterm birth (32-36 wks)		
148/3,814 (3.88)	△	
171/4,094 (4.18)	▲	1.08 (0.87-1.34)
Very preterm birth (<32 wks)		
23/3,814 (0.60)	△	
35/4,094 (0.85)	▲	1.21 (0.69-2.13)
Neonatal mortality (<28 days)		
10/3,820 (0.26)	△	
10/4,112 (0.24)	▲	0.98 (0.39-2.49)
NICU admission		
520/3,822 (13.61)	△	
617/4,115 (14.99)	▲	1.06 (0.94-1.19)
Perinatal mortality		
28/3,856 (0.73)	△	
47/4,159 (1.13)	▲	1.40 (0.86-2.29)
Stillbirth		
23/3,856 (0.60)	△	
37/4,159 (0.89)	▲	1.34 (0.78-2.32)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S4a: Adverse maternal outcomes comparing 2,613 deliveries to Iraqi refugee immigrants (▲ triangles) vs. 4,239 deliveries to Iraqi non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
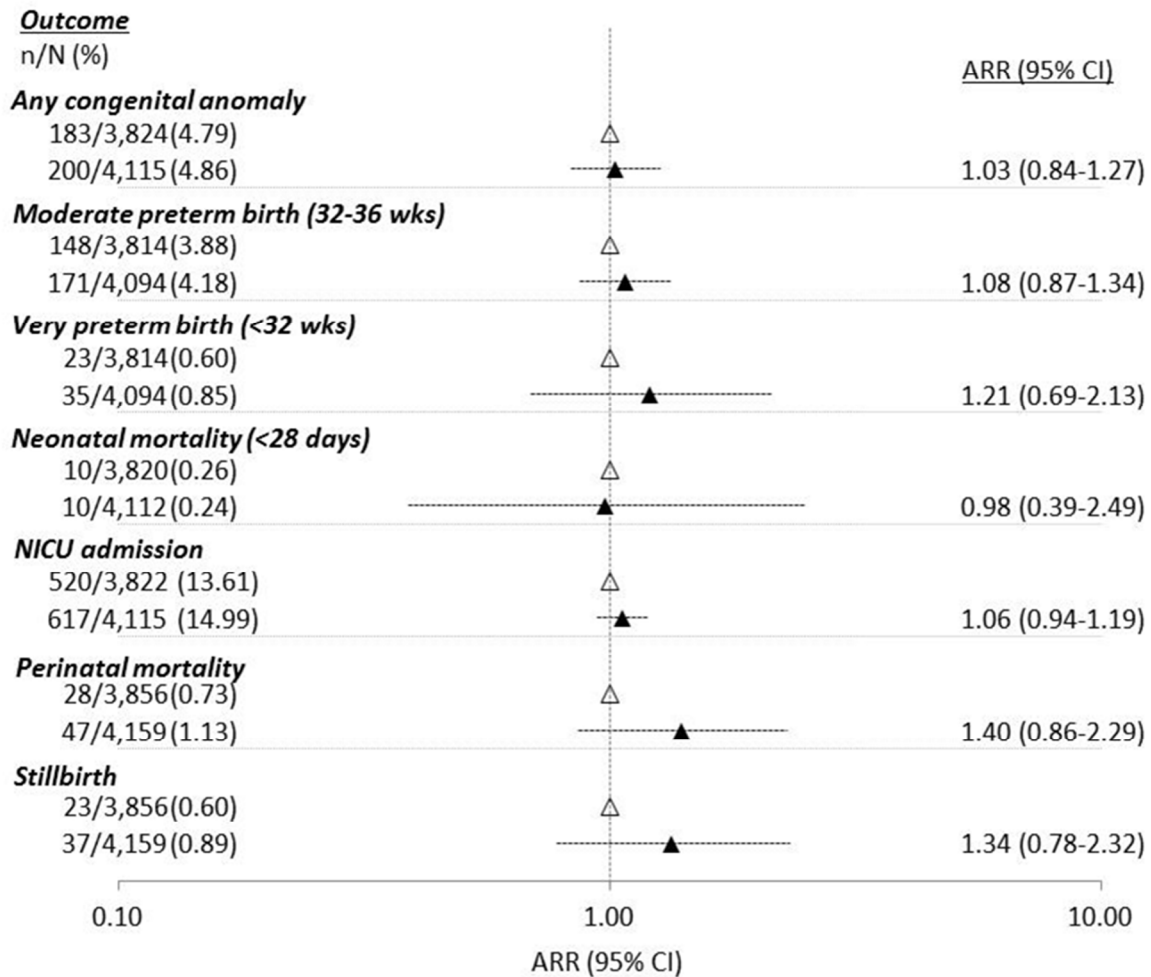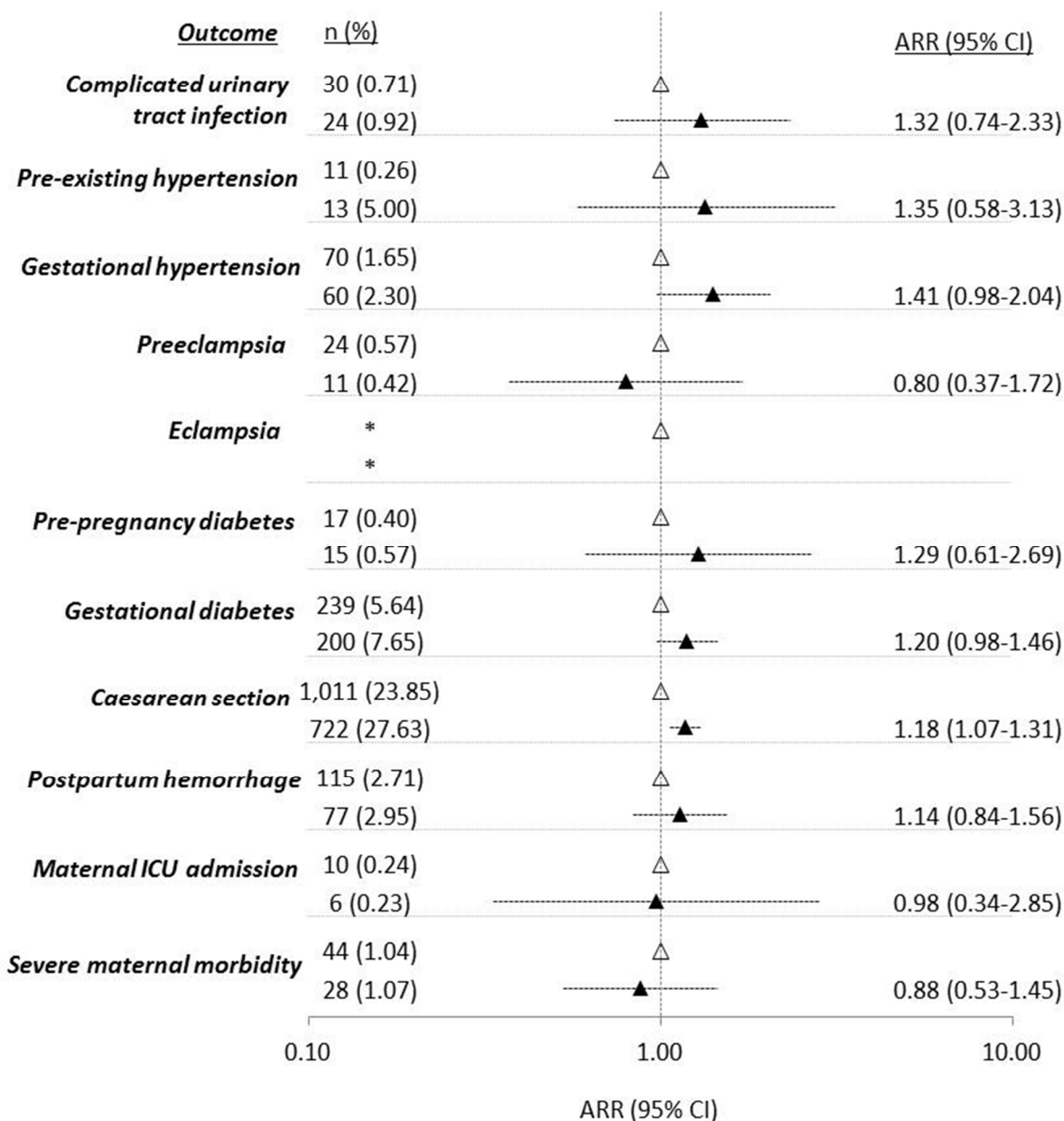

Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	30 (0.71)		
	24 (0.92)		1.32 (0.74-2.33)
Pre-existing hypertension	11 (0.26)		
	13 (5.00)		1.35 (0.58-3.13)
Gestational hypertension	70 (1.65)		
	60 (2.30)		1.41 (0.98-2.04)
Preeclampsia	24 (0.57)		
	11 (0.42)		0.80 (0.37-1.72)
Eclampsia	*		
	*		
Pre-pregnancy diabetes	17 (0.40)		
	15 (0.57)		1.29 (0.61-2.69)
Gestational diabetes	239 (5.64)		
	200 (7.65)		1.20 (0.98-1.46)
Caesarean section	1,011 (23.85)		
	722 (27.63)		1.18 (1.07-1.31)
Postpartum hemorrhage	115 (2.71)		
	77 (2.95)		1.14 (0.84-1.56)
Maternal ICU admission	10 (0.24)		
	6 (0.23)		0.98 (0.34-2.85)
Severe maternal morbidity	44 (1.04)		
	28 (1.07)		0.88 (0.53-1.45)

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

Figure S4b: Adverse perinatal outcomes comparing births to Iraqi refugee immigrants (▲triangles) vs. births to Iraqi non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence
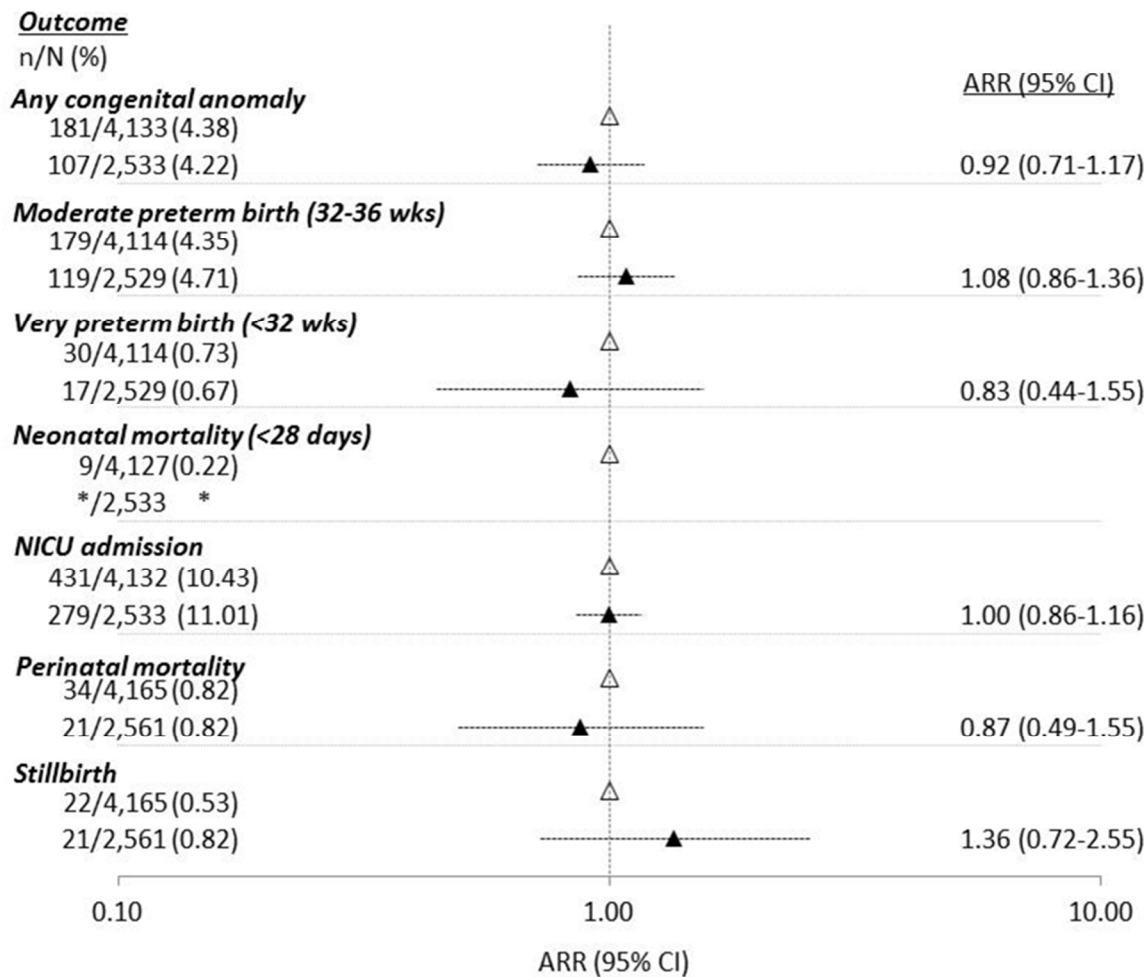

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
181/4,133 (4.38)		
107/2,533 (4.22)		0.92 (0.71-1.17)
Moderate preterm birth (32-36 wks)		
179/4,114 (4.35)		
119/2,529 (4.71)		1.08 (0.86-1.36)
Very preterm birth (<32 wks)		
30/4,114 (0.73)		
17/2,529 (0.67)		0.83 (0.44-1.55)
Neonatal mortality (<28 days)		
9/4,127 (0.22)		
*/2,533 *		
NICU admission		
431/4,132 (10.43)		
279/2,533 (11.01)		1.00 (0.86-1.16)
Perinatal mortality		
34/4,165 (0.82)		
21/2,561 (0.82)		0.87 (0.49-1.55)
Stillbirth		
22/4,165 (0.53)		
21/2,561 (0.82)		1.36 (0.72-2.55)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

Figure S5a: Adverse maternal outcomes comparing 2,527 deliveries to Chinese refugee immigrants (▲ triangles) vs. 37,093 deliveries to Chinese non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
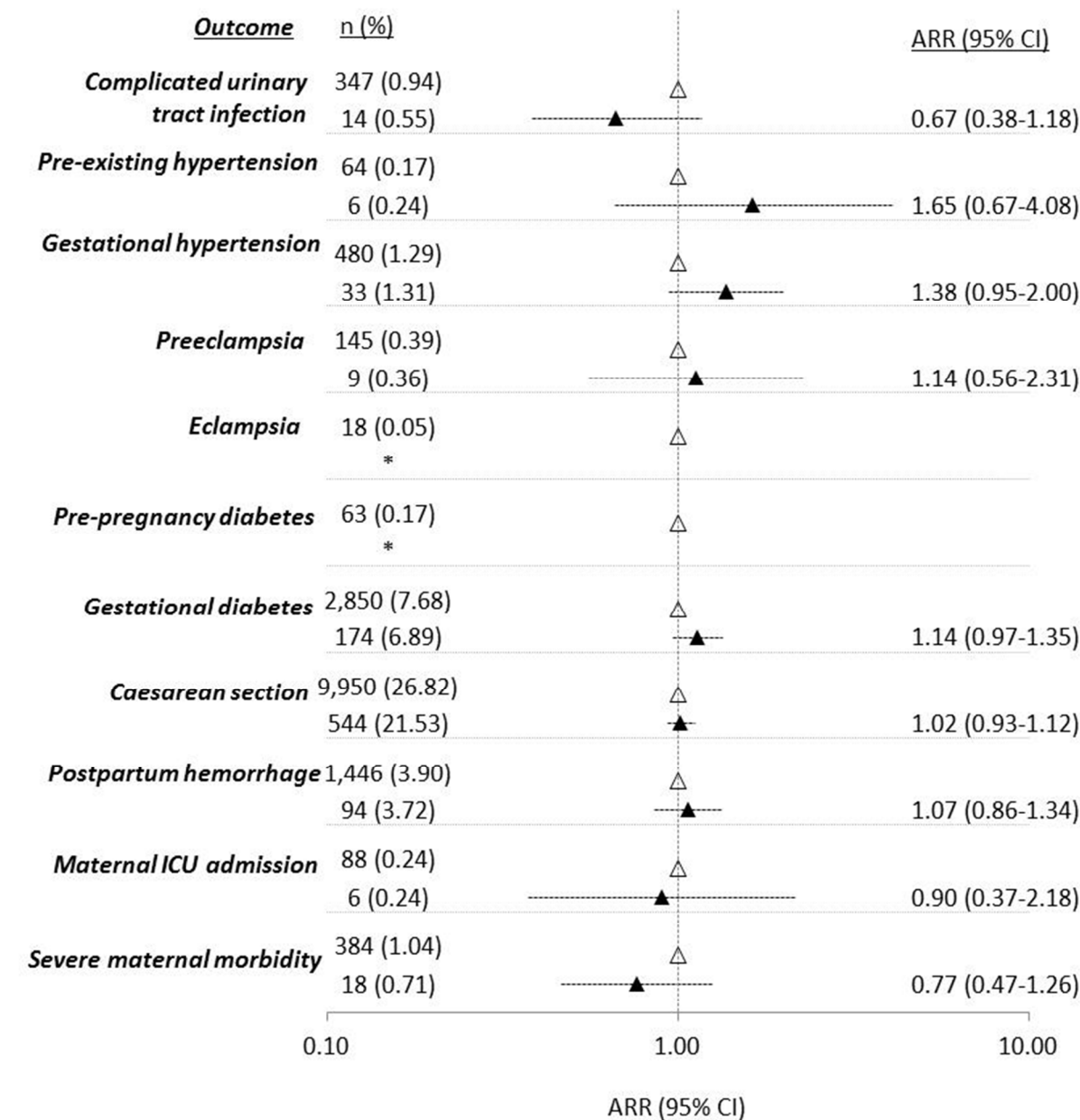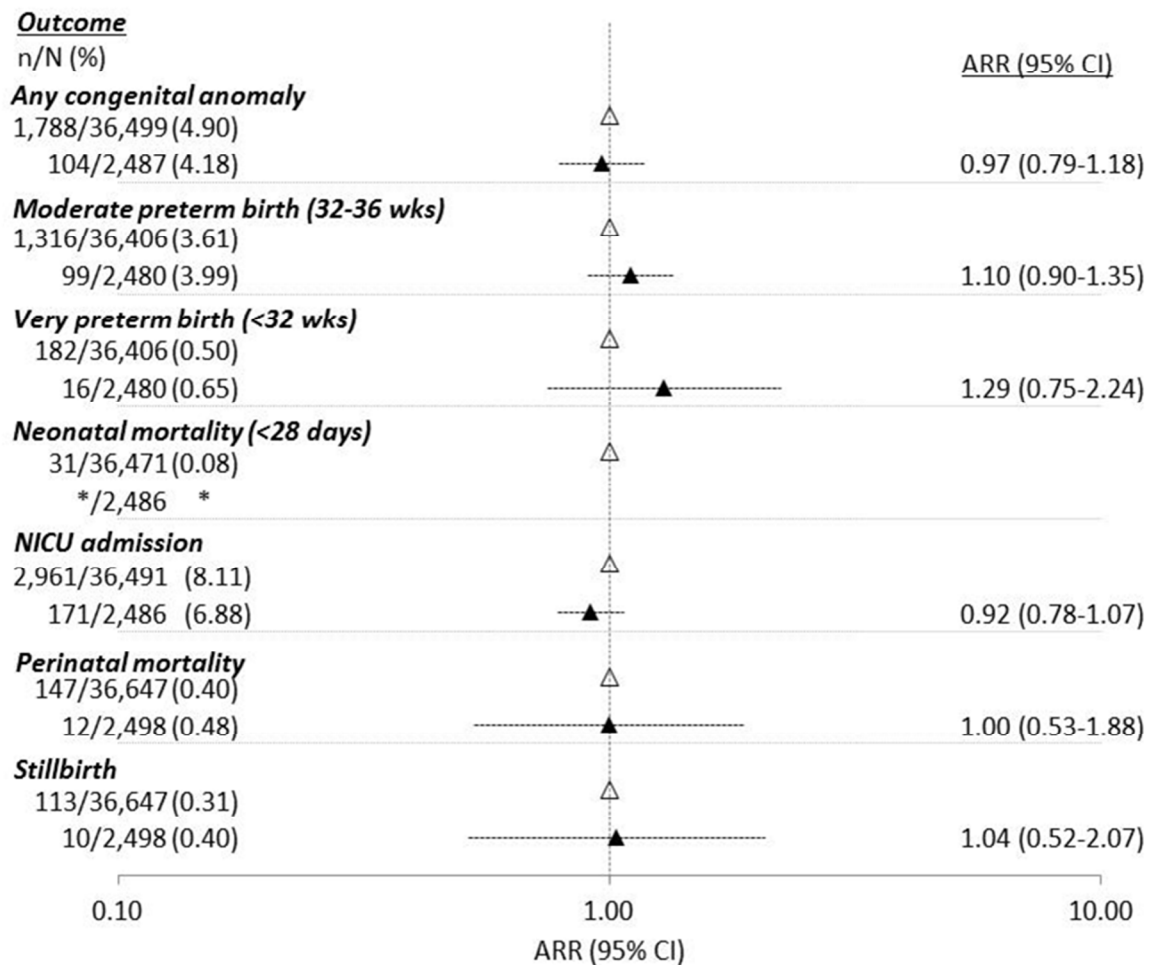
Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	347 (0.94)		
	14 (0.55)		0.67 (0.38-1.18)
Pre-existing hypertension	64 (0.17)		
	6 (0.24)		1.65 (0.67-4.08)
Gestational hypertension	480 (1.29)		
	33 (1.31)		1.38 (0.95-2.00)
Preeclampsia	145 (0.39)		
	9 (0.36)		1.14 (0.56-2.31)
Eclampsia	18 (0.05)		
	*		
Pre-pregnancy diabetes	63 (0.17)		
	*		
Gestational diabetes	2,850 (7.68)		
	174 (6.89)		1.14 (0.97-1.35)
Caesarean section	9,950 (26.82)		
	544 (21.53)		1.02 (0.93-1.12)
Postpartum hemorrhage	1,446 (3.90)		
	94 (3.72)		1.07 (0.86-1.34)
Maternal ICU admission	88 (0.24)		
	6 (0.24)		0.90 (0.37-2.18)
Severe maternal morbidity	384 (1.04)		
	18 (0.71)		0.77 (0.47-1.26)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S5b: Adverse perinatal outcomes comparing births to Chinese refugee immigrants (▲triangles) vs. births to Chinese non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
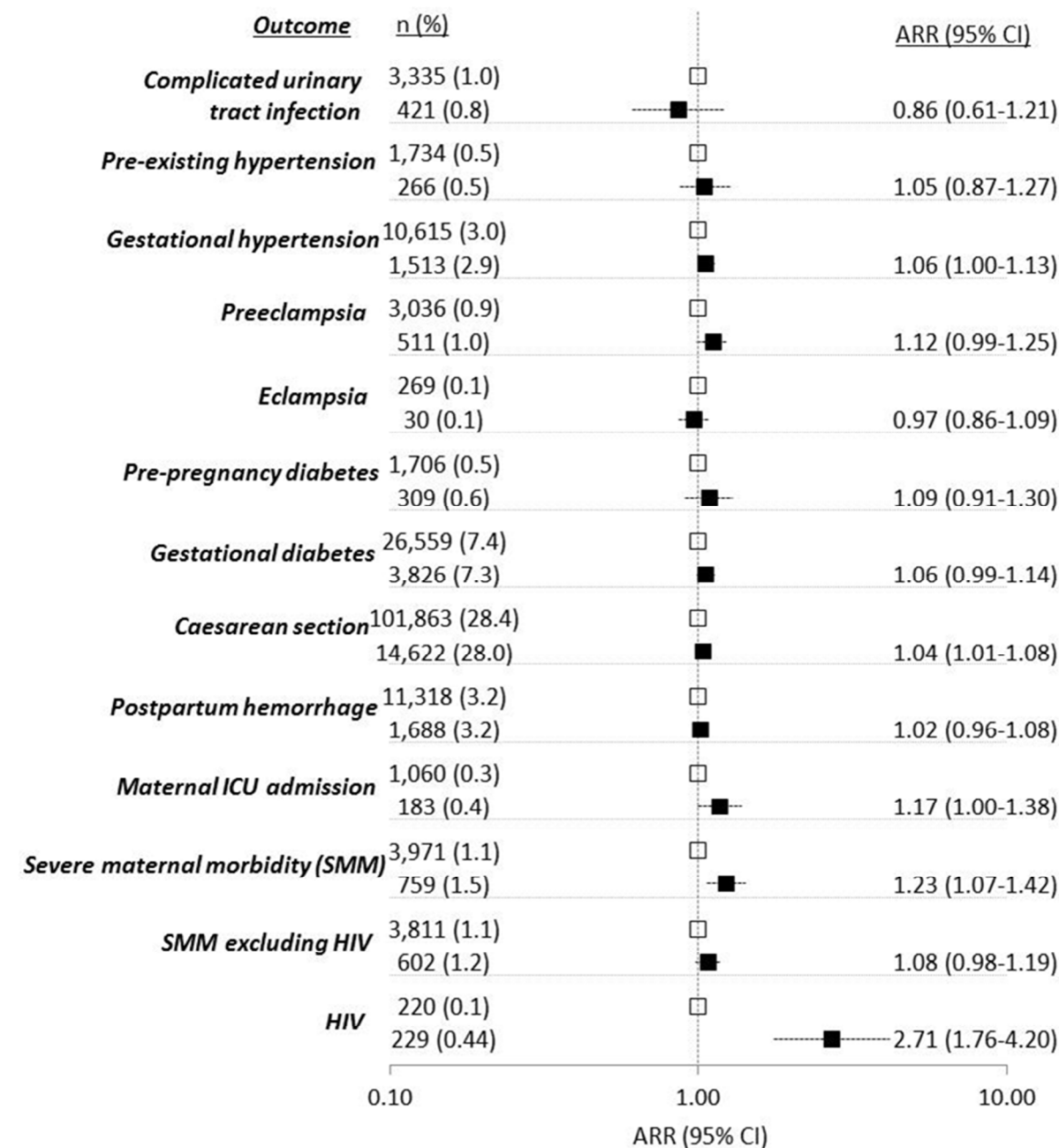

Outcome n/N (%)	ARR (95% CI)
Any congenital anomaly	
1,788/36,499 (4.90)	
104/2,487 (4.18)	0.97 (0.79-1.18)
Moderate preterm birth (32-36 wks)	
1,316/36,406 (3.61)	
99/2,480 (3.99)	1.10 (0.90-1.35)
Very preterm birth (<32 wks)	
182/36,406 (0.50)	
16/2,480 (0.65)	1.29 (0.75-2.24)
Neonatal mortality (<28 days)	
31/36,471 (0.08)	
*/2,486 *	
NICU admission	
2,961/36,491 (8.11)	
171/2,486 (6.88)	0.92 (0.78-1.07)
Perinatal mortality	
147/36,647 (0.40)	
12/2,498 (0.48)	1.00 (0.53-1.88)
Stillbirth	
113/36,647 (0.31)	
10/2,498 (0.40)	1.04 (0.52-2.07)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

Figure S6: Adverse maternal outcomes comparing 52,158 deliveries to ALL refugee immigrants (■ squares) vs. 358,589 deliveries to ALL non-refugee immigrants (□ squares), UNMATCHED on country of birth. Risk ratios* adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
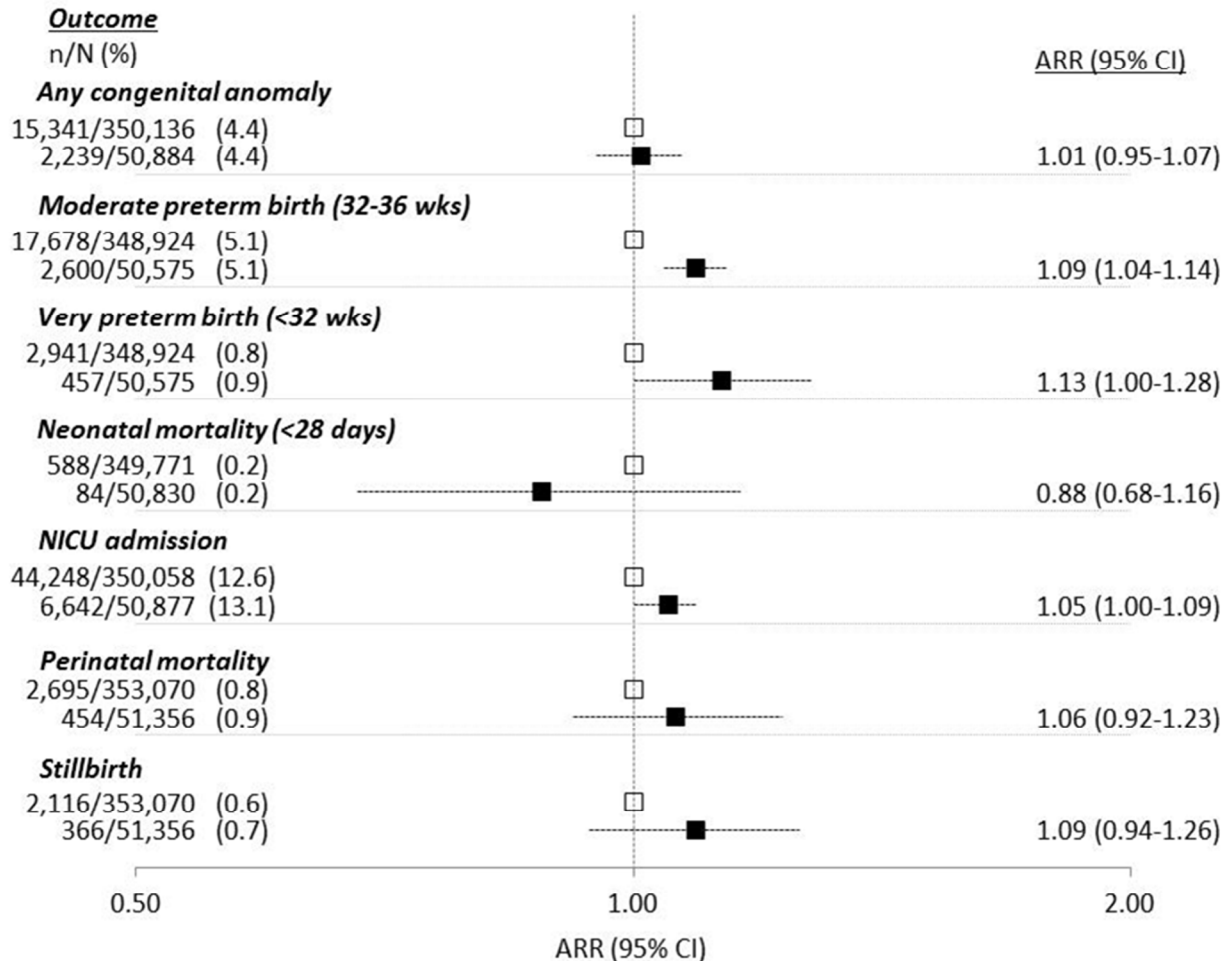
Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	3,335 (1.0) / 421 (0.8)		0.86 (0.61-1.21)
Pre-existing hypertension	1,734 (0.5) / 266 (0.5)		1.05 (0.87-1.27)
Gestational hypertension	10,615 (3.0) / 1,513 (2.9)		1.06 (1.00-1.13)
Preeclampsia	3,036 (0.9) / 511 (1.0)		1.12 (0.99-1.25)
Eclampsia	269 (0.1) / 30 (0.1)		0.97 (0.86-1.09)
Pre-pregnancy diabetes	1,706 (0.5) / 309 (0.6)		1.09 (0.91-1.30)
Gestational diabetes	26,559 (7.4) / 3,826 (7.3)		1.06 (0.99-1.14)
Caesarean section	101,863 (28.4) / 14,622 (28.0)		1.04 (1.01-1.08)
Postpartum hemorrhage	11,318 (3.2) / 1,688 (3.2)		1.02 (0.96-1.08)
Maternal ICU admission	1,060 (0.3) / 183 (0.4)		1.17 (1.00-1.38)
Severe maternal morbidity (SMM)	3,971 (1.1) / 759 (1.5)		1.23 (1.07-1.42)
SMM excluding HIV	3,811 (1.1) / 602 (1.2)		1.08 (0.98-1.19)
HIV	220 (0.1) / 229 (0.44)		2.71 (1.76-4.20)

Axis: 0.10 — 1.00 — 10.00; ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

*Estimated using log-binomial regression with generalized estimating equations to account for potential correlation among mothers from the same country of birth.

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Figure S7: Adverse perinatal outcomes comparing births to ALL refugee immigrants (■ squares) vs. births to ALL non-refugee immigrants (□ squares), UNMATCHED on country of birth. Risk ratios* adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
15,341/350,136 (4.4)		
2,239/50,884 (4.4)		1.01 (0.95-1.07)
Moderate preterm birth (32-36 wks)		
17,678/348,924 (5.1)		
2,600/50,575 (5.1)		1.09 (1.04-1.14)
Very preterm birth (<32 wks)		
2,941/348,924 (0.8)		
457/50,575 (0.9)		1.13 (1.00-1.28)
Neonatal mortality (<28 days)		
588/349,771 (0.2)		
84/50,830 (0.2)		0.88 (0.68-1.16)
NICU admission		
44,248/350,058 (12.6)		
6,642/50,877 (13.1)		1.05 (1.00-1.09)
Perinatal mortality		
2,695/353,070 (0.8)		
454/51,356 (0.9)		1.06 (0.92-1.23)
Stillbirth		
2,116/353,070 (0.6)		
366/51,356 (0.7)		1.09 (0.94-1.26)

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

*Estimated using log-binomial regression with generalized estimating equations to account for potential correlation among mothers from the same country of birth.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3-4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 14- Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Page 14- Table 1
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	All figures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Unadjusted figures in supplementary tables S2 and S3. Confounder adjusted estimates in all figures.
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6
Discussion			
Key results	18	Summarise key results with reference to study objectives	6
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	6-8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

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Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

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Abstract

Objectives: Immigrants are thought to be healthier than their native-born counterparts, but less is known about the health of refugees or forced migrants. Previous studies often equate refugee status with immigration status or country of birth (COB) and none have compared refugee to non-refugee immigrants from the same COB. Herein, we examined whether: i) a refugee mother experiences greater risk of adverse maternal and perinatal health outcomes compared to a similar non-refugee mother from the same COB, and ii) refugee and non-refugee immigrants differ from Canadian-born mothers for maternal and perinatal outcomes.

Design: This is a retrospective population-based database study. We implemented two cohort designs: i) 1:1 matching of refugees to non-refugee immigrants on COB, year and age at arrival (+/- 5 years) and ii) an unmatched design using all data.

Setting and participants: Refugee immigrant mothers (N=34,233), non-refugee immigrant mothers (N=243,439) and Canadian-born mothers (N=615,394) eligible for universal health care insurance who had a hospital birth in Ontario, Canada between 2002 and 2014.

Primary outcomes: Numerous adverse maternal and perinatal health outcomes.

Results: Refugees differed from non-refugee immigrants most notably for HIV, with respective rates of 0.39% and 0.20% and an ARR of 1.51 (95% CI 1.07-2.11). Other elevated outcomes included gestational diabetes mellitus (ARR 1.07, 95% CI 1.00-1.14) caesarean section (ARR 1.03, 95% 1.00-1.05) and moderate preterm birth (ARR 1.06, 95% CI 0.99-1.15). For the majority of outcomes, refugee and non-refugee immigrants experienced similar ARRs when compared with Canadian-born mothers.

Conclusions: Refugee status was associated with a few adverse maternal and perinatal health outcomes but the associations were not strong except for HIV. The definition of refugee status used herein may not sensitively identify refugees at highest risk. Future research would benefit from further refining refugee status based on migration experiences.

Strengths and limitations of this study
- This is a retrospective population-based cohort study from Ontario, Canada linking official permanent resident immigration, hospital and physician billing data to compare births between 2002 and 2014 from refugee mothers (N=34,233) to both non-refugee immigrant mothers (N=243,439) and Canadian-born mothers (N=615,394).
- This is the first study to match refugee immigrant to non-refugee immigrant mothers on country of birth, year and age at arrival; making it possible to explicitly determine whether refugee status confers greater risk of adverse outcomes among two otherwise very similar mothers.
- This is one of the largest studies of refugee maternal and perinatal health in the literature.
- The administrative definition of refugee status used in this study may not be sensitive enough to identify refugees with greater health risks or greater health care needs.

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Introduction

Refugees are considered an extremely vulnerable group for adverse health outcomes.[1] Canada, and other signatories to the United Nations (UN) Convention Relating to the Status of Refugees, define refugees as persons who fear persecution or violence because of their race, religion, nationality or political views and are forced to flee their home countries.[2] In Canada 10% of the 250,000 immigrants who become permanent residents each year are admitted as refugees.[3] Most non-refugee permanent residents are selected based on high levels of education, official language fluency, and work experience or is related to a permanent resident or Canadian citizen. This is in contrast to refugees who are either chosen based on vulnerability by the UN High Commissioner for Refugees (UNHCR) or, claim refugee status upon arrival and have the claim accepted by an independent tribunal.[4]

Given differing exposures in: countries of origin (e.g., conflict), transition countries (e.g., poor access to health services), post-migration exposures (e.g., discrimination); and receiving country immigration policies, the maternal and perinatal health of refugees may differ from their non-refugee immigrant counterparts.[5,6]

Few refugee maternal and perinatal health studies in Canada [5–8] or in other countries [9] compare refugees to non-refugee immigrants. Many studies use a native-born comparator and attribute excess risk to refugee status even though a non-refugee immigrant comparator is absent [10–15]. In addition, many studies rely on country of birth as an indicator of refugee migration [11–18] rather than identifying refugees based on their legal status or migration history. These details are critical, since specialized maternal and perinatal health care tailored to refugees cannot be effectively justified if a "refugee effect" cannot be differentiated from an "immigrant effect" or "country effect". In addition, research often finds that immigrants are healthier than the native-born population, the so-called "healthy migrant effect"[19]. However, the effect may not apply to refugees given their differential exposure to health risks prior to arrival (as described above). Studies are mixed as to whether the healthy migrant effect applies to refugee maternal and perinatal health.[5,6,12]

Given this background our first objective was to determine whether a refugee immigrant mother experiences greater risk of adverse maternal and perinatal health outcomes compared to a similar non-refugee immigrant mother from the same country of birth. Secondary analyses focused on the top 5 refugee source countries (Sri Lanka, Somalia, Afghanistan, Iran, and China). Secondly, we compared maternal and perinatal health outcomes among refugee and non-refugee immigrant mothers to Canadian-born mothers to examine whether the health migrant effect applies to both refugee and non-refugee immigrants. This study used population-based administrative health care and immigration data from Ontario, the province which receives about half of all refugees arriving to Canada [3].

Methods

Study Design and Inclusion/Exclusion Criteria

This retrospective population-based database study included all Ontario hospital childbirth admissions occurring between April 1, 2002 and March 31, 2014. A matched cohort design was used to isolate the excess risk conferred by refugee status beyond that of immigration and country of birth, while a non-matched cohort design used all available data to compare outcomes of refugee and non-refugee immigrants to Canadian-born mothers. Births to refugee and non-refugee immigrant mothers were identified retrospectively through linkage of hospital admissions to the Immigration and Refugees Citizenship Canada Permanent Resident Database (IRCC-PRD). The cost of health care services was not a barrier to accessing care since all mothers were eligible for universal, publicly funded health care insurance. Births not linked to the IRCC PRD were attributed to *Canadian-born mothers* (Indigenous mothers could not be excluded at the time of the linkage). We reduced the bias attributed to unlinked migrant mothers among Canadian-born mothers by further restricting to mothers who: i) became

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eligible for provincial health care insurance on or before 1990 (the first year insurance eligibility was recorded – those eligible prior to 1990 were given an eligibility start year of 1990) and less likely to be immigrants; ii) were born in an Ontario hospital after 1991 (the first year births were available in hospital data) or; iii) became eligible for provincial health care insurance within 1 year of their year of birth and therefore lived in Ontario from a very young age.

For maternal outcomes, the unit of analysis was the delivery episode, where multiple births were counted as a single delivery. For all perinatal outcomes, the unit of analysis was restricted to singletons. Since many of the outcomes in this study are commonly used in epidemiologic surveillance, specifications based on gestational age and/or birthweight used by the Canadian Perinatal Surveillance System [20] were implemented where possible. These specifications relate to including births that are reasonably expected to be at risk for the outcome; births < 500 grams and/or <20 weeks gestation are less likely to be viable. The populations were as follows: for preterm birth (PTB) live births between 22-41 weeks gestational age (GA) and a birth weight (BWT) of ≥500 grams (g); neonatal intensive care (NICU) admission - live births with GA ≥20 weeks or a BWT ≥500 g; neonatal mortality - live births with a BWT ≥500 g; any congenital anomaly - stillbirths and live births with a GA ≥20 weeks or a BWT ≥500 g; stillbirth - GA ≥20 weeks or a BWT ≥500 g; perinatal mortality - stillbirths and live births with a GA ≥20 weeks or a BWT ≥500 g.

Data Sources

We linked five administrative databases held at the Institute for Clinical and Evaluative Sciences (ICES) in Toronto, Ontario. These datasets were linked using unique encoded identifiers (i.e., encrypted health care number) and analyzed at ICES.

The Immigration and Refugees Citizenship Canada Permanent Resident Database (IRCC-PRD) is administered by the Canadian government and used for legal purposes. The Ontario portion of this dataset contains information on all international migrants successful in obtaining permanent residency between 1985 and 2012. The IRCC-PRD contained <1% of missing values for all variables. Linkage between the IRCC-PRD and Ontario's health care registry was necessary to assign each individual in the IRCC-PRD their unique encrypted health care number since this facilitated deterministic linkage to the health care databases used to identify outcomes of interest. Ontario's health care registry consists of all persons eligible for publicly funded health care insurance in the province of Ontario between April 1, 1990 and March 31, 2014. The health care registry contains encrypted unique health care numbers and other personal identifiers. A detailed explanation of the process used to link the IRCC-PRD and Ontario's health care registry can be found elsewhere [21]. In summary, deterministic linkage was undertaken first using several personal identifiers (i.e., sex, last name, given name, birth date) resulting in a 68.2% deterministic linkage rate. Unmatched records were then submitted to a probabilistic and manual review process which resulted in an additional 18.2% of records being linked (13.6% remained unlinked). Bias in the linkage process was investigated by comparing immigration variables between matched and unmatched individuals and little was detected.[21]

Childbirth records were obtained from the Discharge Abstract Database originating from the Canadian Institute of Health Information. Diagnosis and procedure codes using the 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI) identified women with all maternal or perinatal outcomes except early neonatal and neonatal mortality. A validation study supported the use of this database for perinatal research.[22] This dataset also contains information on maternal age at the time of delivery, self-reported parity and birth plurality.

The Office of the Registrar General's Vital Statistics-Death registry was used to identify early neonatal mortality (0-7 days of life) and neonatal mortality (0-28 days of life) between 2002 and 2012. 96.2% of records in the Vital Statistics Registry were successfully linked to the health care registry and

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little bias in the linkage was detected.[21] However, individuals between the ages of 0 and 14 years were more likely to be unlinked. Vital Statistics data were supplemented by mortality recorded in the health care registry and other administrative health care databases, however early neonatal deaths may also be missing in the health care registry because health care numbers may not have been issued.[21]

The Ontario HIV Database (1992-2014) uses an algorithm consisting of at least three physician HIV diagnoses in a 3-year period to identify HIV positive persons. The algorithm demonstrated 96.2% sensitivity and 99.6% specificity when compared to patient charts.[23] HIV diagnoses were restricted to women diagnosed prior to child birth.

Variables

Refugee status was defined using the IRCC-PRD. There are four categories of refugees in the database – i) government sponsored refugees, who are provided with financial and settlement assistance during their 1st year in Canada by the federal government; ii) privately sponsored refugees, who are provided with financial and settlement assistance during their 1st year in Canada by a group of Canadians; iii) refugee claimants, who arrive to Canada unsupported and make a legal claim to refugee status; and iv) refugees who are dependents of a primary refugee applicant. Prior to arrival, the two groups of sponsored refugees were registered with the UN High Commissioner for Refugees (UNHCR) and are chosen for immigration to Canada based on vulnerability. Sponsored refugees become permanent residents and are eligible for provincial health care upon arrival to Canada. Non-sponsored refugees (i.e., refugee claimants) [4,24] are eligible for federally funded health care (administered by the provinces) while they wait for their refugee determination hearing. The proportion of refugee claims approved during the time span of the IRCC-PRD is unknown but recent data indicate approvals have risen from 38.1% in 2013 to 66.1% in 2016 [25]. Successful refugee claimants, who make up the remaining 50% of permanent residents who are refugees, become eligible for permanent residency and for provincial health care once their claim is approved. Unsuccessful refugee claimants are not included in the IRCC-PRD.

Non-refugee immigrants in the IRCC-PRD are predominately skilled immigrants or their family members. Skilled immigrants are selected based on high levels of education, official language fluency, and work experience. Family class immigrants must be related to a permanent resident or Canadian citizen able to provide financial support. Soon after arrival in Canada both groups become permanent residents and are eligible for universal, provincially funded health care.

All immigrants in the IRCC-PRD were subject to an immigration medical exam (IME) during the application process. Prior to 2002 immigration applicants could be rejected if they placed "excessive demand" on health and social services [26]. However, in 2002 the Immigration & Refugee Protection Act (IRPA) [27] came into effect which changed this "excessive demand" criteria so it only applied to skilled immigrants and not family class immigrants or refugees.

Canadian-born women are described above (under "Study Design and Inclusion/Exclusion Criteria").

We examined several maternal and perinatal health outcomes (see Supplementary Table S1 for codes). Severe maternal morbidity (SMM), was evaluated using a composite surveillance indicator [28,29] developed by the Canadian Perinatal Health Surveillance System. A woman had SMM if she had one or more of forty-five ICD-10-CA/CCI diagnoses or procedures reported during hospital admission for labour or delivery.[28] Other maternal health outcomes, documented at the time of delivery, were: complicated urinary tract infection (UTI), pre-existing hypertension, gestational hypertension, preeclampsia, eclampsia, pre-pregnancy diabetes, gestational diabetes mellitus (GDM), caesarean section, post-partum hemorrhage (PPH) and maternal intensive care unit (ICU) admission. Perinatal outcomes, documented at birth, included: any congenital anomaly, moderate preterm birth (moderate PTB) (32-36 weeks gestation), very preterm birth (very PTB) (< 32 weeks gestation), neonatal ICU (NICU) admission and stillbirth. Measurement of early neonatal mortality (0-7 days of life) and neonatal

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mortality (0-28 days of life) were not restricted to the hospital delivery admission. Information from both the ORGD and the RPDB were combined to identify early neonatal and neonatal mortality. Early neonatal mortality was combined with information on stillbirth to identify perinatal mortality.

Potential confounders were identified *a priori*. Some control variables were available for all births, including maternal age at delivery (15-19, 20-24, 25-29, 30-34, 35-39, 40+ years), neighborhood income quintile, parity (0, 1, 2 or ≥ 3 previous births) and plurality. Other control variables were only available for refugees and non-refugee immigrants since this information was collected in the IRCC-PRD. These included: maternal country of birth (COB); COBs categorized into world regions and sub-regions according to the UN classification system with a modification to the developed countries classification [30]; year of arrival (5-year categories); age at arrival (5-year categories); maternal education at arrival (0-9 years, 10-12 years, 13+ years, trade certificate/non-university diploma, University degree); knowledge of official Canadian languages at arrival (English and/or French or neither); and duration of residence in Canada, defined as the time (in years) elapsed between the date of becoming a permanent resident and the date of delivery.

Analysis

Births with missing data for any control variable were excluded. To estimate whether refugee status increases the risk of adverse outcomes between a refugee mother and a non-refugee mother with a similar pre-migration circumstances (objective 1), we 1:1 matched first births in Canada among refugees to non-refugee immigrants on COB, year of arrival (+/- 5 years) and age at arrival (+/- 5 years). Analyses were restricted to the first delivery in the hospitalization database to prevent matching several births from a single refugee mother to births to more than one non-refugee immigrant mother. With this matched cohort design, estimating risk ratios is preferred over odds ratios since it is more appropriate to model the risk in a cohort study and because risk ratios do not exaggerate relative risks for common outcomes (which odds ratios tend to do). For these reasons we opted to use log-binomial regression instead of conditional logistic regression which estimates odds ratios. In addition, to compare refugee and non-refugee immigrants within pairs (or clusters) we used fixed-effects Generalized Estimating Equations (GEE) with an exchangeable correlation matrix.[31] This was deemed an acceptable approach since analysis of clustered data using conditional logistic regression and logistic regression with GEE was shown to provide similar estimates and standard errors.[32]

Models were adjusted for maternal age at delivery, parity, neighborhood income, education at arrival, knowledge of official languages at arrival and duration of residence in Canada. In secondary analyses focusing on refugee and non-refugee immigrants from the top 5 refugee source countries of birth, all births were included and analyzed with log-binomial regression. Non-independence of the outcome among births to the same mother was accounted for with GEE.

To compare refugee and non-refugee mothers to Canadian-born mothers all births were included and log-binomial regression with GEE was used to account for non-independence of the outcome among births from the same mother. Fewer variables were available for Canadian-born women so models were adjusted for maternal age at delivery, parity and neighborhood income.

Research Ethics

This study was approved by the institutional review board at Sunnybrook Health Sciences Centre, and the ethics review board of St. Michael's Hospital, Toronto, Canada.

Results

Table 1 summarizes the characteristics of refugee immigrant mothers (N=34,233), non-refugee immigrant mothers (N=243,439) and Canadian-born mothers (N=615,394). Refugee mothers had 52,360 births in Ontario, non-refugee immigrant mothers had 360,007 births and Canadian mothers had

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977,045 births. More refugee mothers (10%) had high parity (≥ 3 previous births) compared to both non-refugee immigrant (3.2%) and Canadian-born mothers (2.7%) at the first birth in Ontario. A greater proportion of refugees had less than 13 years of education at arrival (72.6%) compared to non-refugee immigrants (43.0%). There were about 5 times as many refugee mothers from Sub-Saharan Africa compared to non-refugee immigrant mothers (22.8% and 4.8%, respectively).

Eighty-five percent of refugee mothers (N= 29,023) were successfully matched to a non-refugee mother on country of birth, and year and age at arrival (+/- 5 years). For most outcomes, differences between matched refugees and non-refugees were non-significant (see Figures 1 and 2). GDM (ARR=1.07 95% CI 1.00-1.14), caesarean section (ARR=1.03 95% CI 1.00-1.05) and HIV (ARR=1.51 95% CI 1.07-2.11 were significantly higher among refugees. Moderate PTB approached statistical significance (ARR=1.06, 95% CI 0.99-1.15). See Supplementary Table S2 for unadjusted results.

Supplementary Figures (S1a/b through S5a/5b) disaggregate results according to the top 5 refugee source countries to Ontario– Sri Lanka, Somalia, Afghanistan, Iraq and China. Afghan and Iraqi refugees had higher risk of caesarean section while Sri Lankan and Somali refugees experienced higher risk of MPTB compared to their same-country non-refugee counterparts.

Figures 3 and 4 compare both refugees to Canadian-born mothers and non-refugee immigrants to Canadian-born mothers. Other than severe maternal morbidity (SMM) and HIV, the two sets of ARRs comparing refugees to Canadian-born mothers and non-refugees to Canadian-born mothers were in the same direction and of a similar magnitude. With respect to SMM (Figure 3), refugees had a significantly higher rate compared to Canadian-born mothers while non-refugee immigrant mothers had a significantly lower rate. However, after HIV was removed from the SMM index refugees experienced a similar rate of SMM to Canadian-born mothers. For other maternal outcomes (Figure 3), both refugees and non-refugees compared to Canadian-born mothers had: *significantly lower risk* of complicated UTI, pre-existing hypertension, gestational hypertension, preeclampsia, eclampsia, pre-pregnancy diabetes, and PPH; and *significantly higher risk* of caesarean section, GDM, maternal ICU admission and HIV. In terms of perinatal outcomes (Figure 4), both refugees and non-refugees compared to Canadian-born mothers had: *significantly lower risk* of any congenital anomaly and moderate PTB; similar risk of very PTB and neonatal mortality; and *significantly higher risk* of NICU admission, perinatal mortality and stillbirth. See Supplementary Table S3 for unadjusted results.

Discussion

We found modest increased risks of gestational diabetes, cesarean section and moderate PTB among refugee compared to non-refugee mothers from the same COB. HIV was the exception with a much greater prevalence. Overall, our findings suggest that refugee status, measured with an administrative definition, is not a strong risk indicator for poor maternal and perinatal health. In addition, we found that refugee and non-refugee mothers experienced a similar magnitude of relative risk for almost all outcomes when each group was separately compared to Canadian-born mothers. About one third of outcomes were significantly worse among refugee and non-refugee immigrant mothers when compared to Canadian-born mothers.

The findings on SMM and HIV are explained in detail in a previous report of ours [5] (although unmatched on country of birth). Our current results are consistent with the previous study however with smaller HIV prevalence ratios. The smaller prevalence ratio can likely be explained by the different method used to capture HIV diagnoses (hospital discharge data in the previous study and HIV physician diagnoses data in the current study) but also because 1:1 matching of refugee to non-refugee immigrants on country of birth, year and age at arrival in the current study accounted for some of the difference between refugee and non-refugee immigrants. In our previous work we found that refugee mothers with HIV did not have any greater maternal morbidity compared to non-refugee immigrant or Canadian-born mothers with HIV, suggesting that HIV during pregnancy is well-managed in Ontario

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regardless of refugee status (with permanent residency). In contrast, a Dutch study [9] describes HIV as a risk indicator for severe acute maternal morbidity among asylum-seekers (refugees without permanent residency); suggesting that a lack of appropriate HIV care may be contributing to SAMM.

Refugee mothers were 3% more likely to have a caesarean section compared their non-refugee counterparts while Afghan and Iraqi refugee mothers were ~20% more likely to experience caesarean section than their same-country non-refugee counterparts. A study involving 10 Canadian hospitals [33] found a significant difference between refugee, asylum-seeker and non-refugee immigrants from South-East and Central Asia. Reasons for the higher caesarean rate among refugees were: higher parity, medical complications, low socio-economic status, socio-cultural factors and sub-optimal perinatal care.[33]

Refugee status was also positively associated with gestational diabetes and moderate PTB. Sri Lankan and Somali refugees had a greater risk of moderate PTB. The relationship between refugee status and gestational diabetes may be explained by a study which found stressful events were associated with 2.5 times greater risk of gestational diabetes.[34] Other research suggests maternal chronic stress is an important risk factor for PTB,[35] particularly among socially disadvantaged populations.[36] Previously published research of ours found that the effect of refugee status on PTB was stronger among refugee mothers who resided in a transition country prior to arriving in Canada [7] with potentially greater exposure to psychosocial stress. The hypothesized physiological mechanism connecting psychosocial stress to both gestational diabetes and PTB involves dysfunction of regulatory hormones in the body - insulin resistance or impaired insulin metabolism leading to gestational diabetes [34] and early release of hormones required for the initiation of labour leading to PTB.[35]

The extent to which refugee and non-refugee immigrants experienced the "healthy migrant effect" (HME) (relative to Canadian-born mothers) for all maternal and perinatal health outcomes was identical. We found that both refugee and non-refugee immigrants experienced higher risk of the same adverse maternal and perinatal health outcomes (1/3 of all outcomes examined) compared to Canadian-born mothers. This suggests that refugee status, using an administrative definition of refugees, is not an important factor in the HME for these outcomes. These findings are also consistent with others who have stated that the HME is not evident for all health outcomes.[37]

Strengths and Limitations

Among studies examining refugee maternal and perinatal health [5–18,38–49], our study has several unique and important strengths. Firstly, our study used official government immigration data to identify women who met the UNHCR definition of a refugee rather than relying on country of birth (COB) as an indicator of refugee status, as many previous studies have done.[11–18] Secondly, we matched refugee and non-refugee immigrant women on country of birth, as well as year and age at arrival (see Supplementary Figures S6 & S7 for unmatched results). By matching on these variables, ours is the first study to effectively address the question of whether refugee status among two otherwise similar immigrant mothers, is a risk indicator for adverse maternal and perinatal outcomes. Thirdly, to our knowledge our study includes the largest sample of mothers legally classified as refugees reported in the literature contributing to adequate statistical power for our main analyses (objectives 1 and 2).

This study is not without limitations. In our main analysis, we matched 85% of refugee mothers to one non-refugee immigrant mother. To ensure that the results of the matched sample were not biased, a sensitivity analysis was conducted where the refugees and non-refugees unmatched on country of birth were matched instead by sub-region of birth (e.g., East Africa) as well as year and age at arrival. With this second round of matching, 99% of all refugee mothers were matched to a non-refugee mother either on country or sub-region of birth. Analysis of this twice-matched cohort yielded very similar risk ratios to those of the first match. Given that the results were similar, and that the first match

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most effectively tells us whether refugee status among immigrant mothers with a similar pre-migration context increases risk of adverse outcomes, we chose to present results from only the first match.

Other limitations are as follows. Firstly, the "refugee experience" as it pertains to health risks may not be consistent with the legally applied definition of "refugee". Risk factors for adverse outcomes (i.e., exposure to violence, forced family separation) are context dependent, such as the length of time in the migration phase and access to health and other supportive services before and during migration - factors for which we did not have data. We addressed context by matching refugees to non-refugees on COB, year and age at arrival a well as restricting analyses to the top 5 refugee-source countries; however even within these COBs there is likely important heterogeneity which we could not examine or account for. A second limitation is the inability to categorize family class non-refugee immigrants according to the permanent residency status of the sponsoring family member (i.e., economic or refugee). This may have caused some refugees to be misclassified as non-refugee immigrants and contributed to biasing estimates in Figures 1 and 2 towards the null. However, since refugees are less likely to have the financial means necessary for sponsorship, the number of family class members who may be refugees is not likely to substantially affect risk estimates. A third limitation may be that estimates in Figures 1 and 2 were over-adjusted given that the majority of non-refugee permanent residents are selected based on their education and official language ability. However, unadjusted estimates (see Supplementary Table S2) demonstrate that adjusting for these variables does not substantially affect our conclusions. A fourth limitation is that we lacked data on body mass index. Finally, our findings are not generalizable to *unsuccessful* refugee claimants (since our study was limited to permanent residents) who may be more representative of refugees and asylum seekers in other countries.

Implications

To help understand modest differences in gestational diabetes and moderate PTB between refugee and non-refugee immigrant women, further research into stressors refugee mothers experience in their countries of origin, in transition countries and in countries of re-settlement may help support development of preconception and pregnancy stress prevention and management strategies.

Research has described that refugees and other immigrants in Canada experience barriers to accessing health care[50], had unaddressed health concerns after birth [51] and experienced culturally insensitive policies [50]. Indeed, such health care deficiencies may have contributed to the 1/3rd of outcomes where refugee and non-refugee immigrant mothers experienced greater risk when compared to Canadian-born mothers. By the same token, it is surprising that refugee mothers did not experience an excess of maternal and infant health risks compared to non-refugee immigrants since these health care deficiencies are likely experienced more acutely by refugee mothers.

There are a few important caveats to our findings. Firstly, and perhaps most importantly, the administrative definition of refugees is broad and is perhaps unable to sensitively identify refugees at highest health risk. Secondly, non-refugee immigrants from refugee-source countries may be just as likely to experience pre-departure health risks (related to persecution) as their refugee counterparts, reducing specificity and minimizing any differences between the groups. Thirdly, all permanent resident refugees to Canada receive financial and social supports (e.g., housing, resettlement), particularly in the first year after arrival as well as universal health care (as described in the method section). Specialized primary health care centres catering to the unique health needs of refugees are available [52,53]. There are also national efforts to highlight the need for a focus on equity in the quality of care received and migrant friendly maternity care [54]. These specialized health and social support efforts may be helping to minimize potential health inequities experienced by refugees. Lastly, despite official immigration policies, such as the Immigration & Refugee Protection Act (IRPA, 2002)[26,27] (see methods section for more detail), it is possible that unofficial processes select refugees based on factors such as skill level and language fluency (i.e., similar to non-refugee immigrants), effectively selecting for healthy refugees.

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Future Research

Refugees should be compared to non-refugee immigrants, preferably from the same country of birth, as this more effectively addresses the question of whether refugees, among all migrants, are at increased risk for poor health. Further refining refugee status based on detailed migration experiences would also be beneficial. Finally, to help facilitate international comparisons, refugee health researchers may find it useful to state if and how immigration policies shape the health of refugees relative to other immigrants within their borders.

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References

1   Gagnon AJ, Merry L, Robinson C. A systematic review of refugee women's reproductive health. *Refuge* 2002.

2   Citizenship and Immigration Canada. Guide 6000 - Convention Refugees Abroad and Humanitarian-Protected Persons Abroad. 2017.http://www.cic.gc.ca/English/information/applications/guides/E16000TOC.asp (accessed 1 May 2017).

3   Immigration, Refugees & Citizenship Canada. Facts & Figures 2015: Immigration Overview - Permanent Residents – Annual IRCC Updates. Canada - Permanent residents by province or territory and category. 2015. http://www.cic.gc.ca/opendata-donneesouvertes/data/IRCC_FFPR_17_F.xls (accessed 11 May 2017).

4   Settlement.org. How does Canada's refugee system work? 2017.http://settlement.org/ontario/immigration-citizenship/refugees/basic-information-for-refugees/how-does-canada-s-refugee-system-work/ (accessed 1 May 2017).

5   Wanigaratne S, Cole DC, Bassil K, *et al.* Contribution of HIV to Maternal Morbidity Among Refugee Women in Canada. *Am J Public Health* 2015;**105**:2449–56. doi:10.2105/AJPH.2015.302886

6   Wanigaratne S, Cole DC, Bassil K, *et al.* Severe Neonatal Morbidity Among Births to Refugee Women. *Matern Child Health J* 2016;**20**:2189–98. doi:10.1007/s10995-016-2047-4

7   Wanigaratne S, Cole DC, Bassil K, *et al.* The influence of refugee status and secondary migration on preterm birth. *J Epidemiol Community Health* 2016;**70**:622–8. doi:10.1136/jech-2015-206529

8   Vigod SN, Bagadia AJ, Hussain-Shamsy N, *et al.* Postpartum mental health of immigrant mothers by region of origin, time since immigration, and refugee status: a population-based study. *Arch Womens Ment Health*;**20**:439–47. doi:10.1007/s00737-017-0721-1

9   Van Hanegem N, Miltenburg AS, Zwart JJ, *et al.* Severe acute maternal morbidity in asylum seekers: a two-year nationwide cohort study in the Netherlands. *Acta Obstet Gynecol Scand* 2011;**90**:1010–6.

10   Gagnon AJ, Dougherty G, Wahoush O, *et al.* International migration to Canada: The post-birth health of mothers and infants by immigration class. *Soc Sci Med* 2012;**76**:197–207.

11   Vangen S, Stoltenberg C, Johansen REB, *et al.* Perinatal complications among ethnic Somalis in Norway. *Acta Obstet Gynecol Scand* 2002;**81**:317–22.

12   Essen B, Hanson BS, Ostergren PO, *et al.* Increased perinatal mortality among sub-Saharan immigrants in a city-population in Sweden. *Acta Obstet Gynecol Scand* 2000;**79**:737–43.

13   Belihu FB, Davey M-A, Small R. Perinatal health outcomes of East African immigrant populations in Victoria, Australia: a population based study. *BMC Pregnancy Childbirth* 2016;**16**. doi:10.1186/s12884-016-0886-z

11

14 Bakken KS, Skjeldal OH, Stray-Pedersen B. Immigrants from conflict-zone countries: an observational comparison study of obstetric outcomes in a low-risk maternity ward in Norway. *BMC Pregnancy Childbirth* 2015;**15**. doi:10.1186/s12884-015-0603-3

15 Miller LS, Robinson JA, Cibula DA. Healthy Immigrant Effect: Preterm Births Among Immigrants and Refugees in Syracuse, NY. *Matern Child Health J* 2016;**20**:484–93. doi:10.1007/s10995-015-1846-3

16 Gibson-Helm M, Teede H, Block A, *et al.* Maternal health and pregnancy outcomes among women of refugee background from African countries: a retrospective, observational study in Australia. *BMC Pregnancy Childbirth* 2014;**14**:392.

17 Gibson-Helm M, Boyle J, Cheng I-H, *et al.* Maternal health and pregnancy outcomes among women of refugee background from Asian countries. *Int J Gynecol Obstet* 2015;**129**:146–51. doi:10.1016/j.ijgo.2014.10.036

18 Gibson-Helm M, Teede H, Cheng I-H, *et al.* Maternal health and pregnancy outcomes comapring migrant women born in humanitarian and nonhumanitarian source courtries: a retrospective, observational study. *Birth* 2015;**42**:116–24.

19 Urquia ML, Gagnon AJ. Glossary: migration and health. *J Epidemiol Community Health* 2011;**65**:467–472.

20 Public Health Agency of Canada. Perinatal Health Indicators for Canada - 2011. 2011. http://www.phac-aspc.gc.ca/rhs-ssg/phi-isp-2011-eng.php (accessed 15 Aug 2013).

21 Chiu M, Lebenbaum M, Lam K, *et al.* Describing the linkages of the immigration, refugees and citizenship Canada permanent resident data and vital statistics death registry to Ontario's administrative health database. *BMC Med Inform Decis Mak* 2016;**16**. doi:10.1186/s12911-016-0375-3

22 Joseph KS, Fahey J. Validation of perinatal data in the Discharge Abstract Database of the Canadian Institute for Health Information. *Chronic Dis Can* 2009;**29**:96–100.

23 Antoniou T, Zagorski B, Loutfy MR, *et al.* Validation of Case-Finding Algorithms Derived from Administrative Data for Identifying Adults Living with Human Immunodeficiency Virus Infection. *PLoS ONE* 2011;**6**:e21748. doi:10.1371/journal.pone.0021748

24 Keung N. The law says refugee claims must be heard in 60 days. So why are people waiting 16 months? Tor. Star. 2017.https://www.thestar.com/news/immigration/2017/09/20/the-law-says-refugee-claims-must-be-heard-in-60-days-so-why-are-asylum-seekers-waiting-16-months.html (accessed 19 Nov 2017).

25 Keung N. Canada's refugee acceptance rate peaked in four years. Tor. Star. 2017.https://www.thestar.com/news/immigration/2017/03/07/canadas-refugee-acceptance-rate-peaked-in-four-years.html (accessed 19 Nov 2017).

26 Immigration, Refugees & Citizenship Canada. Excessive demand on health and social services. 2016.http://www.cic.gc.ca/english/resources/tools/medic/admiss/excessive.asp (accessed 1 May 2017).

12

27   Minister of Justice, Canada. Immigration and Refugee Protection Act S.C. 2001, c.27. 2016.
       http://laws.justice.gc.ca/PDF/I-2.5.pdf (accessed 19 Dec 2016).

28   Joseph KS, Liu S, Rouleau J, *et al.* Severe maternal morbidity in Canada, 2003 to 2007: surveillance
       using routine hospitalization data and ICD-10CA codes. *J Obstet Gynaecol Can* 2010;**32**:837–846.

29   Liu S, Joseph KS, Bartholomew S, *et al.* Temporal trends and regional variations in severe maternal
       morbidity in Canada, 2003 to 2007. *J Obstet Gynaecol Can* 2010;**32**:847–855.

30   United Nations Statistics Division. Composition of macro geographical (continental) regions,
       geographical sub-regions, and selected economic and other groups.
       2013.http://unstats.un.org/unsd/methods/m49/m49regin.htm (accessed 13 Oct 2016).

31   Alexander MT, Kufera JA. Butting heads on matched cohort analysis using SAS software. 2007.
       https://www.researchgate.net/publication/228891709_Butting_heads_on_matched_cohort_analys
       is_using_SASR_software (accessed 2 Nov 2017).

32   Ying G, Liu C. Statistical analysis of clustered data SAS System. 2006.
       www.lexjansen.com/nesug/nesug06/an/da01.pdf (accessed 17 Nov 2017).

33   Gagnon AJ, Van Hulst A, Merry L, *et al.* Cesarean section rate differences by migration indicators.
       Arch Gynecol Obstet 2013;**287**:633–9. doi:10.1007/s00404-012-2609-7

34   Hosler AS, Nayak SG, Radigan AM. Stressful events, smoking exposure and other maternal risk
       factors associated with gestational diabetes mellitus. *Paediatr Perinat Epidemiol* 2011;**25**:566–574.

35   Latendresse G. The interaction between chronic stress and pregnancy: preterm birth from a
       biobehavioral perspective. *J Midwifery Women's Health* 2009;**54**:8–17.

36   Wadhwa PD, Entringer S, Buss C, *et al.* The contribution of maternal stress to preterm birth: issues
       and considerations. *Clin Perinatol* 2011;**38**:351–84. doi:10.1016/j.clp.2011.06.007

37   Vang ZM, Sigouin J, Flenon A, *et al.* Are immigrants healthier than native-born Canadians? A
       systematic review of the healthy immigrant effect in Canada. *Ethn Health* 2017;**22**:209–41.
       doi:10.1080/13557858.2016.1246518

38   Goosen S, Hoebe CJ, Waldhober Q, *et al.* High HIV prevalence among asylum seekers who gave birth
       in the Netherlands: a nationwide study based on antenatal HIV tests. *PloS One* 2015;**10**:e0134724.

39   Dennis C-L, Merry L, Stewart D, *et al.* Prevalence, continuation, and identification of postpartum
       depressive symptomatology among refugee, asylum-seeking, non-refugee immigrant, and
       Canadian-born women: results from a prospective cohort study. *Arch Womens Ment Health*
       2016;**19**:959–67. doi:10.1007/s00737-016-0633-5

40   Dennis C-L, Merry L, Gagnon AJ. Postpartum depression risk factors among recent refugee, asylum-
       seeking, non-refugee immigrant, and Canadian-born women: results from a prospective cohort
       study. *Soc Psychiatry Psychiatr Epidemiol* 2017;**52**:411–22. doi:10.1007/s00127-017-1353-5

13

41 Gann P, Nghiem L, Warner S. Pregnancy characteristics and outcomes of Cambodian refugees. *Am J Public Health* 1989;**79**:1251–7.

42 Flynn PM, Foster EM, Brost BC. Indicators of acculturation related to Somali refugee women's birth outcomes in Minnesota. *J Immigr Minor Health* 2011;**13**:224–231.

43 Kandasamy T, Berniak R, Shah R, *et al.* Obstetric Risks and Outcomes of Refugee Women at a Single Centre in Toronto. *J Obstet Gynaecol Can* 2014;**36**:296–302.

44 Davis JM, Goldenring J, McChesney M, *et al.* Pregnancy outcomes of Indochinese refugees, Santa Clara County, California. *Am J Public Health* 1982;**72**:742–4.

45 Lalchandani S, MacQuillan K, Sheil O. Obstetric profiles and pregnancy outcomes of immigrant women with refugee status. *Ir Med J* 2001;**94**:79–80.

46 King PA, Duthie SJ, Li DFH, *et al.* Obstetric outcome among Vietnamese refugees in Hong Kong: an age-matched case-controlled study. *Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet* 1990;**33**:203–10.

47 Malamitsi-Puchner A, Tzala L, Minaretzis D, *et al.* Preterm delivery and low birthweight among refugees in Greece. *Paediatr Perinat Epidemiol* 1994;**8**:384–390.

48 Kuvacic I, Skrablin S, Hodzic D, *et al.* Possible influence of expatriation on perinatal outcome. *Acta Obstet Gynecol Scand* 1996;**75**:367–71.

49 Liu C, Urquia M, Cnattingius S, *et al.* Migration and preterm birth in war refugees: a Swedish cohort study. *Eur J Epidemiol* 2014;**29**:141–3. doi:10.1007/s10654-013-9877-9

50 Stewart M, Dennis CL, Kariwo M, *et al.* Challenges Faced by Refugee New Parents from Africa in Canada. *J Immigr Minor Health* 2015;**17**:1146–56. doi:10.1007/s10903-014-0062-3

51 Gagnon AJ, Dougherty G, Platt RW, *et al.* Refugee and refugee-claimant women and infants post-birth: migration histories as a predictor of Canadian health system response to needs. *Can J Public Health Rev Can Sante Publique* 2007;**98**:287–91.

52 Women's College Hospital. Crossroads Clinic. http://www.womenscollegehospital.ca/programs-and-services/crossroads-clinic/ (accessed 21 Jul 2017).

53 Access Alliance Multicultural Health and Community Services. http://accessalliance.ca/ (accessed 21 Jul 2017).

54 Gagnon AJ, DeBruyn R, Essén B, *et al.* Development of the Migrant Friendly Maternity Care Questionnaire (MFMCQ) for migrants to Western societies: an international Delphi consensus process. *BMC Pregnancy Childbirth* 2014;**14**:200.

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Data Sharing Statement: There are no additional unpublished data available from this study.

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Table 1: Characteristics of refugee immigrant, non-refugee immigrant and Canadian-born mothers in Ontario, Canada 2002-2014.

	Refugee immigrant (N = 34,233)	Non-refugee immigrant (N = 243,439)	Canadian-born (N = 615,394)
Maternal age at first birth, years			
15-19	989 (2.9)	3,469 (1.4)	40,905 (6.6)
20-24	5,271 (15.4)	30,330 (12.5)	98,808 (16.1)
25-29	10,231 (29.9)	75,982 (31.2)	180,850 (29.4)
30-34	10,032 (29.3)	79,885 (32.8)	191,433 (31.1)
35-39	5,958 (17.4)	42,893 (17.6)	84,383 (13.7)
≥ 40	1,742 (5.1)	10,843 (4.5)	18,624 (3.0)
Missing	10 (0.0)	37 (0.0)	391 (0.1)
Parity at first birth in Ontario			
0	18,826 (55.0)	152,530 (62.7)	445,715 (72.4)
1	7,631 (22.3)	62,708 (25.8)	109,462 (17.8)
2	4,317 (12.6)	20,091 (8.3)	42,656 (6.9)
≥3	3,421 (10.0)	7,892 (3.2)	16,635 (2.7)
Missing	38 (0.1)	218 (0.1)	926 (0.2)
Number of births in Ontario			
1	20,406 (59.6)	148,694 (61.1)	328,458 (53.4)
2	10,356 (30.3)	76,411 (31.4)	225,838 (36.7)
3	2,800 (8.2)	15,473 (6.4)	50,262 (8.2)
≥ 4	671 (2.0)	2,861 (1.2)	10,836 (1.8)
Neighbourhood income quintile			
1 (lowest)	15,332 (44.8)	78,309 (32.2)	111,281 (18.1)
2,3,4 (middle)	16,804 (49.1)	141,357 (58.1)	386,578 (62.8)
5 (highest)	2001 (5.8)	22,926 (9.4)	113,769 (18.5)
Missing	96 (0.3)	847 (0.3)	3,766 (0.6)
Official language ability at immigration			
English and/or French	19,633 (57.4)	157,788 (64.8)	--
Neither English or French	14,600 (42.6)	85,645 (35.2)	--
Missing	0 (0.0)	6 (0.0)	--
Level of education at immigration			
0-9 years	14,923 (43.6)	56,485 (23.2)	--
10-12 years	9,931 (29.0)	48,137 (19.8)	--
≥ 13 years	3,010 (8.8)	22,380 (9.2)	--
Trade, Diplomas	3,720 (10.9)	30,852 (12.7)	--
Bachelors, Masters, Doctorate	2,649 (7.7)	85,585 (35.2)	--
Duration of residence, years			
< 10	21,569 (63.0)	184,508 (75.8)	--
≥ 10	12,664 (37.0)	58,931 (24.2)	--
World region of birth			
South Asia	9,233 (27.0)	78,184 (32.1)	--
Sub Saharan Africa	7,810 (22.8)	11,733 (4.8)	--
Latin America & Caribbean	4,928 (14.4)	33,075 (13.6)	--
Western & Central Asia, North Africa	3,458 (10.1)	17,502 (7.2)	--
Eastern Europe	3,189 (9.3)	18,542 (7.6)	--
Southeast Asia, Oceania Islands	1,514 (4.4)	28,514 (11.7)	--

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East Asia (excluding Japan)	1,878 (5.5)	35,669 (14.7)	--
Southern Europe	1,966 (25.1)	8,003 (30.8)	--
Developed Countries	250 (22.4)	12,152 (25.5)	--
Missing	7 (0.0)	65 (0.0)	--

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FIGURE LEGEND

Figure 1: Adverse maternal outcomes comparing 29,023 first births in Ontario to refugee immigrants (● circles) vs. 29,023 first births in Ontario births to non-refugee immigrants (○circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Figure 1 footnote: ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

Figure 2: Adverse perinatal outcomes comparing first births in Ontario to refugee immigrants (● circles) vs. first births in Ontario to non-refugee immigrants (○circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Denominators vary with the outcome examined. Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Figure 2 footnote: ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

Figure 3: Adverse maternal outcomes comparing 52,360 births to refugee immigrants (●circles) and 360,007 births to non-refugee immigrants (●circles) vs. 977,045 births to Canadian-born (○circles) mothers. Risk ratios adjusted for maternal age, parity and income quintile.

Figure 3 footnote: ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

Figure 4: Adverse perinatal outcomes comparing births to refugee immigrants (●circles) and births to non-refugee immigrants (●circles) vs. births to Canadian-born mothers (○circles). Denominators vary with the outcome examined. Risk ratios adjusted for maternal age, parity, and income quintile.

Figure 4 footnote: ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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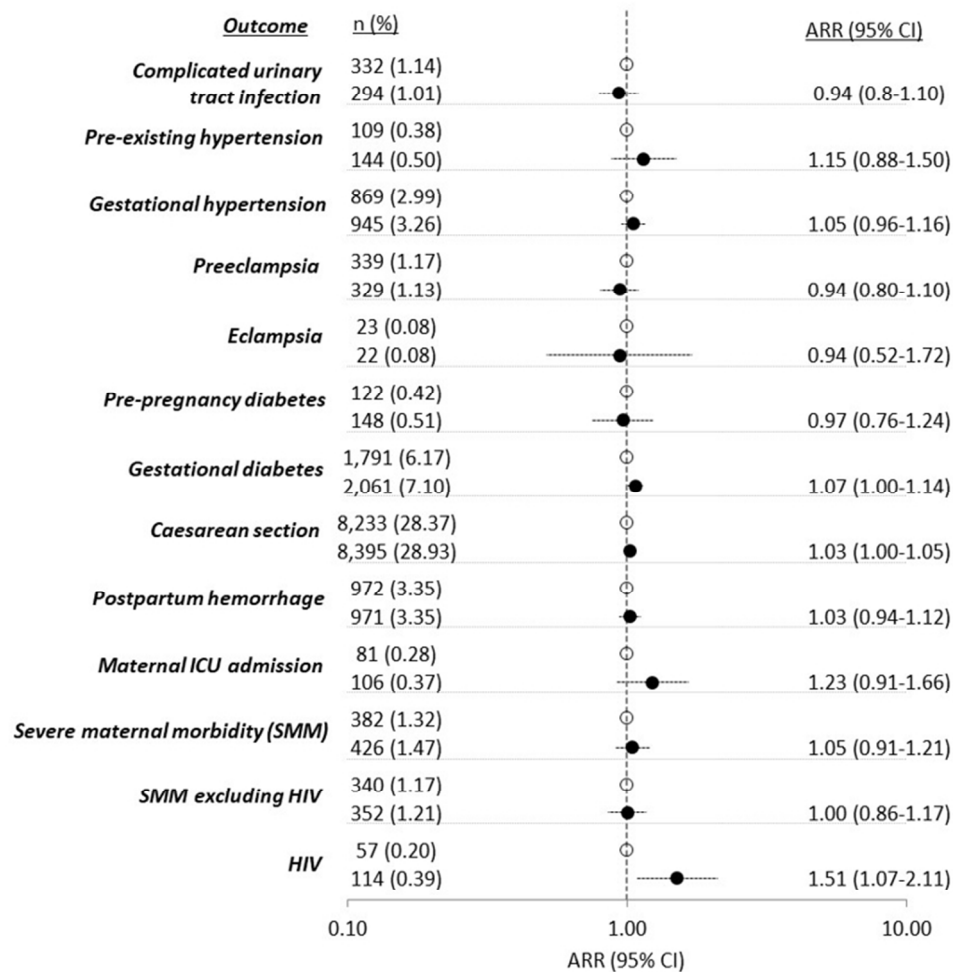
Figure 1: Adverse maternal outcomes comparing 29,023 first births in Ontario to refugee immigrants (black circles) vs. 29,023 first births in Ontario births to non-refugee immigrants (white circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

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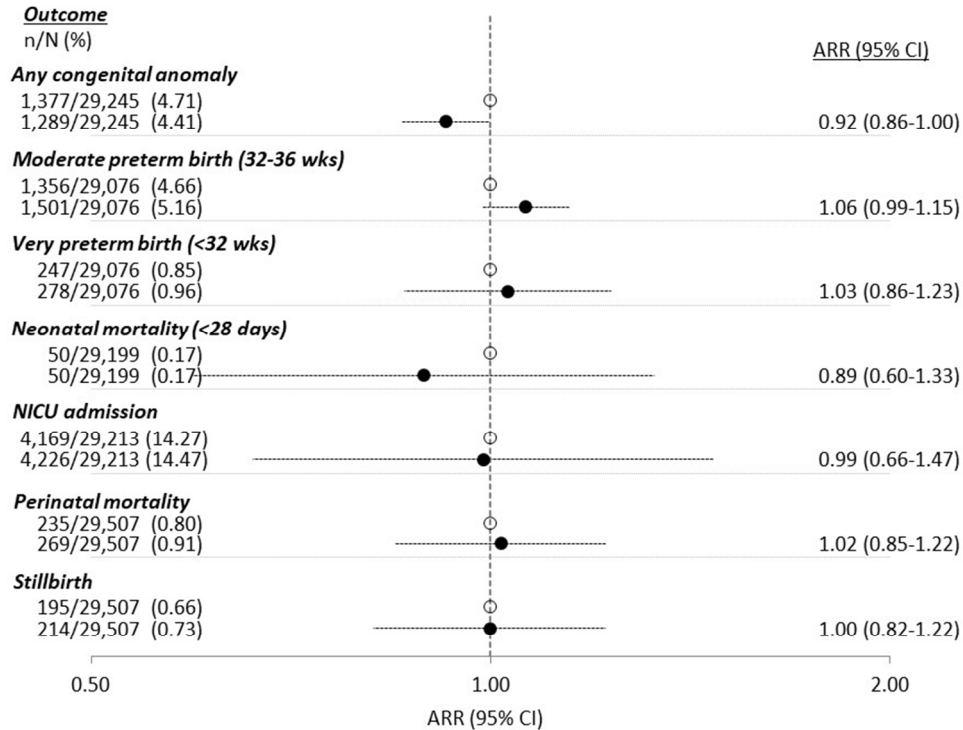
Figure 2: Adverse perinatal outcomes comparing first births in Ontario to refugee immigrants (black circles) vs. first births in Ontario to non-refugee immigrants (white circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Denominators vary with the outcome examined. Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

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Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	11,852 (1.22) 3,335 (0.93) 421 (0.81)		0.79 (0.76-0.82) 0.71 (0.64-0.78)
Pre-existing hypertension	5,386 (0.56) 1,734 (0.48) 266 (0.51)		0.72 (0.68-0.77) 0.74 (0.65-0.85)
Gestational hypertension	42,146 (4.35) 10,615 (2.96) 1,513 (2.90)		0.65 (0.64-0.67) 0.67 (0.63-0.71)
Preeclampsia	11,368 (1.17) 3,036 (0.85) 511 (0.98)		0.70 (0.67-0.73) 0.87 (0.79-0.95)
Eclampsia	957 (0.10) 269 (0.08) 30 (0.06)		0.76 (0.66-0.87) 0.76 (0.66-0.87)
Pre-pregnancy diabetes	6,301 (0.65) 1,706 (0.48) 309 (0.59)		0.63 (0.59-0.67) 0.73 (0.65-0.83)
Gestational diabetes	30,901 (3.19) 26,559 (7.41) 3,826 (7.34)		1.98 (1.94-2.01) 1.90 (1.83-1.97)
Caesarean section	265,859 (27.43) 101,863 (28.41) 14,622 (28.03)		1.01 (1.00-1.01) 1.02 (1.00-1.03)
Postpartum hemorrhage	39,619 (4.09) 11,318 (3.16) 1,688 (3.24)		0.79 (0.78-0.81) 0.83 (0.79-0.87)
Maternal ICU admission	2,317 (0.24) 1,060 (0.30) 183 (0.35)		1.14 (1.06-1.23) 1.33 (1.14-1.55)
Severe maternal morbidity (SMM)	10,910 (1.13) 3,971 (1.11) 759 (1.46)		0.94 (0.90-0.97) 1.20 (1.11-1.29)
SMM excluding HIV	10,758 (1.11) 3,811 (1.06) 602 (1.15)		0.92 (0.88-0.95) 0.97 (0.90-1.06)
HIV	315 (0.03) 220 (0.06) 229 (0.44)		1.52 (1.23-1.87) 10.09 (8.14-12.51)

0.10   1.00   10.00

ARR (95% CI)

Figure 3: Adverse maternal outcomes comparing 52,360 births to refugee immigrants   (black circles) and 360,007 births to non-refugee immigrants (grey circles) vs. 977,045 births to Canadian-born (white circles) mothers. Risk ratios adjusted for maternal age, parity and income quintile.

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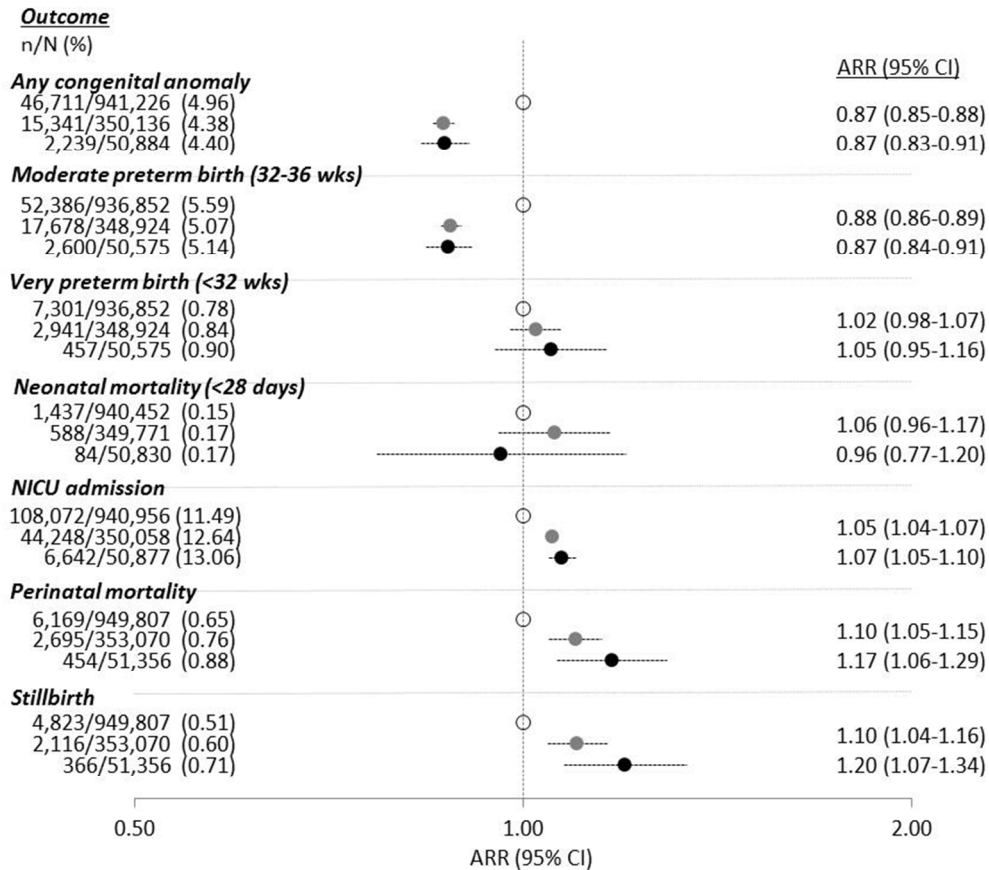
Figure 4: Adverse perinatal outcomes comparing births to refugee immigrants (black circles) and births to non-refugee immigrants (grey circles) vs. births to Canadian-born mothers (white circles). Denominators vary with the outcome examined. Risk ratios adjusted for maternal age, parity, and income quintile.

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Wanigaratne *et al* - Supplementary Material

Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

SUPPLEMENTARY TABLES

Table S1: List of 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI) codes for maternal and perinatal outcomes

Maternal or Perinatal Outcome	Definition	Source Database	ICD-10-CA/CCI
Complicated urinary tract infection		CIHI-DAD	O23, O86, N39
Pre-existing hypertension		CIHI-DAD	O10, O11
Gestational hypertension		CIHI-DAD	O13
Preeclampsia			O14
Eclampsia		CIHI-DAD	O15
Pre-pregnancy diabetes mellitus		CIHI-DAD	O24.0-O24.3
Gestational diabetes mellitus (GDM)		CIHI-DAD	O24.4
Caesarean delivery		CIHI-DAD	5.MD.60.^^
Post-partum hemorrhage		CIHI-DAD	O72
Maternal intensive care unit (ICU) admission		CIHI-DAD	Special Care Unit 1-6
Severe maternal morbidity		CIHI-DAD	See Joseph et al, 2010*
HIV	Three physician diagnoses within three years.	Ontario HIV DB	
Congenital anomaly	An abnormality of structure or function present at birth	CIHI-DAD	ICD-10: Q00-Q99
Moderate preterm birth (PTB)	Live birth with gestational age 32-36 weeks	CIHI-DAD	32-36 weeks gestation recorded on CIHI-DAD birth record
Very preterm birth (VPTB)	Live birth with gestational age <32 weeks	CIHI-DAD	< 32 weeks gestation recorded on CIHI-DAD birth record
Neonatal mortality	Death <28 days of life	RPDB, ORG-VSD	
Neonatal intensive care unit (NICU) admission		CIHI-DAD	Special care unit admission, any level
Perinatal mortality	Stillbirth or death of live born infant < 7 days of life	RPDB, ORG-VSD	
Stillbirth	Intrauterine fetal death ≥ 20 weeks gestation and > 500 g birthweight	CIHI-DAD	Maternal record: Z371, Z373-7, O364. Infant record: P95

Abbreviations

ICD-10-CA/CCI - 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI)

CIHI-DAD – Canadian Institute for Health Information – Discharge Abstract Database

RPDB – Registered Persons Database (referred to as "Ontario Health Care Registry" in paper)

ORGD-VSD – Office of the Registrar General's Vital Statistics-Death Registry

* Joseph KS, Liu S, Rouleau J, Kirby RS, Kramer MS, Sauve R, et al. Severe maternal morbidity in Canada, 2003 to 2007: surveillance using routine hospitalization data and ICD-10CA codes. J Obstet Gynaecol Can. 2010;32(9):837

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Wanigaratne *et al* - Supplementary Material

Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

Table S2: Unadjusted Risk Ratios (RR) (95% CI) for Figures 1 and 2

FIGURE 1	
OUTCOME	**UNADJUSTED RR (95% CI)**
Complicated urinary tract infection	0.89 (0.76-1.03)
Pre-existing hypertension	1.32 (1.03-1.69)
Gestational hypertension	1.09 (0.99-1.19)
Preeclampsia	0.97 (0.83-1.13)
Eclampsia	0.96 (0.53-1.72)
Pre-pregnancy diabetes mellitus	1.21 (0.96-1.54)
Gestational diabetes mellitus (GDM)	1.15 (1.08-1.22)
Caesarean delivery	1.02 (0.99-1.05)
Post-partum hemorrhage	1.00 (0.92-1.09)
Maternal intensive care unit admission	1.31 (0.98-1.75)
Severe maternal morbidity (SMM)	1.12 (0.97-1.28)
SMM excluding HIV	1.04 (0.89-1.20)
HIV	2.00 (1.46-2.73)
FIGURE 2	
OUTCOME	**UNADJUSTED RR (95% CI)**
Congenital anomaly	0.94 (0.87-1.01)
Moderate preterm birth (MPTB)	1.11 (1.03-1.19)
Very preterm birth (VPTB)	1.13 (0.95-1.34)
Neonatal mortality	1.00 (0.68-1.48)
Neonatal intensive care unit admission	1.01 (0.98-1.05)
Perinatal mortality	1.14 (0.96-1.36)
Stillbirth	1.10 (0.90-1.33)

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Table S3: Unadjusted Risk Ratios (RR) (95% CI) for Figures 3 and 4

FIGURE 3	UNADJUSTED RR (95% CI)	
OUTCOME	REFUGEES VS. CDN	NON-REFUGEES VS. CDN
Complicated urinary tract infection	0.66 (0.60-0.73)	0.76 (0.73-0.79)
Pre-existing hypertension	0.92 (0.81-1.05)	0.86 (0.81-0.91)
Gestational hypertension	0.67 (0.63-0.70)	0.68 (0.66-0.69)
Preeclampsia	0.83 (0.76-0.91)	0.72 (0.69-0.75)
Eclampsia	0.58 (0.40-0.84)	0.60 (0.42-0.86)
Pre-pregnancy diabetes mellitus	0.35 (0.30-0.39)	0.72 (0.68-0.76)
Gestational diabetes mellitus (GDM)	2.27 (2.19-2.36)	2.30 (2.26-2.34)
Caesarean delivery	1.03 (1.02-1.05)	1.05 (1.05-1.06)
Post-partum hemorrhage (PPH)	0.80 (0.76-0.84)	0.78 (0.77-0.80)
Maternal intensive care unit admission	1.46 (1.26-1.70)	1.23 (1.15-1.33)
Severe maternal morbidity (SMM)	1.29 (1.20-1.40)	0.98 (0.95-1.02)
SMM without HIV	1.04 (0.96-1.13)	0.96 (0.92-0.99)
HIV	13.84 (11.32-16.93)	1.85 (1.51-2.26)
FIGURE 4		
OUTCOME		
Congenital anomaly	0.89 (0.85-0.92)	0.88 (0.87-0.90)
Moderate preterm birth (MPTB)	0.92 (0.89-0.96)	0.91 (0.89-0.92)
Very preterm birth (VPTB)	1.08 (1.03-1.13)	1.16 (1.06-1.28)
Neonatal mortality	1.08 (0.87-1.35)	1.10 (1.00-1.21)
Neonatal intensive care unit (NICU) admission	1.13 (1.11-1.16)	1.10 (1.09-1.11)
Perinatal mortality	1.36 (1.24-1.50)	1.17 (1.12-1.23)
Stillbirth	1.40 (1.26-1.56)	1.18 (1.12-1.24)

SUPPLEMENTARY FIGURES

Figure S1a: Adverse maternal outcomes comparing 5,724 births to Sri Lankan refugee immigrants (▲ triangles) vs. 17,373 births to Sri Lankan non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

| *Outcome*	n (%)		ARR (95% CI)
Complicated urinary tract infection	101 (0.58)	△	
	40 (0.70)	▲	1.11 (0.74-1.68)
Pre-existing hypertension	54 (0.31)	△	
	25 (0.44)	▲	0.90 (0.54-1.51)
Gestational hypertension	502 (2.89)	△	
	184 (3.21)	▲	1.20 (0.99-1.45)
Preeclampsia	136 (0.78)	△	
	52 (0.91)	▲	0.99 (0.69-1.41)
Eclampsia	10 (0.06)	△	
	*		
Pre-pregnancy diabetes	147 (0.85)	△	
	62 (1.08)	▲	0.95 (0.68-1.33)
Gestational diabetes	2,062 (11.87)	△	
	790 (13.80)	▲	1.08 (0.99-1.18)
Caesarean section	5,359 (30.85)	△	
	1,722 (30.08)	▲	0.97 (0.91-1.03)
Postpartum hemorrhage	465 (2.68)	△	
	132 (2.31)	▲	0.83 (0.67-1.03)
Maternal ICU admission	44 (0.25)	△	
	15 (0.26)	▲	0.81 (0.43-1.55)
Severe maternal morbidity	165 (0.95)	△	
	47 (0.82)	▲	0.83 (0.58-1.19)

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       0.10                    1.00                    10.00
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ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S1b: Adverse perinatal outcomes comparing births to Sri Lankan refugee immigrants (▲triangles) vs. births to Sri Lankan non-refugee immigrants (△triangles). Risk ratios adjusted for maternal ae, parity, income quintile, official language ability, education and duration of residence.
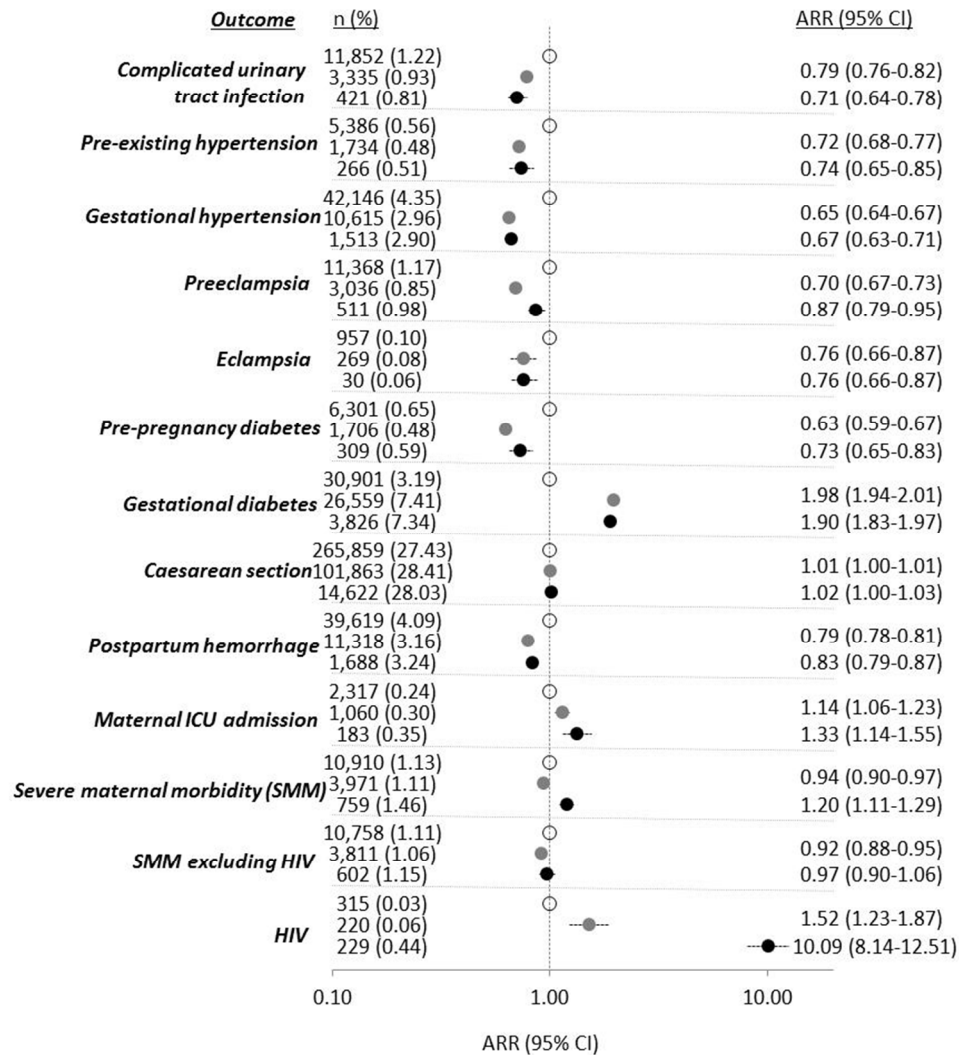

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S2a: Adverse maternal outcomes comparing 2,453 births to Somali refugee immigrants (▲ triangles) vs. 4,499 births to Somali non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)	ARR (95% CI)
Complicated urinary tract infection	14 (0.57)	
	39 (0.87)	1.42 (0.73-2.75)
Pre-existing hypertension	9 (0.37)	
	18 (0.40)	0.98 (0.41-2.34)
Gestational hypertension	51 (2.08)	
	109 (2.42)	1.10 (0.76-1.59)
Preeclampsia	28 (1.14)	
	46 (1.02)	0.80 (0.47-1.37)
Eclampsia	*	
	*	
Pre-pregnancy diabetes	24 (0.98)	
	33 (0.73)	0.87 (0.48-1.56)
Gestational diabetes	183 (7.46)	
	379 (8.42)	1.18 (0.97-1.43)
Caesarean section	583 (23.77)	
	1,124 (24.98)	0.98 (0.88-1.09)
Postpartum hemorrhage	98 (4.00)	
	173 (3.85)	1.00 (0.76-1.31)
Maternal ICU admission	13 (0.53)	
	23 (0.51)	1.19 (0.55-2.54)
Severe maternal morbidity (SMM)	42 (1.71)	
	68 (1.51)	0.82 (0.54-1.26)
SMM excluding HIV	36 (1.47)	
	36 (0.80)	0.89 (0.57-1.41)

ARR (95% CI)

0.10   1.00   10.00

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S2b: Adverse perinatal outcomes comparing births to Somali refugee immigrants (▲triangles) vs. births to Somali non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome		ARR (95% CI)
n/N (%)		
Any congenital anomaly		
111/2,370(4.68)	△	
199/4,375 (4.55)	▲	1.01 (0.78-1.29)
Moderate preterm birth (32-36 wks)		
81/2,311(3.50)	△	
198/4,272 (4.63)	▲	1.29 (1.03-1.63)
Very preterm birth (<32 wks)		
16/2,311(0.69)	△	
34/4,272 (0.80)	▲	0.99 (0.51-1.93)
Neonatal mortality (<28 days)		
*/2,368 *	△	
12/4,374 (0.27)		
NICU admission		
344/2,369 (14.52)	△	
665/4,375 (15.20)	▲	1.02 (0.89-1.17)
Perinatal mortality		
34/2,408(1.41)	△	
51/4,432 (1.15)	▲	0.55 (0.34-0.89)
Stillbirth		
32/2,408(1.33)	△	
42/4,432 (0.95)	▲	0.48 (0.29-0.80)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S3a: Adverse maternal outcomes comparing 4,210 births to Afghan refugee immigrants (▲ triangles) vs. 3,905 births to Afghan non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		ARR (95% CI)
Complicated urinary tract infection	21 (0.54)		
	12 (0.29)		0.60 (0.28-1.28)
Pre-existing hypertension	*		
	10 (0.24)		
Gestational hypertension	61 (1.56)		
	87 (2.07)		1.19 (0.82-1.71)
Preeclampsia	26 (0.67)		
	38 (0.90)		1.25 (0.74-2.14)
Eclampsia	*		
	*		
Pre-pregnancy diabetes	11 (0.28)		
	29 (0.69)		1.42 (0.70-2.90)
Gestational diabetes	248 (6.35)		
	426 (10.12)		1.26 (1.07-1.49)
Caesarean section	788 (20.18)		
	1,159 (27.53)		1.20 (1.09-1.33)
Postpartum hemorrhage	96 (2.46)		
	123 (2.92)		1.13 (0.85-1.51)
Maternal ICU admission	9 (0.23)		
	22 (0.52)		1.71 (0.75-3.89)
Severe maternal morbidity	41 (1.05)		
	47 (1.12)		0.92 (0.59-1.45)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

Figure S3b: Adverse perinatal outcomes comparing births to Afghan refugee immigrants (▲triangles) vs. births to Afghan non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
183/3,824 (4.79)		
200/4,115 (4.86)		1.03 (0.84-1.27)
Moderate preterm birth (32-36 wks)		
148/3,814 (3.88)		
171/4,094 (4.18)		1.08 (0.87-1.34)
Very preterm birth (<32 wks)		
23/3,814 (0.60)		
35/4,094 (0.85)		1.21 (0.69-2.13)
Neonatal mortality (<28 days)		
10/3,820 (0.26)		
10/4,112 (0.24)		0.98 (0.39-2.49)
NICU admission		
520/3,822 (13.61)		
617/4,115 (14.99)		1.06 (0.94-1.19)
Perinatal mortality		
28/3,856 (0.73)		
47/4,159 (1.13)		1.40 (0.86-2.29)
Stillbirth		
23/3,856 (0.60)		
37/4,159 (0.89)		1.34 (0.78-2.32)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S4a: Adverse maternal outcomes comparing 2,613 births to Iraqi refugee immigrants (▲ triangles) vs. 4,239 births to Iraqi non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)	ARR (95% CI)
Complicated urinary tract infection	30 (0.71)	
	24 (0.92)	1.32 (0.74-2.33)
Pre-existing hypertension	11 (0.26)	
	13 (5.00)	1.35 (0.58-3.13)
Gestational hypertension	70 (1.65)	
	60 (2.30)	1.41 (0.98-2.04)
Preeclampsia	24 (0.57)	
	11 (0.42)	0.80 (0.37-1.72)
Eclampsia	*	
	*	
Pre-pregnancy diabetes	17 (0.40)	
	15 (0.57)	1.29 (0.61-2.69)
Gestational diabetes	239 (5.64)	
	200 (7.65)	1.20 (0.98-1.46)
Caesarean section	1,011 (23.85)	
	722 (27.63)	1.18 (1.07-1.31)
Postpartum hemorrhage	115 (2.71)	
	77 (2.95)	1.14 (0.84-1.56)
Maternal ICU admission	10 (0.24)	
	6 (0.23)	0.98 (0.34-2.85)
Severe maternal morbidity	44 (1.04)	
	28 (1.07)	0.88 (0.53-1.45)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S4b: Adverse perinatal outcomes comparing births to Iraqi refugee immigrants (▲triangles) vs. births to Iraqi non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence
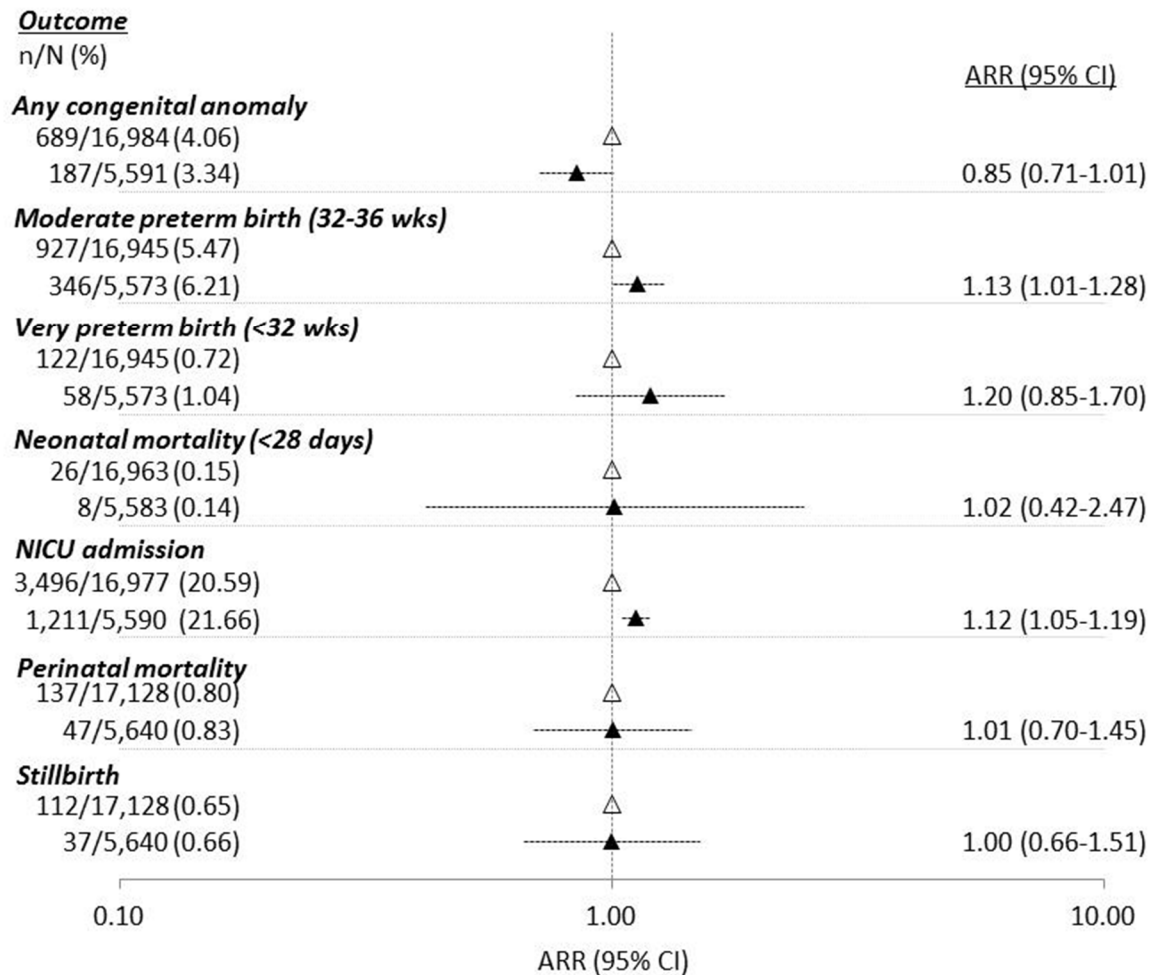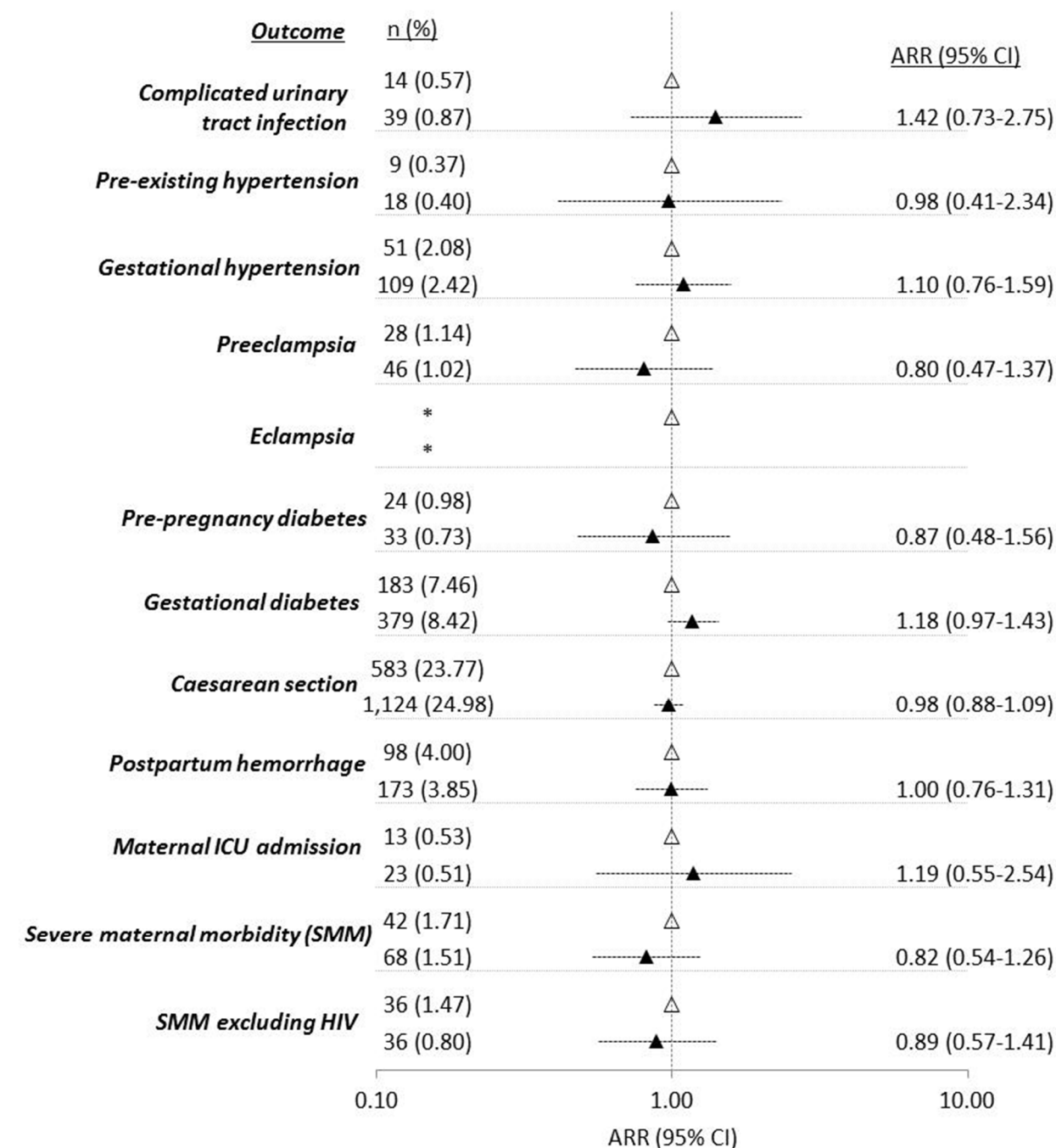

Outcome n/N (%)		ARR (95% CI)
Any congenital anomaly		
181/4,133 (4.38)		
107/2,533 (4.22)		0.92 (0.71-1.17)
Moderate preterm birth (32-36 wks)		
179/4,114 (4.35)		
119/2,529 (4.71)		1.08 (0.86-1.36)
Very preterm birth (<32 wks)		
30/4,114 (0.73)		
17/2,529 (0.67)		0.83 (0.44-1.55)
Neonatal mortality (<28 days)		
9/4,127 (0.22)		
*/2,533 *		
NICU admission		
431/4,132 (10.43)		
279/2,533 (11.01)		1.00 (0.86-1.16)
Perinatal mortality		
34/4,165 (0.82)		
21/2,561 (0.82)		0.87 (0.49-1.55)
Stillbirth		
22/4,165 (0.53)		
21/2,561 (0.82)		1.36 (0.72-2.55)

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

Figure S5a: Adverse maternal outcomes comparing 2,527 births to Chinese refugee immigrants (▲ triangles) vs. 37,093 births to Chinese non-refugee immigrants (△ triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
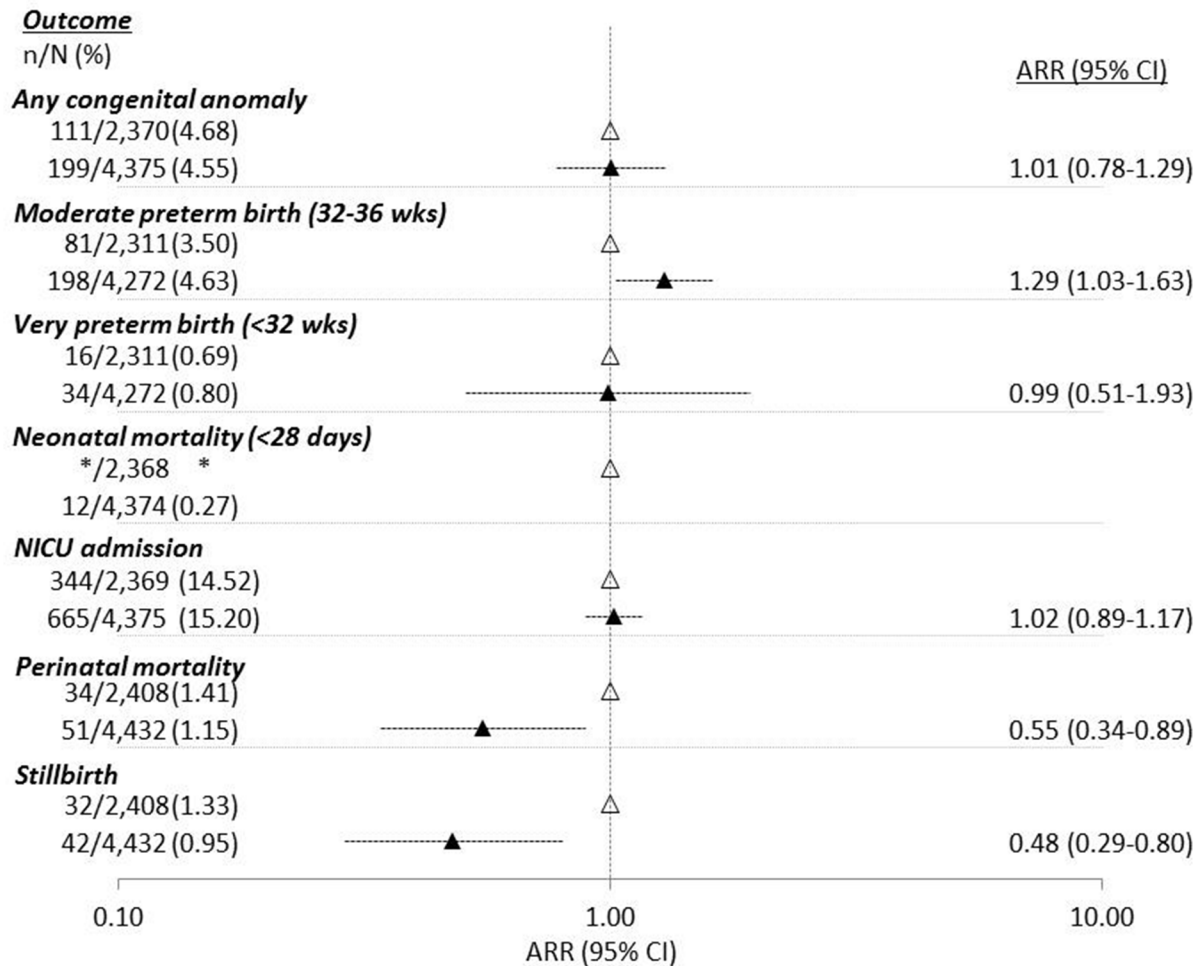

Outcome	n (%)	ARR (95% CI)
Complicated urinary tract infection	347 (0.94)	
	14 (0.55)	0.67 (0.38-1.18)
Pre-existing hypertension	64 (0.17)	
	6 (0.24)	1.65 (0.67-4.08)
Gestational hypertension	480 (1.29)	
	33 (1.31)	1.38 (0.95-2.00)
Preeclampsia	145 (0.39)	
	9 (0.36)	1.14 (0.56-2.31)
Eclampsia	18 (0.05)	
	*	
Pre-pregnancy diabetes	63 (0.17)	
	*	
Gestational diabetes	2,850 (7.68)	
	174 (6.89)	1.14 (0.97-1.35)
Caesarean section	9,950 (26.82)	
	544 (21.53)	1.02 (0.93-1.12)
Postpartum hemorrhage	1,446 (3.90)	
	94 (3.72)	1.07 (0.86-1.34)
Maternal ICU admission	88 (0.24)	
	6 (0.24)	0.90 (0.37-2.18)
Severe maternal morbidity	384 (1.04)	
	18 (0.71)	0.77 (0.47-1.26)

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S5b: Adverse perinatal outcomes comparing births to Chinese refugee immigrants (▲triangles) vs. births to Chinese non-refugee immigrants (△triangles). Risk ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
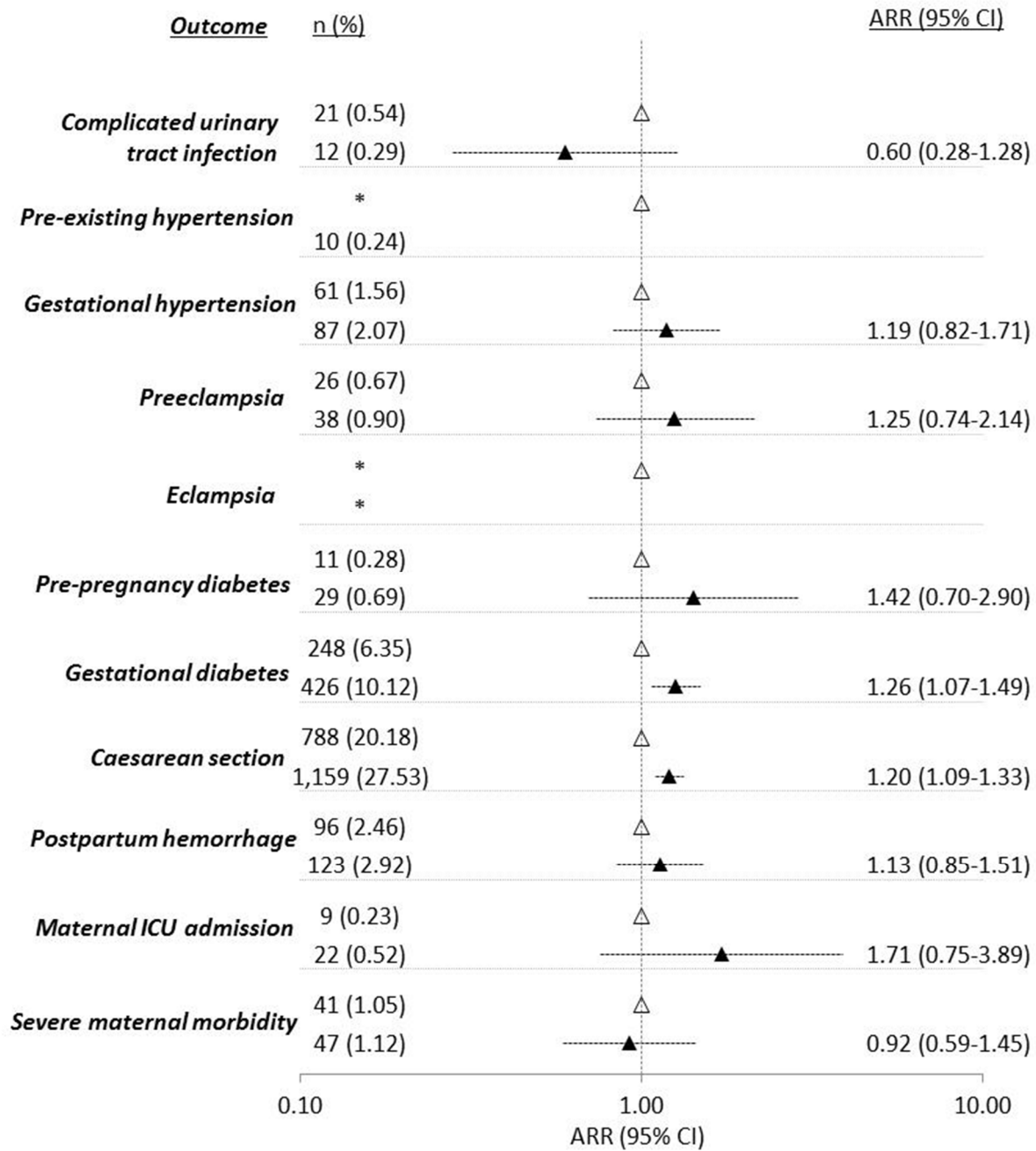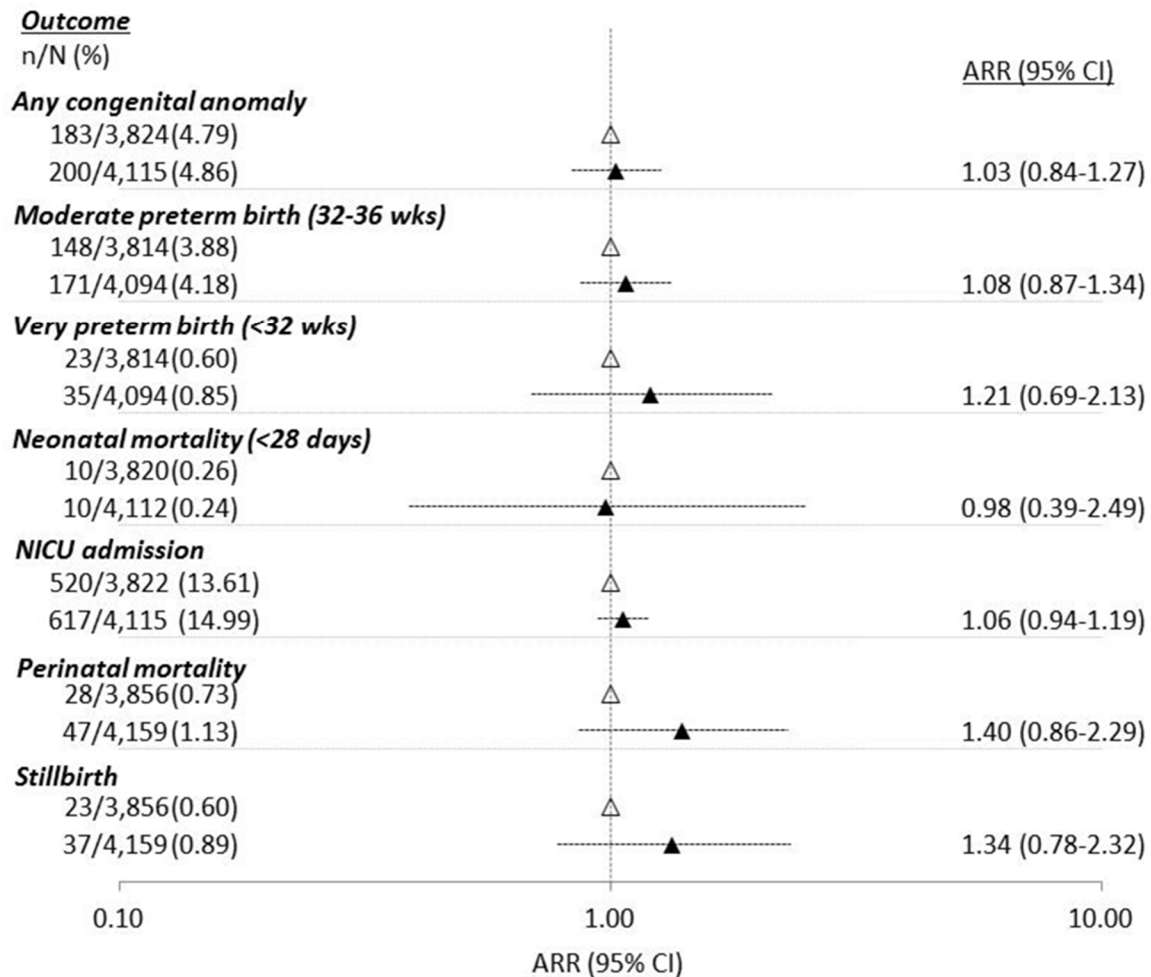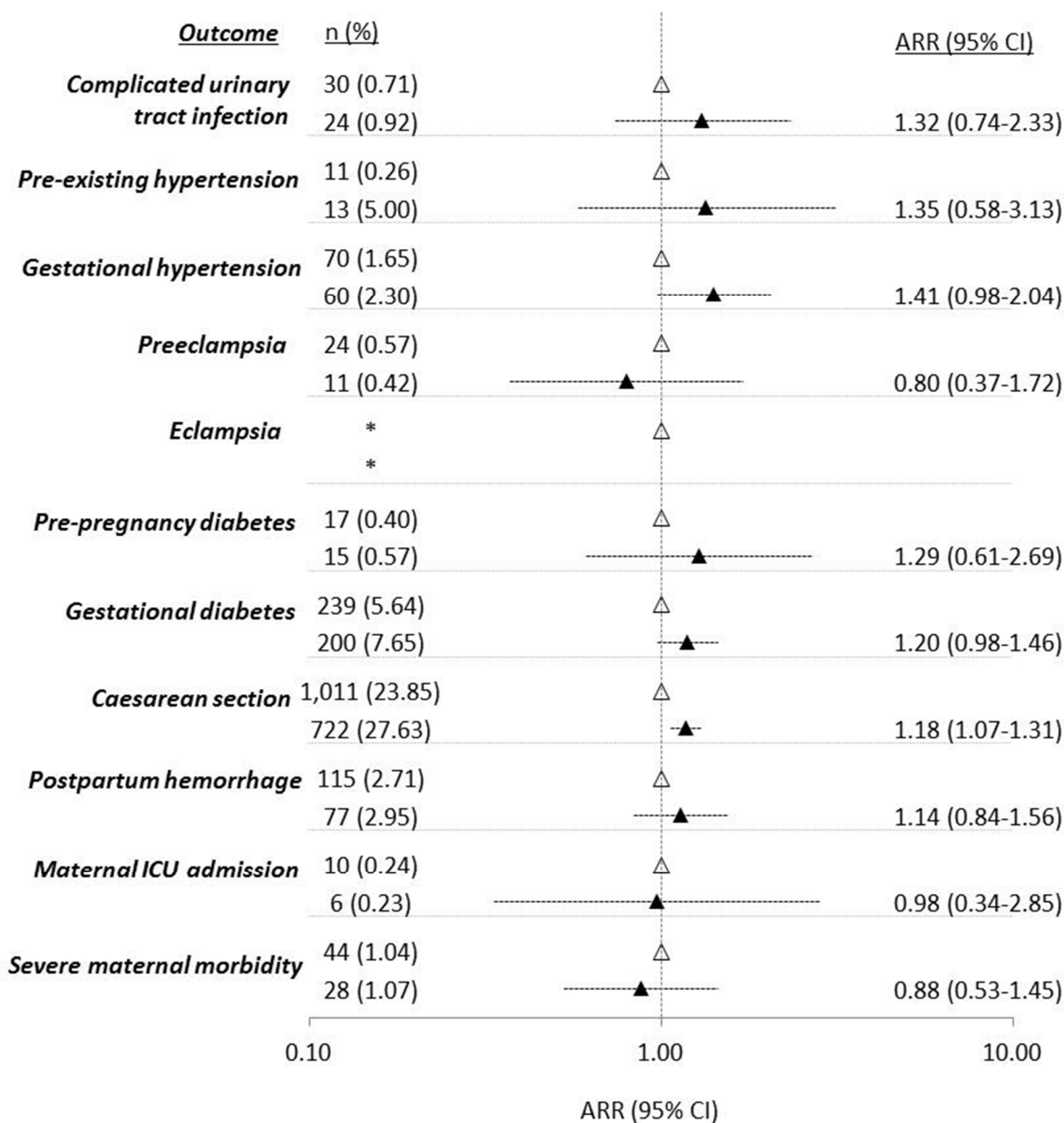

Outcome
n/N (%)   ARR (95% CI)

Any congenital anomaly
1,788/36,499 (4.90)
104/2,487 (4.18)   0.97 (0.79-1.18)

Moderate preterm birth (32-36 wks)
1,316/36,406 (3.61)
99/2,480 (3.99)   1.10 (0.90-1.35)

Very preterm birth (<32 wks)
182/36,406 (0.50)
16/2,480 (0.65)   1.29 (0.75-2.24)

Neonatal mortality (<28 days)
31/36,471 (0.08)
*/2,486   *

NICU admission
2,961/36,491 (8.11)
171/2,486 (6.88)   0.92 (0.78-1.07)

Perinatal mortality
147/36,647 (0.40)
12/2,498 (0.48)   1.00 (0.53-1.88)

Stillbirth
113/36,647 (0.31)
10/2,498 (0.40)   1.04 (0.52-2.07)

0.10   1.00   10.00
ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S6: Adverse maternal outcomes comparing 52,158 births to ALL refugee immigrants (■ squares) vs. 358,589 births to ALL non-refugee immigrants (□ squares), UNMATCHED on country of birth. Risk ratios* adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
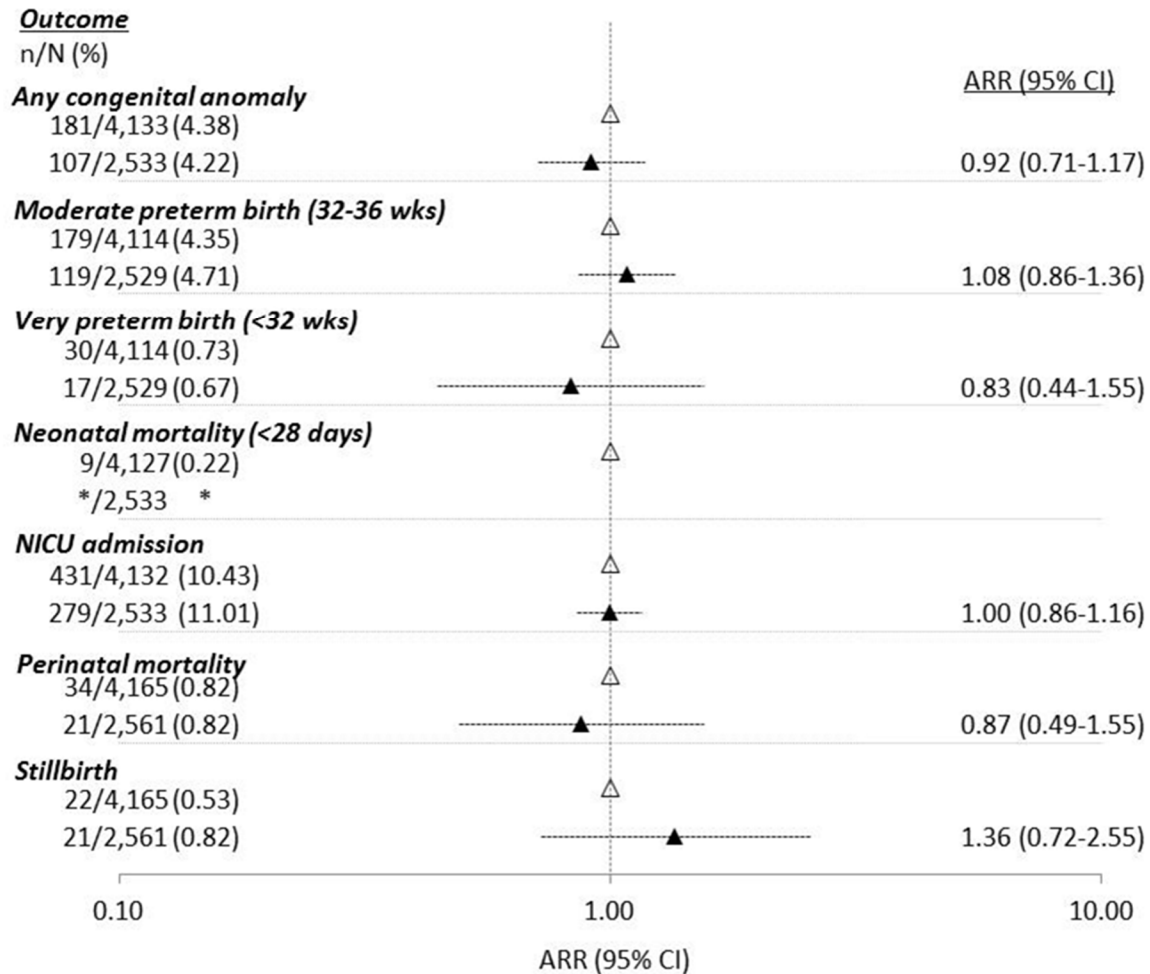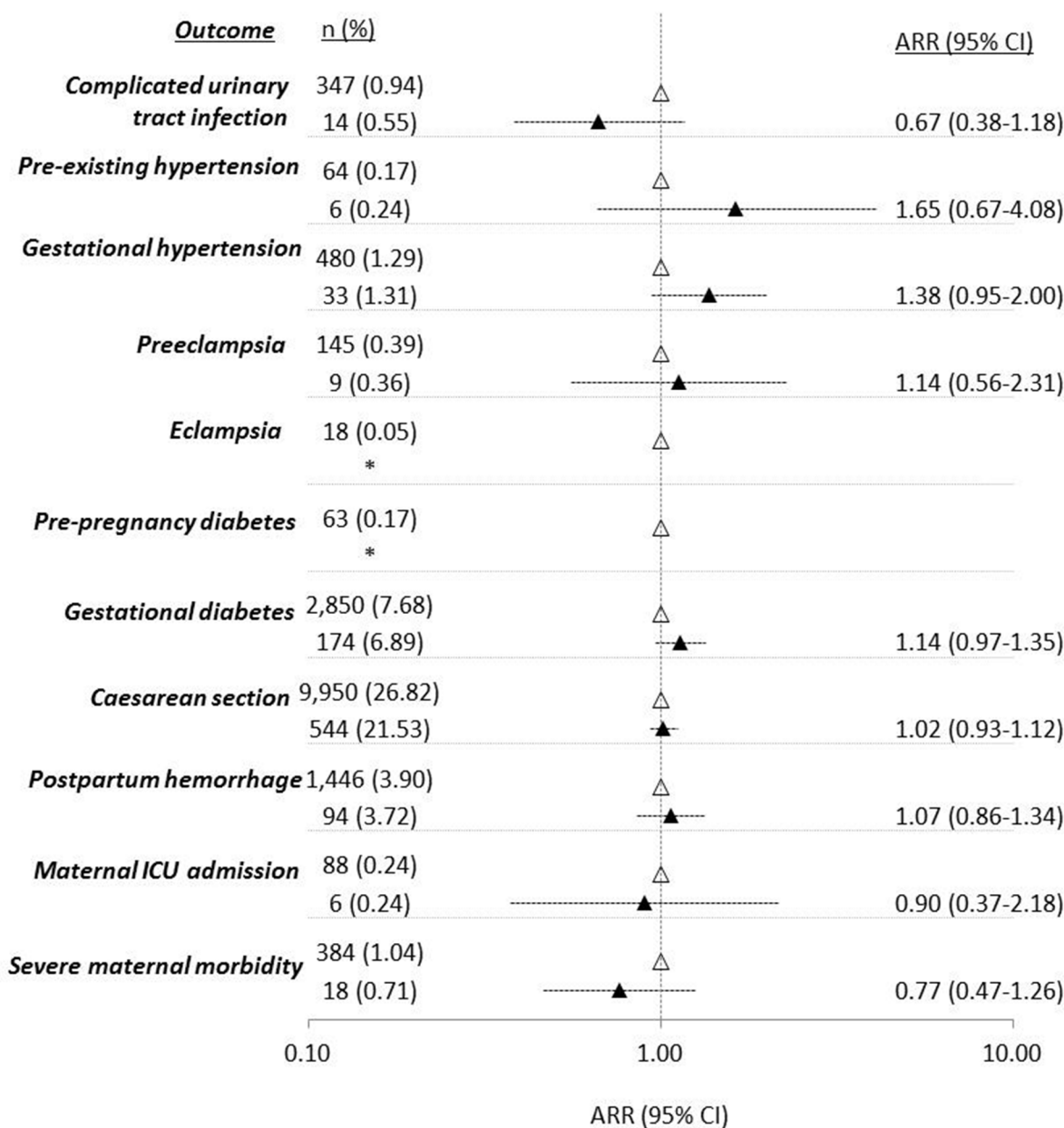
Outcome	n (%)	ARR (95% CI)
Complicated urinary tract infection	3,335 (1.0)	
	421 (0.8)	0.86 (0.61-1.21)
Pre-existing hypertension	1,734 (0.5)	
	266 (0.5)	1.05 (0.87-1.27)
Gestational hypertension	10,615 (3.0)	
	1,513 (2.9)	1.06 (1.00-1.13)
Preeclampsia	3,036 (0.9)	
	511 (1.0)	1.12 (0.99-1.25)
Eclampsia	269 (0.1)	
	30 (0.1)	0.97 (0.86-1.09)
Pre-pregnancy diabetes	1,706 (0.5)	
	309 (0.6)	1.09 (0.91-1.30)
Gestational diabetes	26,559 (7.4)	
	3,826 (7.3)	1.06 (0.99-1.14)
Caesarean section	101,863 (28.4)	
	14,622 (28.0)	1.04 (1.01-1.08)
Postpartum hemorrhage	11,318 (3.2)	
	1,688 (3.2)	1.02 (0.96-1.08)
Maternal ICU admission	1,060 (0.3)	
	183 (0.4)	1.17 (1.00-1.38)
Severe maternal morbidity (SMM)	3,971 (1.1)	
	759 (1.5)	1.23 (1.07-1.42)
SMM excluding HIV	3,811 (1.1)	
	602 (1.2)	1.08 (0.98-1.19)
HIV	220 (0.1)	
	229 (0.44)	2.71 (1.76-4.20)

0.10   1.00   10.00

ARR (95% CI)

ARR – adjusted risk ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

*Estimated using log-binomial regression with generalized estimating equations to account for potential correlation among mothers from the same country of birth.

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Refugee maternal and perinatal health in Ontario Canada: a retrospective population-based study

Figure S7: Adverse perinatal outcomes comparing births to ALL refugee immigrants (■ squares) vs. births to ALL non-refugee immigrants (☐ squares), UNMATCHED on country of birth. Risk ratios* adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
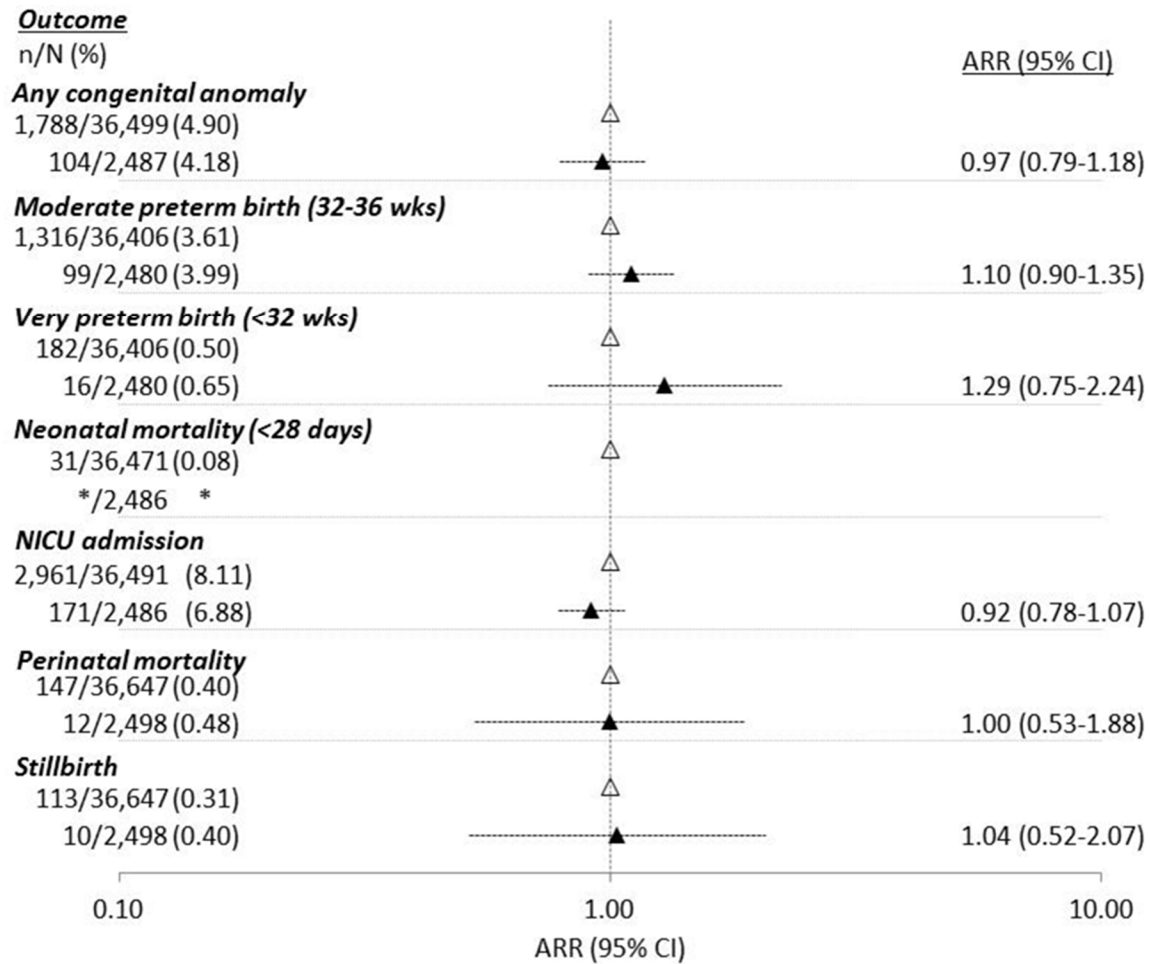

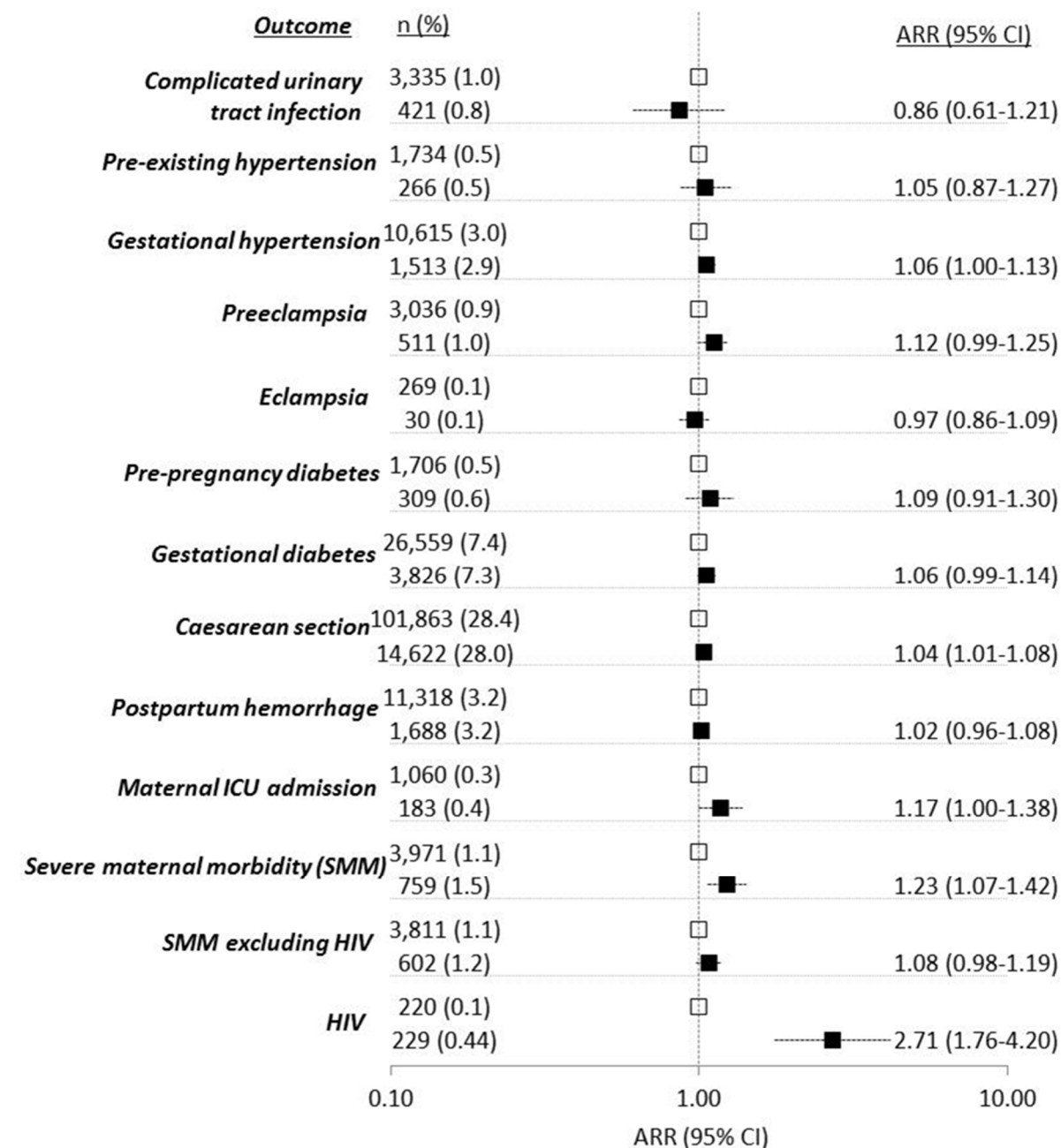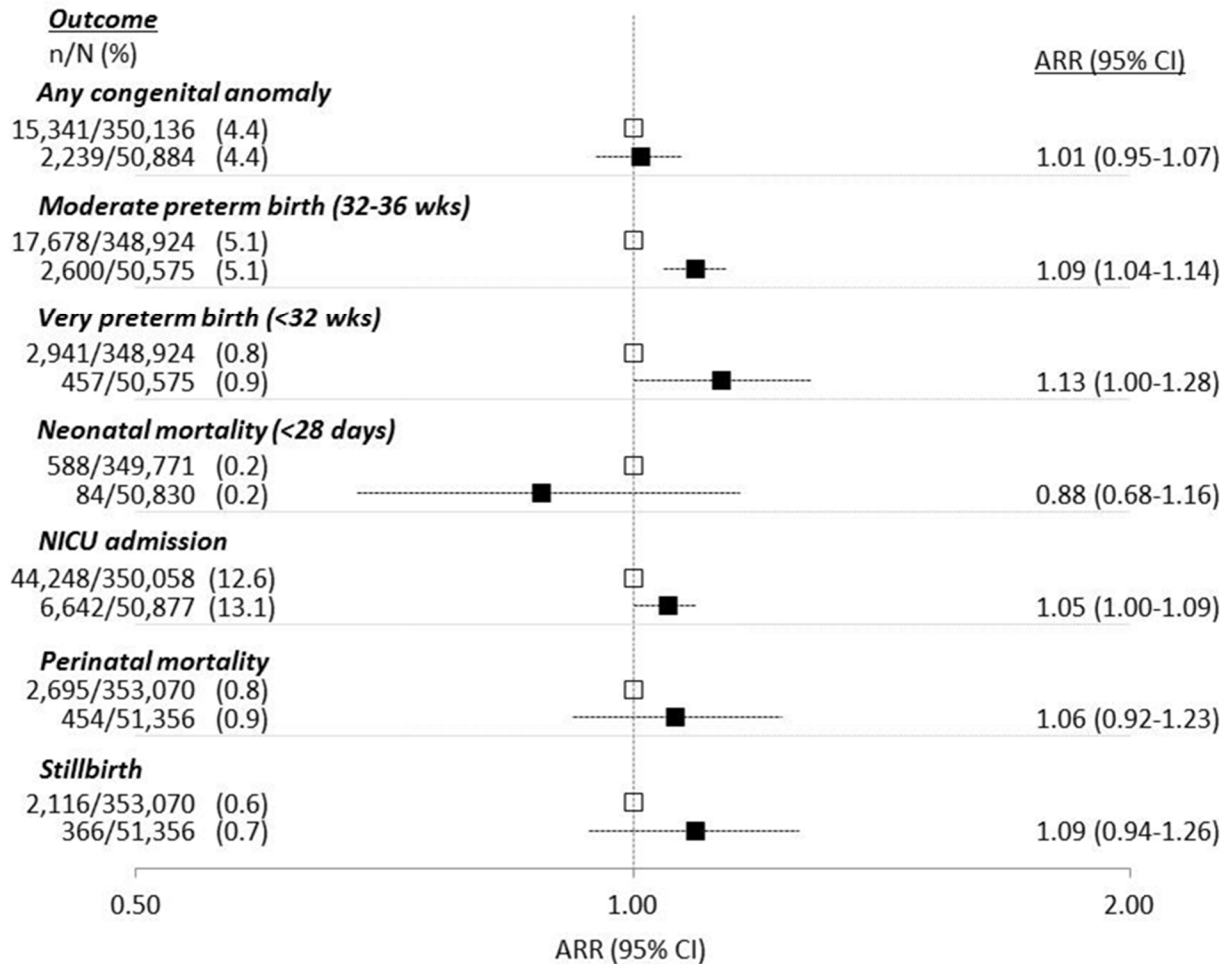ARR – adjusted risk ratio; CI – confidence interval; NICU – neonatal intensive care unit

*Estimated using log-binomial regression with generalized estimating equations to account for potential correlation among mothers from the same country of birth.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3-4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	5,6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 16- Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Page 16- Table 1
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	All figures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Unadjusted figures in supplementary tables S2 and S3. Confounder adjusted estimates in all figures.
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-8
Generalisability	21	Discuss the generalisability (external validity) of the study results	9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Refugee maternal and perinatal health in Ontario, Canada: a retrospective population-based study

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Refugee maternal and perinatal health in Ontario, Canada: a retrospective population-based study

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Abstract

Objectives: Immigrants are thought to be healthier than their native-born counterparts, but less is known about the health of refugees or forced migrants. Previous studies often equate refugee status with immigration status or country of birth (COB) and none have compared refugee to non-refugee immigrants from the same COB. Herein, we examined whether: i) a refugee mother experiences greater odds of adverse maternal and perinatal health outcomes compared to a similar non-refugee mother from the same COB, and ii) refugee and non-refugee immigrants differ from Canadian-born mothers for maternal and perinatal outcomes.

Design: This is a retrospective population-based database study. We implemented two cohort designs: i) 1:1 matching of refugees to non-refugee immigrants on COB, year and age at arrival (+/- 5 years) and ii) an unmatched design using all data.

Setting and participants: Refugee immigrant mothers (N=34,233), non-refugee immigrant mothers (N=243,439) and Canadian-born mothers (N=615,394) eligible for universal health care insurance who had a hospital birth in Ontario, Canada between 2002 and 2014.

Primary outcomes: Numerous adverse maternal and perinatal health outcomes.

Results: Refugees differed from non-refugee immigrants most notably for HIV, with respective rates of 0.39% and 0.20% and an adjusted odds ratio (AOR) of 1.82 (95% confidence intervals [CI] 1.19-2.79). Other elevated outcomes included caesarean section (AOR 1.04, 95% 1.00-1.08) and moderate preterm birth (AOR 1.08, 95% CI 0.99-1.17). For the majority of outcomes, refugee and non-refugee immigrants experienced similar AORs when compared with Canadian-born mothers.

Conclusions: Refugee status was associated with a few adverse maternal and perinatal health outcomes but the associations were not strong except for HIV. The definition of refugee status used herein may not sensitively identify refugees at highest risk. Future research would benefit from further refining refugee status based on migration experiences.

Strengths and limitations of this study
- This is a retrospective population-based cohort study from Ontario, Canada linking official permanent resident immigration, hospital and physician billing data to compare births between 2002 and 2014 from refugee mothers (N=34,233) to both non-refugee immigrant mothers (N=243,439) and Canadian-born mothers (N=615,394).
- This is the first study to match refugee immigrant to non-refugee immigrant mothers on country of birth, year and age at arrival; making it possible to explicitly determine whether refugee status confers greater risk of adverse outcomes among two otherwise very similar mothers.
- This is one of the largest studies of refugee maternal and perinatal health in the literature.
- The administrative definition of refugee status used in this study may not be sensitive enough to identify refugees with greater health risks or greater health care needs.

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Introduction

Refugees are considered an extremely vulnerable group for adverse health outcomes.[1] Canada, and other signatories to the United Nations (UN) Convention Relating to the Status of Refugees, define refugees as persons who fear persecution or violence because of their race, religion, nationality or political views and are forced to flee their home countries.[2] In Canada 10% of the 250,000 immigrants who become permanent residents each year are admitted as refugees.[3] Most non-refugee permanent residents are selected based on high levels of education, official language fluency, and work experience or are related to a permanent resident or Canadian citizen. This is in contrast to refugees who are either chosen based on vulnerability by the UN High Commissioner for Refugees (UNHCR) or, claim refugee status upon arrival and have the claim accepted by an independent tribunal.[4]

Given differing exposures in: countries of origin (e.g., conflict), transition countries (e.g., poor access to health services), post-migration exposures (e.g., discrimination); and receiving country immigration policies, the maternal and perinatal health of refugees may differ from their non-refugee immigrant counterparts.[5,6]

Few refugee maternal and perinatal health studies in Canada [5–8] or in other countries [9] compare refugees to non-refugee immigrants. Many studies use a native-born comparator and attribute excess risk to refugee status even though a non-refugee immigrant comparator is absent [10–15]. In addition, many studies rely on country of birth as an indicator of refugee migration [11–18] rather than identifying refugees based on their legal status or migration history. These details are critical, since specialized maternal and perinatal health care tailored to refugees cannot be effectively justified if a "refugee effect" cannot be differentiated from an "immigrant effect" or "country effect". In addition, research often finds that immigrants are healthier than the native-born population, the so-called "healthy migrant effect"[19]. However, the effect may not apply to refugees given their differential exposure to health risks prior to arrival (as described above). Studies are mixed as to whether the healthy migrant effect applies to refugee maternal and perinatal health.[5,6,12]

Given this background our first objective was to determine whether a refugee immigrant mother experiences greater odds of adverse maternal and perinatal health outcomes compared to a similar non-refugee immigrant mother from the same country of birth. Secondary analyses focused on the top 5 refugee source countries (Sri Lanka, Somalia, Afghanistan, Iran, and China). Secondly, we compared maternal and perinatal health outcomes among refugee and non-refugee immigrant mothers to Canadian-born mothers to examine whether the healthy migrant effect applies to both refugee and non-refugee immigrants. This study used population-based administrative health care and immigration data from Ontario, the province which receives about half of all refugees arriving to Canada [3].

Methods

Study Design and Inclusion/Exclusion Criteria

This retrospective population-based database study included all Ontario hospital childbirth admissions occurring between April 1, 2002 and March 31, 2014. A matched cohort design was used to isolate the excess risk conferred by refugee status beyond that of immigration and country of birth, while a non-matched cohort design used all available data to compare outcomes of refugee and non-refugee immigrants to Canadian-born mothers. Births to refugee and non-refugee immigrant mothers were identified retrospectively through linkage of hospital admissions to the Immigration and Refugees Citizenship Canada Permanent Resident Database (IRCC-PRD). The cost of health care services was not a barrier to accessing care since all mothers were eligible for universal, publicly funded health care insurance. Births not linked to the IRCC-PRD were attributed to *Canadian-born mothers* (Indigenous mothers could not be excluded at the time of the linkage). We reduced the bias attributed to unlinked migrant mothers among Canadian-born mothers by further restricting to mothers who: i) became

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eligible for provincial health care insurance on or before 1990 (the first year insurance eligibility was recorded – those eligible prior to 1990 were given an eligibility start year of 1990) and less likely to be immigrants; ii) were born in an Ontario hospital after 1991 (the first year births were available in hospital data) or; iii) became eligible for provincial health care insurance within 1 year of their year of birth and therefore lived in Ontario from a very young age.

For maternal outcomes, the unit of analysis was the delivery episode, where multiple births were counted as a single delivery. For all perinatal outcomes, the unit of analysis was restricted to singletons. Since many of the outcomes in this study are commonly used in epidemiologic surveillance, specifications based on gestational age and/or birthweight used by the Canadian Perinatal Surveillance System [20] were implemented where possible. These specifications relate to including births that are reasonably expected to be at risk for the outcome; births < 500 grams and/or <20 weeks gestation are less likely to be viable. The populations were as follows: for preterm birth (PTB) live births between 22-41 weeks gestational age (GA) and a birth weight (BWT) of ≥500 grams (g); neonatal intensive care (NICU) admission - live births with GA ≥20 weeks or a BWT ≥500 g; neonatal mortality - live births with a BWT ≥500 g; any congenital anomaly - stillbirths and live births with a GA ≥20 weeks or a BWT ≥500 g; stillbirth - GA ≥20 weeks or a BWT ≥500 g; perinatal mortality - stillbirths and live births with a GA ≥20 weeks or a BWT ≥500 g.

Data Sources

We linked five administrative databases held at the Institute for Clinical and Evaluative Sciences (ICES) in Toronto, Ontario. These datasets were linked using unique encoded identifiers (i.e., encrypted health care number) and analyzed at ICES.

The Immigration and Refugees Citizenship Canada Permanent Resident Database (IRCC-PRD) is administered by the Canadian government and used for legal purposes. The Ontario portion of this dataset contains information on all international migrants successful in obtaining permanent residency between 1985 and 2012. The IRCC-PRD contained <1% of missing values for all variables. Linkage between the IRCC-PRD and Ontario's health care registry was necessary to assign each individual in the IRCC-PRD their unique encrypted health care number since this facilitated deterministic linkage to the health care databases used to identify outcomes of interest. Ontario's health care registry consists of all persons eligible for publicly funded health care insurance in the province of Ontario between April 1, 1990 and March 31, 2014. The health care registry contains encrypted unique health care numbers and other personal identifiers. A detailed explanation of the process used to link the IRCC-PRD and Ontario's health care registry can be found elsewhere [21]. In summary, deterministic linkage was undertaken first using several personal identifiers (i.e., sex, last name, given name, birth date) resulting in a 68.2% deterministic linkage rate. Unmatched records were then submitted to a probabilistic and manual review process which resulted in an additional 18.2% of records being linked (13.6% remained unlinked). Bias in the linkage process was investigated by comparing immigration variables between matched and unmatched individuals and little bias was detected.[21]

Childbirth records were obtained from the Discharge Abstract Database originating from the Canadian Institute of Health Information. Diagnosis and procedure codes using the 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI) identified women with all maternal or perinatal outcomes except early neonatal and neonatal mortality. A validation study supported the use of this database for perinatal research.[22] This dataset also contains information on maternal age at the time of delivery, self-reported parity and birth plurality.

The Office of the Registrar General's Vital Statistics-Death registry was used to identify early neonatal mortality (0-7 days of life) and neonatal mortality (0-28 days of life) between 2002 and 2012. 96.2% of records in the Vital Statistics Registry were successfully linked to the health care registry and

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little bias in the linkage was detected.[21] However, individuals between the ages of 0 and 14 years were more likely to be unlinked. Vital Statistics data were supplemented by mortality recorded in the health care registry and other administrative health care databases, however early neonatal deaths may also be missing in the health care registry because health care numbers may not have been issued.[21]

The Ontario HIV Database (1992-2014) uses an algorithm consisting of at least three physician HIV diagnoses in a 3-year period to identify HIV positive persons. The algorithm demonstrated 96.2% sensitivity and 99.6% specificity when compared to patient charts.[23] HIV diagnoses were restricted to women diagnosed prior to child birth.

Variables

Refugee status was defined using the IRCC-PRD. There are four categories of refugees in the database – i) government sponsored refugees, who are provided with financial and settlement assistance during their 1st year in Canada by the federal government; ii) privately sponsored refugees, who are provided with financial and settlement assistance during their 1st year in Canada by a group of Canadians; iii) refugee claimants, who arrive to Canada unsupported and make a legal claim to refugee status; and iv) refugees who are dependents of a primary refugee applicant. Prior to arrival, the two groups of sponsored refugees were registered with the UN High Commissioner for Refugees (UNHCR) and are chosen for immigration to Canada based on vulnerability. Sponsored refugees become permanent residents and are eligible for provincial health care upon arrival to Canada. Non-sponsored refugees (i.e., refugee claimants) [4,24] are eligible for federally funded health care (administered by the provinces) while they wait for their refugee determination hearing. The proportion of refugee claims approved during the time span of the IRCC-PRD is unknown but recent data indicate approvals have risen from 38.1% in 2013 to 66.1% in 2016 [25]. Successful refugee claimants, who make up the remaining 50% of permanent residents who are refugees, become eligible for permanent residency and for provincial health care once their claim is approved. Unsuccessful refugee claimants are not included in the IRCC-PRD.

Non-refugee immigrants in the IRCC-PRD are predominately skilled immigrants or their family members. Skilled immigrants are selected based on high levels of education, official language fluency, and work experience. Family class immigrants must be related to a permanent resident or Canadian citizen able to provide financial support. Soon after arrival in Canada both groups become permanent residents and are eligible for universal, provincially funded health care.

All immigrants in the IRCC-PRD were subject to an immigration medical exam (IME) during the application process. Prior to 2002 immigration applicants could be rejected if they placed "excessive demand" on health and social services [26]. However, in 2002 the Immigration & Refugee Protection Act (IRPA) [27] came into effect which changed this "excessive demand" criteria so it only applied to skilled immigrants and not family class immigrants or refugees.

Canadian-born women are described above (under "Study Design and Inclusion/Exclusion Criteria").

We examined several maternal and perinatal health outcomes (see Supplementary Table S1 for codes). Severe maternal morbidity (SMM), was evaluated using a composite surveillance indicator [28,29] developed by the Canadian Perinatal Health Surveillance System. A woman had SMM if she had one or more of forty-five ICD-10-CA/CCI diagnoses or procedures reported during hospital admission for labour or delivery.[28] Other maternal health outcomes, documented at the time of delivery, were: complicated urinary tract infection (UTI), pre-existing hypertension, gestational hypertension, preeclampsia, eclampsia, pre-pregnancy diabetes, gestational diabetes mellitus (GDM), caesarean section, post-partum hemorrhage (PPH) and maternal intensive care unit (ICU) admission. Perinatal outcomes, documented at birth, included: any congenital anomaly, moderate preterm birth (moderate PTB) (32-36 weeks gestation), very preterm birth (very PTB) (< 32 weeks gestation), neonatal ICU (NICU) admission and stillbirth. Measurement of early neonatal mortality (0-7 days of life) and neonatal

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mortality (0-28 days of life) were not restricted to the hospital delivery admission. Information from both the ORGD and the RPDB were combined to identify early neonatal and neonatal mortality. Early neonatal mortality was combined with information on stillbirth to identify perinatal mortality.

Potential confounders were identified *a priori*. Some control variables were available for all births, including maternal age at delivery (15-19, 20-24, 25-29, 30-34, 35-39, 40+ years), neighborhood income quintile, parity (0, 1, 2 or ≥ 3 previous births) and plurality. Other control variables were only available for refugees and non-refugee immigrants since this information was collected in the IRCC-PRD. These included: maternal country of birth (COB); COBs categorized into world regions and sub-regions according to the UN classification system with a modification to the developed countries classification [30]; year of arrival (5-year categories); age at arrival (5-year categories); maternal education at arrival (0-9 years, 10-12 years, 13+ years, trade certificate/non-university diploma, University degree); knowledge of official Canadian languages at arrival (English and/or French or neither); and duration of residence in Canada, defined as the time (in years) elapsed between the date of becoming a permanent resident and the date of delivery.

Analysis

Births with missing data for any control variable were excluded. To estimate whether refugee status increases the odds of adverse outcomes between a refugee mother and a non-refugee mother with similar pre-migration circumstances (objective 1), we 1:1 matched first births in Canada among refugees to non-refugee immigrants on COB, year of arrival (+/- 5 years) and age at arrival (+/- 5 years). Analyses were restricted to the first delivery in the hospitalization database to prevent matching several births from a single refugee mother to births to more than one non-refugee immigrant mother. We conducted a matched pair analysis using conditional logistic regression. In secondary analyses focusing on refugee and non-refugee immigrants from each of the top 5 refugee source countries of birth, all births were included and analyzed with logistic regression. All the above models were adjusted for maternal age at delivery, parity, neighborhood income, education at arrival, knowledge of official languages at arrival and duration of residence in Canada. In a sensitivity analysis, all births to refugee mothers were compared to all births to non-refugee mothers using logistic regression with Generalized Estimating Equations (GEE) to account for the non-independence of the outcome among mothers from the same COB.

To compare refugee and non-refugee mothers to Canadian-born mothers all births were included and logistic regression with GEE were used to account for non-independence of the outcome among births to the same mother. Fewer variables were available for Canadian-born women so models were adjusted for maternal age at delivery, parity and neighborhood income.

Research Ethics

This study was approved by the institutional review board at Sunnybrook Health Sciences Centre, and the ethics review board of St. Michael's Hospital, Toronto, Canada.

Results

Table 1 summarizes the characteristics of refugee immigrant mothers (N=34,233), non-refugee immigrant mothers (N=243,439) and Canadian-born mothers (N=615,394). Refugee mothers had 52,360 births in Ontario, non-refugee immigrant mothers had 360,007 births and Canadian mothers had 977,045 births. More refugee mothers (10%) had high parity (≥ 3 previous births) compared to both non-refugee immigrant (3.2%) and Canadian-born mothers (2.7%) at the first birth in Ontario. A greater proportion of refugees had less than 13 years of education at arrival (72.6%) compared to non-refugee immigrants (43.0%). There were about 5 times as many refugee mothers from Sub-Saharan Africa compared to non-refugee immigrant mothers (22.8% and 4.8%, respectively).

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Eighty-five percent of refugee mothers (N= 29,023) were successfully matched to a non-refugee mother on country of birth, and year and age at arrival (+/- 5 years). For most outcomes, differences between matched refugees and non-refugees were non-significant (see Figures 1 and 2). Caesarean section (adjusted odds ratio [AOR]=1.04 95% CI 1.00-1.08) and HIV (AOR=1.82 95% CI 1.19-2.79) were significantly higher among refugees. Moderate PTB approached statistical significance (AOR=1.08, 95% CI 0.99-1.17). See Supplementary Table S2 for unadjusted results.

Supplementary Figures (S1a/b through S5a/5b) disaggregate results according to the top 5 refugee source countries to Ontario – Sri Lanka, Somalia, Afghanistan, Iraq and China. Afghan and Iraqi refugees had higher odds of caesarean section. Refugee mothers from all countries either had significantly greater odds of GDM (Afghanistan AOR=1.29 95% CI 1.09-1.54) or borderline greater odds of GDM (Sri Lanka AOR=1.09 95% CI 0.99-1.21; Somalia AOR=1.20 95% CI 0.98-1.48; Iraq AOR=1.22 95% CI 0.99-1.50; China AOR=1.16 95% CI 0.98-1.37) compared to their non-refugee counterparts.

Figures 3 and 4 compare both refugees to Canadian-born mothers and non-refugee immigrants to Canadian-born mothers. Other than severe maternal morbidity (SMM) and HIV, the two sets of AORs comparing refugees to Canadian-born mothers and non-refugees to Canadian-born mothers were in the same direction and of a similar magnitude. With respect to SMM (see Figure 3), refugees had significantly higher odds compared to Canadian-born mothers while non-refugee immigrant mothers had significantly lower odds. However, after HIV was removed from the SMM index, refugees experienced similar odds of SMM to Canadian-born mothers. For other maternal outcomes (Figure 3), both refugees and non-refugees compared to Canadian-born mothers had: *significantly lower odds* of complicated UTI, pre-existing hypertension, gestational hypertension, preeclampsia, eclampsia, pre-pregnancy diabetes, and PPH; and *significantly higher odds* of caesarean section, GDM, maternal ICU admission and HIV. In terms of perinatal outcomes (Figure 4), both refugees and non-refugees compared to Canadian-born mothers had: *significantly lower odds* of any congenital anomaly and moderate PTB; similar odds of very PTB and neonatal mortality; and *significantly higher odds* of NICU admission, perinatal mortality and stillbirth. See Supplementary Table S3 for unadjusted results.

Discussion

We found modest increased odds of cesarean section and moderate PTB among refugee compared to non-refugee mothers from the same COB. HIV was the exception with a much greater prevalence. Overall, our findings suggest that refugee status, measured with an administrative definition, is not a strong risk indicator for poor maternal and perinatal health. In addition, we found that refugee and non-refugee mothers experienced a similar magnitude of odds ratios for almost all outcomes when each group was separately compared to Canadian-born mothers. About one third of outcomes were significantly worse among refugee and non-refugee immigrant mothers when compared to Canadian-born mothers.

The SMM and HIV findings are explained in detail in a previous report of ours [5] (although unmatched on country of birth). Our current results are consistent with the previous study however with smaller HIV prevalence ratios. The smaller prevalence ratio can likely be explained by the different method used to capture HIV diagnoses (hospital discharge data in the previous study and HIV physician diagnoses data in the current study) but also because 1:1 matching of refugee to non-refugee immigrants on country of birth, year and age at arrival in the current study accounted for some of the difference between refugee and non-refugee immigrants. In our previous work we found that refugee mothers with HIV did not have any greater maternal morbidity compared to non-refugee immigrant or Canadian-born mothers with HIV, suggesting that HIV during pregnancy is well-managed in Ontario regardless of refugee status (with permanent residency). In contrast, a Dutch study [9] describes HIV as a risk indicator for severe acute maternal morbidity among asylum-seekers (refugees without permanent residency); suggesting that a lack of appropriate HIV care may be contributing to SAMM.

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Refugee mothers were 4% more likely to have a caesarean section compared their non-refugee counterparts while Afghan and Iraqi refugee mothers were ~30% more likely to experience caesarean section than their same-country non-refugee counterparts. A study involving 10 Canadian hospitals [31] found a significant difference between refugee, asylum-seeker and non-refugee immigrants from South-East and Central Asia. Reasons for the higher caesarean rate among refugees were: higher parity, medical complications, low socio-economic status, socio-cultural factors and sub-optimal perinatal care.[31]

Refugee status was also positively associated with moderate PTB and with gestational diabetes among mothers from the top 5 refugee-receiving countries. The relationship between refugee status and gestational diabetes may be explained by a study which found stressful events were associated with 2.5 times greater risk of gestational diabetes.[32] Other research suggests maternal chronic stress is an important risk factor for PTB,[33] particularly among socially disadvantaged populations.[34] Previously published research of ours found that the effect of refugee status on PTB was stronger among refugee mothers who resided in a transition country prior to arriving in Canada [7] with potentially greater exposure to psychosocial stress. The hypothesized physiological mechanism connecting psychosocial stress to both gestational diabetes and PTB involves dysfunction of regulatory hormones in the body-insulin resistance or impaired insulin metabolism leading to gestational diabetes [32] and early release of hormones required for the initiation of labour leading to PTB.[33]

The extent to which refugee and non-refugee immigrants experienced the "healthy migrant effect" (HME) (relative to Canadian-born mothers) for all maternal and perinatal health outcomes was identical. We found that both refugee and non-refugee immigrants experienced higher odds of the same adverse maternal and perinatal health outcomes (1/3 of all outcomes examined) compared to Canadian-born mothers. This suggests that refugee status, using an administrative definition of refugees, is not an important factor in the HME for these outcomes. These findings are also consistent with others who have stated that the HME is not evident for all health outcomes.[35]

Strengths and Limitations

Among studies examining refugee maternal and perinatal health [5–18,36–47], our study has several unique and important strengths. Firstly, our study used official government immigration data to identify women who met the UNHCR definition of a refugee rather than relying on country of birth (COB) as an indicator of refugee status, as many previous studies have done.[11–18] Secondly, we matched refugee and non-refugee immigrant women on country of birth, as well as year and age at arrival (see Supplementary Figures S6 & S7 for unmatched results). By matching on these variables, ours is the first study to effectively address the question of whether refugee status among two otherwise similar immigrant mothers, is a risk indicator for adverse maternal and perinatal outcomes. Thirdly, to our knowledge our study includes the largest sample of mothers legally classified as refugees reported in the literature contributing to adequate statistical power for our main analyses (objectives 1 and 2).

This study is not without limitations. In our main analysis, we matched 85% of refugee mothers to one non-refugee immigrant mother. To ensure that the results of the matched sample were not biased, a sensitivity analysis was conducted where the refugees and non-refugees unmatched on country of birth were matched instead by sub-region of birth (e.g., East Africa) as well as year and age at arrival. With this second round of matching, 99% of all refugee mothers were matched to a non-refugee mother either on country or sub-region of birth. Analysis of this twice-matched cohort yielded very similar odds ratios to those of the first match. Given that the results were similar, and that the first match most effectively tells us whether refugee status among immigrant mothers with a similar pre-migration context increases risk of adverse outcomes, we chose to present results from only the first match.

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Other limitations are as follows. Firstly, the "refugee experience" as it pertains to health risks may not be consistent with the legally applied definition of "refugee". Risk factors for adverse outcomes (i.e., exposure to violence, forced family separation) are context dependent, such as the length of time in the migration phase and access to health and other supportive services before and during migration - factors for which we did not have data. We addressed context by matching refugees to non-refugees on COB, year and age at arrival a well as restricting analyses to the top 5 refugee-source countries; however even within these COBs there is likely important heterogeneity which we could not examine or account for. A second limitation is the inability to categorize family class non-refugee immigrants according to the permanent residency status of the sponsoring family member (i.e., economic or refugee). This may have caused some refugees to be misclassified as non-refugee immigrants and contributed to biasing estimates in Figures 1 and 2 towards the null. However, since refugees are less likely to have the financial means necessary for sponsorship, the number of family class members who may be refugees is not likely to substantially affect estimates. A third limitation may be that estimates in Figures 1 and 2 were over-adjusted given that the majority of non-refugee permanent residents are selected based on their education and official language ability. However, unadjusted estimates (see Supplementary Table S2) demonstrate that adjusting for these variables does not substantially affect our conclusions. A fourth limitation is that we lacked data on body mass index. Finally, our findings are not generalizable to *unsuccessful* refugee claimants (since our study was limited to permanent residents) who may be more representative of refugees and asylum seekers in other countries.

Implications

To help understand modest differences in gestational diabetes and moderate PTB between refugee and non-refugee immigrant women, further research into stressors refugee mothers experience in their countries of origin, in transition countries and in countries of re-settlement may help support development of preconception and pregnancy stress prevention and management strategies.

Research has described that refugees and other immigrants in Canada experience barriers to accessing health care [48], had unaddressed health concerns after birth [49] and experienced culturally insensitive policies [48]. Indeed, such health care deficiencies may have contributed to the 1/3rd of outcomes where refugee and non-refugee immigrant mothers experienced greater odds when compared to Canadian-born mothers. By the same token, it is surprising that refugee mothers did not experience an excess of maternal and infant health risks compared to non-refugee immigrants since these health care deficiencies are likely experienced more acutely by refugee mothers.

There are a few important caveats to our findings. Firstly, and perhaps most importantly, the administrative definition of refugees is broad and is perhaps unable to sensitively identify refugees at highest health risk. Secondly, non-refugee immigrants from refugee-source countries may be just as likely to experience pre-departure health risks (related to persecution) as their refugee counterparts, reducing specificity and minimizing any differences between the groups. Thirdly, all permanent resident refugees to Canada receive financial and social supports (e.g., housing, resettlement), particularly in the first year after arrival as well as universal health care (as described in the methods section). Specialized primary health care centres catering to the unique health needs of refugees are available [50,51]. There are also national efforts to focus on equity in the quality of care received and migrant friendly maternity care [52]. These specialized health and social support efforts may be helping to minimize potential health inequities experienced by refugees. Lastly, despite official immigration policies, such as the Immigration & Refugee Protection Act (IRPA, 2002)[26,27] (see methods section for more detail), it is possible that unofficial processes select refugees based on factors such as skill level and language fluency (i.e., similar to non-refugee immigrants), effectively selecting for healthy refugees.

Future Research

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Refugees should be compared to non-refugee immigrants, preferably from the same country of birth, as this more effectively addresses the question of whether refugees, among all migrants, are at increased risk for poor health. Further refining refugee status based on detailed migration experiences would also be beneficial. Finally, to help facilitate international comparisons, refugee health researchers may find it useful to state if and how immigration policies shape the health of refugees relative to other immigrants within their borders.

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References

1   Gagnon AJ, Merry L, Robinson C. A systematic review of refugee women's reproductive health. *Refuge* 2002.

2   Citizenship and Immigration Canada. Guide 6000 - Convention Refugees Abroad and Humanitarian-Protected Persons Abroad. 2017.http://www.cic.gc.ca/English/information/applications/guides/E16000TOC.asp (accessed 1 May 2017).

3   Immigration, Refugees & Citizenship Canada. Facts & Figures 2015: Immigration Overview - Permanent Residents – Annual IRCC Updates. Canada - Permanent residents by province or territory and category. 2015. http://www.cic.gc.ca/opendata-donneesouvertes/data/IRCC_FFPR_17_F.xls (accessed 11 May 2017).

4   Settlement.org. How does Canada's refugee system work? 2017.http://settlement.org/ontario/immigration-citizenship/refugees/basic-information-for-refugees/how-does-canada-s-refugee-system-work/ (accessed 1 May 2017).

5   Wanigaratne S, Cole DC, Bassil K, *et al.* Contribution of HIV to Maternal Morbidity Among Refugee Women in Canada. *Am J Public Health* 2015;**105**:2449–56. doi:10.2105/AJPH.2015.302886

6   Wanigaratne S, Cole DC, Bassil K, *et al.* Severe Neonatal Morbidity Among Births to Refugee Women. *Matern Child Health J* 2016;**20**:2189–98. doi:10.1007/s10995-016-2047-4

7   Wanigaratne S, Cole DC, Bassil K, *et al.* The influence of refugee status and secondary migration on preterm birth. *J Epidemiol Community Health* 2016;**70**:622–8. doi:10.1136/jech-2015-206529

8   Vigod SN, Bagadia AJ, Hussain-Shamsy N, *et al.* Postpartum mental health of immigrant mothers by region of origin, time since immigration, and refugee status: a population-based study. *Arch Womens Ment Health*;**20**:439–47. doi:10.1007/s00737-017-0721-1

9   Van Hanegem N, Miltenburg AS, Zwart JJ, *et al.* Severe acute maternal morbidity in asylum seekers: a two-year nationwide cohort study in the Netherlands. *Acta Obstet Gynecol Scand* 2011;**90**:1010–6.

10   Gagnon AJ, Dougherty G, Wahoush O, *et al.* International migration to Canada: The post-birth health of mothers and infants by immigration class. *Soc Sci Med* 2012;**76**:197–207.

11   Vangen S, Stoltenberg C, Johansen REB, *et al.* Perinatal complications among ethnic Somalis in Norway. *Acta Obstet Gynecol Scand* 2002;**81**:317–22.

12   Essen B, Hanson BS, Ostergren PO, *et al.* Increased perinatal mortality among sub-Saharan immigrants in a city-population in Sweden. *Acta Obstet Gynecol Scand* 2000;**79**:737–43.

13   Belihu FB, Davey M-A, Small R. Perinatal health outcomes of East African immigrant populations in Victoria, Australia: a population based study. *BMC Pregnancy Childbirth* 2016;**16**. doi:10.1186/s12884-016-0886-z

11

14   Bakken KS, Skjeldal OH, Stray-Pedersen B. Immigrants from conflict-zone countries: an observational comparison study of obstetric outcomes in a low-risk maternity ward in Norway. *BMC Pregnancy Childbirth* 2015;**15**. doi:10.1186/s12884-015-0603-3

15   Miller LS, Robinson JA, Cibula DA. Healthy Immigrant Effect: Preterm Births Among Immigrants and Refugees in Syracuse, NY. *Matern Child Health J* 2016;**20**:484–93. doi:10.1007/s10995-015-1846-3

16   Gibson-Helm M, Teede H, Block A, *et al.* Maternal health and pregnancy outcomes among women of refugee background from African countries: a retrospective, observational study in Australia. *BMC Pregnancy Childbirth* 2014;**14**:392.

17   Gibson-Helm M, Boyle J, Cheng I-H, *et al.* Maternal health and pregnancy outcomes among women of refugee background from Asian countries. *Int J Gynecol Obstet* 2015;**129**:146–51. doi:10.1016/j.ijgo.2014.10.036

18   Gibson-Helm M, Teede H, Cheng I-H, *et al.* Maternal health and pregnancy outcomes comapring migrant women born in humanitarian and nonhumanitarian source courtries: a retrospective, observational study. *Birth* 2015;**42**:116–24.

19   Urquia ML, Gagnon AJ. Glossary: migration and health. *J Epidemiol Community Health* 2011;**65**:467–472.

20   Public Health Agency of Canada. Perinatal Health Indicators for Canada - 2011. 2011. http://www.phac-aspc.gc.ca/rhs-ssg/phi-isp-2011-eng.php (accessed 15 Aug 2013).

21   Chiu M, Lebenbaum M, Lam K, *et al.* Describing the linkages of the immigration, refugees and citizenship Canada permanent resident data and vital statistics death registry to Ontario's administrative health database. *BMC Med Inform Decis Mak* 2016;**16**. doi:10.1186/s12911-016-0375-3

22   Joseph KS, Fahey J. Validation of perinatal data in the Discharge Abstract Database of the Canadian Institute for Health Information. *Chronic Dis Can* 2009;**29**:96–100.

23   Antoniou T, Zagorski B, Loutfy MR, *et al.* Validation of Case-Finding Algorithms Derived from Administrative Data for Identifying Adults Living with Human Immunodeficiency Virus Infection. *PLoS ONE* 2011;**6**:e21748. doi:10.1371/journal.pone.0021748

24   Keung N. The law says refugee claims must be heard in 60 days. So why are people waiting 16 months? Tor. Star. 2017.https://www.thestar.com/news/immigration/2017/09/20/the-law-says-refugee-claims-must-be-heard-in-60-days-so-why-are-asylum-seekers-waiting-16-months.html (accessed 19 Nov 2017).

25   Keung N. Canada's refugee acceptance rate peaked in four years. Tor. Star. 2017.https://www.thestar.com/news/immigration/2017/03/07/canadas-refugee-acceptance-rate-peaked-in-four-years.html (accessed 19 Nov 2017).

26   Immigration, Refugees & Citizenship Canada. Excessive demand on health and social services. 2016.http://www.cic.gc.ca/english/resources/tools/medic/admiss/excessive.asp (accessed 1 May 2017).

12

27 Minister of Justice, Canada. Immigration and Refugee Protection Act S.C. 2001, c.27. 2016. http://laws.justice.gc.ca/PDF/I-2.5.pdf (accessed 19 Dec 2016).

28 Joseph KS, Liu S, Rouleau J, *et al.* Severe maternal morbidity in Canada, 2003 to 2007: surveillance using routine hospitalization data and ICD-10CA codes. *J Obstet Gynaecol Can* 2010;**32**:837–846.

29 Liu S, Joseph KS, Bartholomew S, *et al.* Temporal trends and regional variations in severe maternal morbidity in Canada, 2003 to 2007. *J Obstet Gynaecol Can* 2010;**32**:847–855.

30 United Nations Statistics Division. Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groups. 2013.http://unstats.un.org/unsd/methods/m49/m49regin.htm (accessed 13 Oct 2016).

31 Gagnon AJ, Van Hulst A, Merry L, *et al.* Cesarean section rate differences by migration indicators. *Arch Gynecol Obstet* 2013;**287**:633–9. doi:10.1007/s00404-012-2609-7

32 Hosler AS, Nayak SG, Radigan AM. Stressful events, smoking exposure and other maternal risk factors associated with gestational diabetes mellitus. *Paediatr Perinat Epidemiol* 2011;**25**:566–574.

33 Latendresse G. The interaction between chronic stress and pregnancy: preterm birth from a biobehavioral perspective. *J Midwifery Women's Health* 2009;**54**:8–17.

34 Wadhwa PD, Entringer S, Buss C, *et al.* The contribution of maternal stress to preterm birth: issues and considerations. *Clin Perinatol* 2011;**38**:351–84. doi:10.1016/j.clp.2011.06.007

35 Vang ZM, Sigouin J, Flenon A, *et al.* Are immigrants healthier than native-born Canadians? A systematic review of the healthy immigrant effect in Canada. *Ethn Health* 2017;**22**:209–41. doi:10.1080/13557858.2016.1246518

36 Goosen S, Hoebe CJ, Waldhober Q, *et al.* High HIV prevalence among asylum seekers who gave birth in the Netherlands: a nationwide study based on antenatal HIV tests. *PloS One* 2015;**10**:e0134724.

37 Dennis C-L, Merry L, Stewart D, *et al.* Prevalence, continuation, and identification of postpartum depressive symptomatology among refugee, asylum-seeking, non-refugee immigrant, and Canadian-born women: results from a prospective cohort study. *Arch Womens Ment Health* 2016;**19**:959–67. doi:10.1007/s00737-016-0633-5

38 Dennis C-L, Merry L, Gagnon AJ. Postpartum depression risk factors among recent refugee, asylum-seeking, non-refugee immigrant, and Canadian-born women: results from a prospective cohort study. *Soc Psychiatry Psychiatr Epidemiol* 2017;**52**:411–22. doi:10.1007/s00127-017-1353-5

39 Gann P, Nghiem L, Warner S. Pregnancy characteristics and outcomes of Cambodian refugees. *Am J Public Health* 1989;**79**:1251–7.

40 Flynn PM, Foster EM, Brost BC. Indicators of acculturation related to Somali refugee women's birth outcomes in Minnesota. *J Immigr Minor Health* 2011;**13**:224–231.

41 Kandasamy T, Berniak R, Shah R, *et al.* Obstetric Risks and Outcomes of Refugee Women at a Single Centre in Toronto. *J Obstet Gynaecol Can* 2014;**36**:296–302.

13

42 Davis JM, Goldenring J, McChesney M, *et al.* Pregnancy outcomes of Indochinese refugees, Santa Clara County, California. *Am J Public Health* 1982;**72**:742–4.

43 Lalchandani S, MacQuillan K, Sheil O. Obstetric profiles and pregnancy outcomes of immigrant women with refugee status. *Ir Med J* 2001;**94**:79–80.

44 King PA, Duthie SJ, Li DFH, *et al.* Obstetric outcome among Vietnamese refugees in Hong Kong: an age-matched case-controlled study. *Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet* 1990;**33**:203–10.

45 Malamitsi-Puchner A, Tzala L, Minaretzis D, *et al.* Preterm delivery and low birthweight among refugees in Greece. *Paediatr Perinat Epidemiol* 1994;**8**:384–390.

46 Kuvacic I, Skrablin S, Hodzic D, *et al.* Possible influence of expatriation on perinatal outcome. *Acta Obstet Gynecol Scand* 1996;**75**:367–71.

47 Liu C, Urquia M, Cnattingius S, *et al.* Migration and preterm birth in war refugees: a Swedish cohort study. *Eur J Epidemiol* 2014;**29**:141–3. doi:10.1007/s10654-013-9877-9

48 Stewart M, Dennis CL, Kariwo M, *et al.* Challenges Faced by Refugee New Parents from Africa in Canada. *J Immigr Minor Health* 2015;**17**:1146–56. doi:10.1007/s10903-014-0062-3

49 Gagnon AJ, Dougherty G, Platt RW, *et al.* Refugee and refugee-claimant women and infants post-birth: migration histories as a predictor of Canadian health system response to needs. *Can J Public Health Rev Can Sante Publique* 2007;**98**:287–91.

50 Women's College Hospital. Crossroads Clinic. http://www.womenscollegehospital.ca/programs-and-services/crossroads-clinic/ (accessed 21 Jul 2017).

51 Access Alliance Multicultural Health and Community Services. http://accessalliance.ca/ (accessed 21 Jul 2017).

52 Gagnon AJ, DeBruyn R, Essén B, *et al.* Development of the Migrant Friendly Maternity Care Questionnaire (MFMCQ) for migrants to Western societies: an international Delphi consensus process. *BMC Pregnancy Childbirth* 2014;**14**:200.

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Data Sharing Statement: There are no additional unpublished data available from this study.

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Table 1: Characteristics of refugee immigrant, non-refugee immigrant and Canadian-born mothers in Ontario, Canada 2002-2014.

	Refugee immigrant (N = 34,233)	Non-refugee immigrant (N = 243,439)	Canadian-born (N = 615,394)
Maternal age at first birth, years			
15-19	989 (2.9)	3,469 (1.4)	40,905 (6.6)
20-24	5,271 (15.4)	30,330 (12.5)	98,808 (16.1)
25-29	10,231 (29.9)	75,982 (31.2)	180,850 (29.4)
30-34	10,032 (29.3)	79,885 (32.8)	191,433 (31.1)
35-39	5,958 (17.4)	42,893 (17.6)	84,383 (13.7)
≥ 40	1,742 (5.1)	10,843 (4.5)	18,624 (3.0)
Missing	10 (0.0)	37 (0.0)	391 (0.1)
Parity at first birth in Ontario			
0	18,826 (55.0)	152,530 (62.7)	445,715 (72.4)
1	7,631 (22.3)	62,708 (25.8)	109,462 (17.8)
2	4,317 (12.6)	20,091 (8.3)	42,656 (6.9)
≥3	3,421 (10.0)	7,892 (3.2)	16,635 (2.7)
Missing	38 (0.1)	218 (0.1)	926 (0.2)
Number of births in Ontario			
1	20,406 (59.6)	148,694 (61.1)	328,458 (53.4)
2	10,356 (30.3)	76,411 (31.4)	225,838 (36.7)
3	2,800 (8.2)	15,473 (6.4)	50,262 (8.2)
≥ 4	671 (2.0)	2,861 (1.2)	10,836 (1.8)
Neighbourhood income quintile			
1 (lowest)	15,332 (44.8)	78,309 (32.2)	111,281 (18.1)
2,3,4 (middle)	16,804 (49.1)	141,357 (58.1)	386,578 (62.8)
5 (highest)	2001 (5.8)	22,926 (9.4)	113,769 (18.5)
Missing	96 (0.3)	847 (0.3)	3,766 (0.6)
Official language ability at immigration			
English and/or French	19,633 (57.4)	157,788 (64.8)	--
Neither English or French	14,600 (42.6)	85,645 (35.2)	--
Missing	0 (0.0)	6 (0.0)	--
Level of education at immigration			
0-9 years	14,923 (43.6)	56,485 (23.2)	--
10-12 years	9,931 (29.0)	48,137 (19.8)	--
≥ 13 years	3,010 (8.8)	22,380 (9.2)	--
Trade, Diplomas	3,720 (10.9)	30,852 (12.7)	--
Bachelors, Masters, Doctorate	2,649 (7.7)	85,585 (35.2)	--
Duration of residence, years			
< 10	21,569 (63.0)	184,508 (75.8)	--
≥ 10	12,664 (37.0)	58,931 (24.2)	--
World region of birth			
South Asia	9,233 (27.0)	78,184 (32.1)	--
Sub Saharan Africa	7,810 (22.8)	11,733 (4.8)	--
Latin America & Caribbean	4,928 (14.4)	33,075 (13.6)	--
Western & Central Asia, North Africa	3,458 (10.1)	17,502 (7.2)	--
Eastern Europe	3,189 (9.3)	18,542 (7.6)	--
Southeast Asia, Oceania Islands	1,514 (4.4)	28,514 (11.7)	--

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East Asia (excluding Japan)	1,878 (5.5)	35,669 (14.7)	--
Southern Europe	1,966 (25.1)	8,003 (30.8)	--
Developed Countries	250 (22.4)	12,152 (25.5)	--
Missing	7 (0.0)	65 (0.0)	--

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FIGURE LEGEND

Figure 1: Adverse maternal outcomes comparing 29,023 first births in Ontario to refugee immigrants (● circles) vs. 29,023 first births in Ontario births to non-refugee immigrants (○circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Figure 1 footnote: AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

Figure 2: Adverse perinatal outcomes comparing first births in Ontario to refugee immigrants (● circles) vs. first births in Ontario to non-refugee immigrants (○circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Denominators vary with the outcome examined. Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Figure 2 footnote: AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

Figure 3: Adverse maternal outcomes comparing 52,360 births to refugee immigrants (●circles) and 360,007 births to non-refugee immigrants (●circles) vs. 977,045 births to Canadian-born (○circles) mothers. Odds ratios adjusted for maternal age, parity and income quintile.

Figure 3 footnote: AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

Figure 4: Adverse perinatal outcomes comparing births to refugee immigrants (●circles) and births to non-refugee immigrants (●circles) vs. births to Canadian-born mothers (○circles). Denominators vary with the outcome examined. Odds ratios adjusted for maternal age, parity, and income quintile.

Figure 4 footnote: AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Outcome	n (%)		AOR (95% CI)
Complicated urinary tract infection	332 (1.14) 294 (1.01)	○ ●	1.02 (0.84-1.23)
Pre-existing hypertension	109 (0.38) 144 (0.50)	○ ●	1.25 (0.92-1.70)
Gestational hypertension	869 (2.99) 945 (3.26)	○ ●	1.08 (0.97-1.20)
Preeclampsia	339 (1.17) 329 (1.13)	○ ●	0.96 (0.80-1.14)
Eclampsia	23 (0.08) 22 (0.08)	○ ●	1.02 (0.41-2.51)
Pre-pregnancy diabetes	122 (0.42) 148 (0.51)	○ ●	1.00 (0.73-1.38)
Gestational diabetes	1,791 (6.17) 2,061 (7.10)	○ ●	1.05 (0.97-1.14)
Caesarean section	8,233 (28.37) 8,395 (28.93)	○ ●	1.04 (1.00-1.08)
Postpartum hemorrhage	972 (3.35) 971 (3.35)	○ ●	1.04 (0.94-1.15)
Maternal ICU admission	81 (0.28) 106 (0.37)	○ ●	1.38 (0.96-1.98)
Severe maternal morbidity (SMM)	382 (1.32) 426 (1.47)	○ ●	1.11 (0.95-1.29)
SMM excluding HIV	340 (1.17) 352 (1.21)	○ ●	1.06 (0.89-1.25)
HIV	57 (0.20) 114 (0.39)	○ ●	1.82 (1.19-2.79)

0.10   1.00   10.00

AOR (95% CI)

Figure 1: Adverse maternal outcomes comparing 29,023 first births in Ontario to refugee immigrants (black circles) vs. 29,023 first births in Ontario births to non-refugee immigrants (open circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Figure 1 footnote: AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

72x85mm (300 x 300 DPI)

Outcome
n/N (%)   AOR (95% CI)

Any congenital anomaly
1,377/29,245 (4.71)
1,289/29,245 (4.41)   0.91 (0.83-0.99)

Moderate preterm birth (32-36 wks)
1,356/29,076 (4.66)
1,501/29,076 (5.16)   1.08 (0.99-1.17)

Very preterm birth (<32 wks)
247/29,076 (0.85)
278/29,076 (0.96)   1.08 (0.89-1.32)

Neonatal mortality (<28 days)
50/29,199 (0.17)
50/29,199 (0.17)   1.08 (0.63-1.85)

NICU admission
4,169/29,213 (14.27)
4,226/29,213 (14.47)   1.01 (0.96-1.07)

Perinatal mortality
235/29,507 (0.80)
269/29,507 (0.91)   1.04 (0.85-1.28)

Stillbirth
195/29,507 (0.66)
214/29,507 (0.73)   1.07 (0.85-1.34)

0.50   1.00   2.00

AOR (95% CI)

Figure 2: Adverse perinatal outcomes comparing first births in Ontario to refugee immigrants (black circles) vs. first births in Ontario to non-refugee immigrants (open circles), 1:1 matched on country of birth, year and age at arrival (+/- 5 years). Denominators vary with the outcome examined. Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Figure 2 footnote: AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Outcome — n (%)
○ Canadian-born (N=977,045)
● Non-Refugee Immigrants (N=360,007)
● Refugee Immigrants (N=52,360)

AOR (95% CI)

Outcome	n (%)	AOR (95% CI)
Complicated urinary tract infection	11,852 (1.2)	
	3,335 (0.9)	0.79 (0.76-0.82)
	421 (0.8)	0.71 (0.64-0.78)
Pre-existing hypertension	5,386 (0.6)	
	1,734 (0.5)	0.72 (0.68-0.76)
	266 (0.5)	0.74 (0.65-0.85)
Gestational hypertension	42,146 (4.3)	
	10,615 (3)	0.64 (0.63-0.66)
	1,513 (2.9)	0.67 (0.63-0.71)
Preeclampsia	11,368 (1.2)	
	3,036 (0.8)	0.70 (0.67-0.73)
	511 (1)	0.87 (0.79-0.95)
Eclampsia	957 (0.1)	
	269 (0.1)	0.76 (0.66-0.87)
	30 (0.1)	0.76 (0.66-0.87)
Pre-pregnancy diabetes	6,301 (0.7)	
	1,706 (0.5)	0.63 (0.59-0.67)
	309 (0.6)	0.73 (0.65-0.83)
Gestational diabetes	30,901 (3.2)	
	26,559 (7.4)	2.07 (2.03-2.11)
	3,826 (7.3)	1.90 (1.83-1.97)
Caesarean section	265,859 (27.4)	
	101,863 (28.4)	1.00 (0.99-1.01)
	14,622 (28)	1.02 (1.00-1.03)
Postpartum hemorrhage	39,619 (4.1)	
	11,318 (3.2)	0.79 (0.77-0.80)
	1,688 (3.2)	0.83 (0.79-0.87)
Maternal ICU admission	2,317 (0.2)	
	1,060 (0.3)	1.14 (1.06-1.23)
	183 (0.4)	1.33 (1.14-1.55)
Severe maternal morbidity (SMM)	10,910 (1.1)	
	3,971 (1.1)	0.94 (0.90-0.97)
	759 (1.5)	1.20 (1.11-1.29)
SMM excluding HIV	10,758 (1.1)	
	3,811 (1.1)	0.92 (0.88-0.95)
	602 (1.2)	0.97 (0.90-1.06)
HIV	315 (0)	
	220 (0.1)	1.52 (1.23-1.87)
	229 (0.4)	10.09 (8.14-12.51)

0.10   1.00   10.00
AOR (95% CI)

Figure 3: Adverse maternal outcomes comparing 52,360 births to refugee immigrants (black circles) and 360,007 births to non-refugee immigrants (grey circles) vs. 977,045 births to Canadian-born (open circles) mothers. Odds ratios adjusted for maternal age, parity and income quintile.

Figure 3 footnote: AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

64x76mm (300 x 300 DPI)

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Outcome
○ Canadian-born n/N (%)
● Non-Refugee Immigrants n/N (%)
● Refugee Immigrants n/N (%)

AOR (95% CI)

Any congenital anomaly
46,711/941,226 (5.0)   0.86 (0.84-0.88)
15,341/350,136 (4.4)   0.87 (0.83-0.91)
2,239/50,884 (4.4)

Moderate preterm birth (32-36 wks)
52,386/936,852 (5.6)   0.87 (0.86-0.89)
17,678/348,924 (5.1)   0.90 (0.87-0.93)
2,600/50,575 (5.1)

Very preterm birth (<32 wks)
7,301/936,852 (0.8)   1.02 (0.98-1.07)
2,941/348,924 (0.8)   1.05 (0.95-1.16)
457/50,575 (0.9)

Neonatal mortality (<28 days)
1,437/940,452 (0.2)   1.06 (0.96-1.17)
588/349,771 (0.2)   0.96 (0.77-1.20)
84/50,830 (0.2)

NICU admission
108,072/940,956 (11.5)   1.06 (1.05-1.07)
44,248/350,058 (12.6)   1.07 (1.05-1.10)
6,642/50,877 (13.1)

Perinatal mortality
6,169/949,807 (0.6)   1.10 (1.05-1.15)
2,695/353,070 (0.8)   1.17 (1.06-1.29)
454/51,356 (0.9)

Stillbirth
4,823/949,807 (0.5)   1.10 (1.04-1.16)
2,116/353,070 (0.6)   1.20 (1.07-1.34)
366/51,356 (0.7)

0.50   1.00   2.00
AOR (95% CI)

Figure 4: Adverse perinatal outcomes comparing births to refugee immigrants (black circles) and births to non-refugee immigrants (grey circles) vs. births to Canadian-born mothers (open circles). Denominators vary with the outcome examined. Odds ratios adjusted for maternal age, parity, and income quintile.

Figure 4 footnote: AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

76x73mm (300 x 300 DPI)

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SUPPLEMENTARY TABLES

Table S1: List of 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI) codes for maternal and perinatal outcomes

Maternal or Perinatal Outcome	Definition	Source Database	ICD-10-CA/CCI
Complicated urinary tract infection		CIHI-DAD	O23, O86, N39
Pre-existing hypertension		CIHI-DAD	O10, O11
Gestational hypertension		CIHI-DAD	O13
Preeclampsia			O14
Eclampsia		CIHI-DAD	O15
Pre-pregnancy diabetes mellitus		CIHI-DAD	O24.0-O24.3
Gestational diabetes mellitus (GDM)		CIHI-DAD	O24.4
Caesarean delivery		CIHI-DAD	5.MD.60.^^
Post-partum hemorrhage		CIHI-DAD	O72
Maternal intensive care unit (ICU) admission		CIHI-DAD	Special Care Unit 1-6
Severe maternal morbidity		CIHI-DAD	See Joseph et al, 2010*
HIV	Three physician diagnoses within three years.	Ontario HIV DB	
Congenital anomaly	An abnormality of structure or function present at birth	CIHI-DAD	ICD-10: Q00-Q99
Moderate preterm birth (PTB)	Live birth with gestational age 32-36 weeks	CIHI-DAD	32-36 weeks gestation recorded on CIHI-DAD birth record
Very preterm birth (VPTB)	Live birth with gestational age <32 weeks	CIHI-DAD	< 32 weeks gestation recorded on CIHI-DAD birth record
Neonatal mortality	Death <28 days of life	RPDB, ORG-VSD	
Neonatal intensive care unit (NICU) admission		CIHI-DAD	Special care unit admission, any level
Perinatal mortality	Stillbirth or death of live born infant < 7 days of life	RPDB, ORG-VSD	
Stillbirth	Intrauterine fetal death ≥ 20 weeks gestation and > 500 g birthweight	CIHI-DAD	Maternal record: Z371, Z373-7, O364. Infant record: P95

Abbreviations

ICD-10-CA/CCI - 10th revision of the *International Statistical Classification of Diseases and Related Health Problems*, Canadian enhancement, and *Canadian Classification of Health Interventions* (ICD-10-CA/CCI)

CIHI-DAD – Canadian Institute for Health Information – Discharge Abstract Database

RPDB – Registered Persons Database (referred to as "Ontario Health Care Registry" in paper)

ORGD-VSD – Office of the Registrar General's Vital Statistics-Death Registry

* Joseph KS, Liu S, Rouleau J, Kirby RS, Kramer MS, Sauve R, et al. Severe maternal morbidity in Canada, 2003 to 2007: surveillance using routine hospitalization data and ICD-10CA codes. J Obstet Gynaecol Can. 2010;32(9):837

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Table S2: Unadjusted Odds Ratios (OR) (95% CI) for Figures 1 and 2

FIGURE 1	
OUTCOME	**UNADJUSTED OR (95% CI)**
Complicated urinary tract infection	0.88 (0.75-1.04)
Pre-existing hypertension	1.32 (1.03-1.69)
Gestational hypertension	1.09 (0.99-1.20)
Preeclampsia	0.97 (0.83-1.13)
Eclampsia	0.96 (0.53-1.72)
Pre-pregnancy diabetes mellitus	1.22 (0.96-1.55)
Gestational diabetes mellitus (GDM)	1.17 (1.09-1.25)
Caesarean delivery	1.03 (0.99-1.07)
Post-partum hemorrhage	1.00 (0.91-1.09)
Maternal intensive care unit admission	1.31 (0.98-1.75)
Severe maternal morbidity (SMM)	1.12 (0.97-1.28)
SMM excluding HIV	1.04 (0.89-1.20)
HIV	2.06 (1.48-2.85)
FIGURE 2	
OUTCOME	**UNADJUSTED OR (95% CI)**
Congenital anomaly	0.93 (0.86-1.01)
Moderate preterm birth (MPTB)	1.11 (1.03-1.20)
Very preterm birth (VPTB)	1.13 (0.95-1.34)
Neonatal mortality	1.00 (0.68-1.48)
Neonatal intensive care unit admission	1.02 (0.97-1.07)
Perinatal mortality	1.15 (0.96-1.37)
Stillbirth	1.10 (0.91-1.34)

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Table S3: Unadjusted Odds Ratios (OR) (95% CI) for Figures 3 and 4

FIGURE 3	UNADJUSTED OR (95% CI)	
OUTCOME	REFUGEES VS. CDN	NON-REFUGEES VS. CDN
Complicated urinary tract infection	0.66 (0.60-0.73)	0.76 (0.73-0.79)
Pre-existing hypertension	0.92 (0.81-1.05)	0.86 (0.81-0.91)
Gestational hypertension	0.65 (0.62-0.69)	0.67 (0.65-0.68)
Preeclampsia	0.83 (0.76-0.91)	0.72 (0.69-0.75)
Eclampsia	0.58 (0.40-0.84)	0.76 (0.66-0.87)
Pre-pregnancy diabetes mellitus	0.90 (0.79-1.02)	0.72 (0.67-0.76)
Gestational diabetes mellitus (GDM)	2.38 (2.29-2.47)	2.40 (2.36-2.45)
Caesarean delivery	1.05 (1.02-1.07)	1.07 (1.06-1.09)
Post-partum hemorrhage (PPH)	0.79 (0.75-0.84)	0.78 (0.76-0.79)
Maternal intensive care unit admission	1.47 (1.26-1.71)	1.24 (1.15-1.33)
Severe maternal morbidity (SMM)	1.30 (1.20-1.41)	0.98 (0.95-1.02)
SMM without HIV	1.04 (0.96-1.13)	0.96 (0.92-0.99)
HIV	13.91 (11.37-17.01)	1.85 (1.51-2.26)
FIGURE 4		
OUTCOME		
Congenital anomaly	0.88 (0.84-0.92)	0.88 (0.86-0.89)
Moderate preterm birth (MPTB)	0.92 (0.88-0.96)	0.90 (0.88-0.92)
Very preterm birth (VPTB)	1.16 (1.06-1.28)	1.08 (1.03-1.13)
Neonatal mortality	1.08 (0.87-1.35)	1.10 (1.00-1.21)
Neonatal intensive care unit (NICU) admission	1.15 (1.12-1.19)	1.11 (1.10-1.13)
Perinatal mortality	1.37 (1.24-1.51)	1.17 (1.12-1.23)
Stillbirth	1.41 (1.26-1.57)	1.18 (1.12-1.24)

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SUPPLEMENTARY FIGURES

Figure S1a: Adverse maternal outcomes comparing 5,724 births to Sri Lankan refugee immigrants (▲ triangles) vs. 17,373 births to Sri Lankan non-refugee immigrants (△ triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		AOR (95% CI)
Complicated urinary tract infection	101 (0.58)		
	40 (0.70)		1.11 (0.74-1.68)
Pre-existing hypertension	54 (0.31)		
	25 (0.44)		0.90 (0.53-1.51)
Gestational hypertension	502 (2.89)		
	184 (3.21)		1.21 (1.00-1.47)
Preeclampsia	136 (0.78)		
	52 (0.91)		0.99 (0.69-1.42)
Eclampsia	10 (0.06)		
	*		
Pre-pregnancy diabetes	147 (0.85)		
	62 (1.08)		0.95 (0.68-1.33)
Gestational diabetes	2,062 (11.87)		
	790 (13.80)		1.09 (0.99-1.21)
Caesarean section	5,359 (30.85)		
	1,722 (30.08)		0.95 (0.89-1.03)
Postpartum hemorrhage	465 (2.68)		
	132 (2.31)		0.83 (0.66-1.03)
Maternal ICU admission	44 (0.25)		
	15 (0.26)		0.81 (0.43-1.55)
Severe maternal morbidity	165 (0.95)		
	47 (0.82)		0.83 (0.58-1.19)

0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus
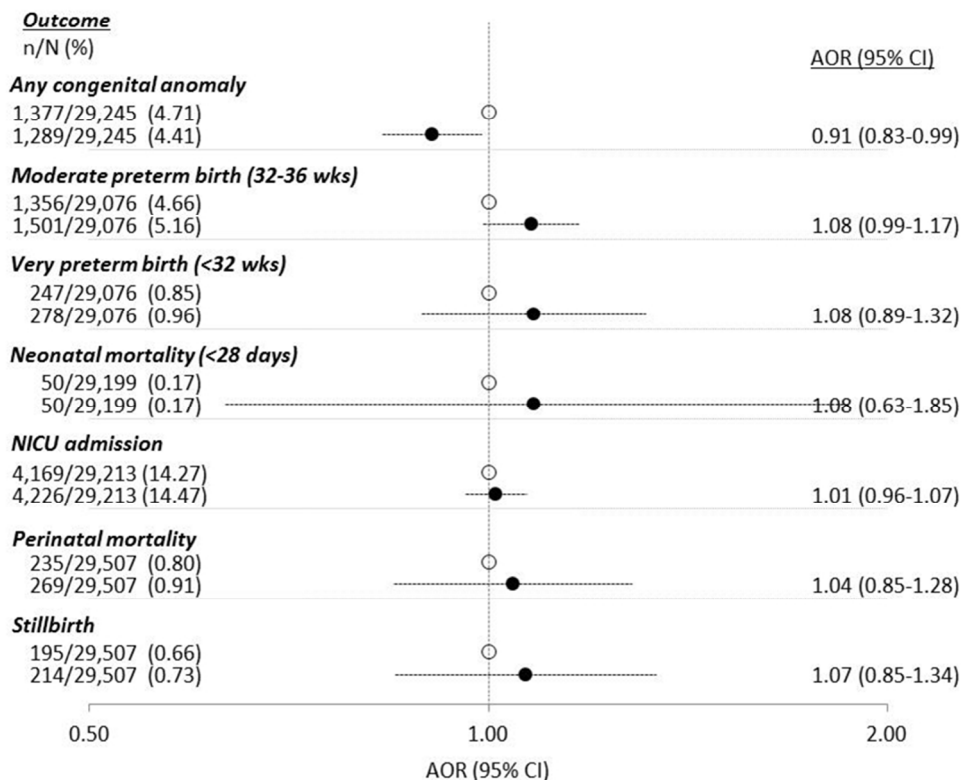
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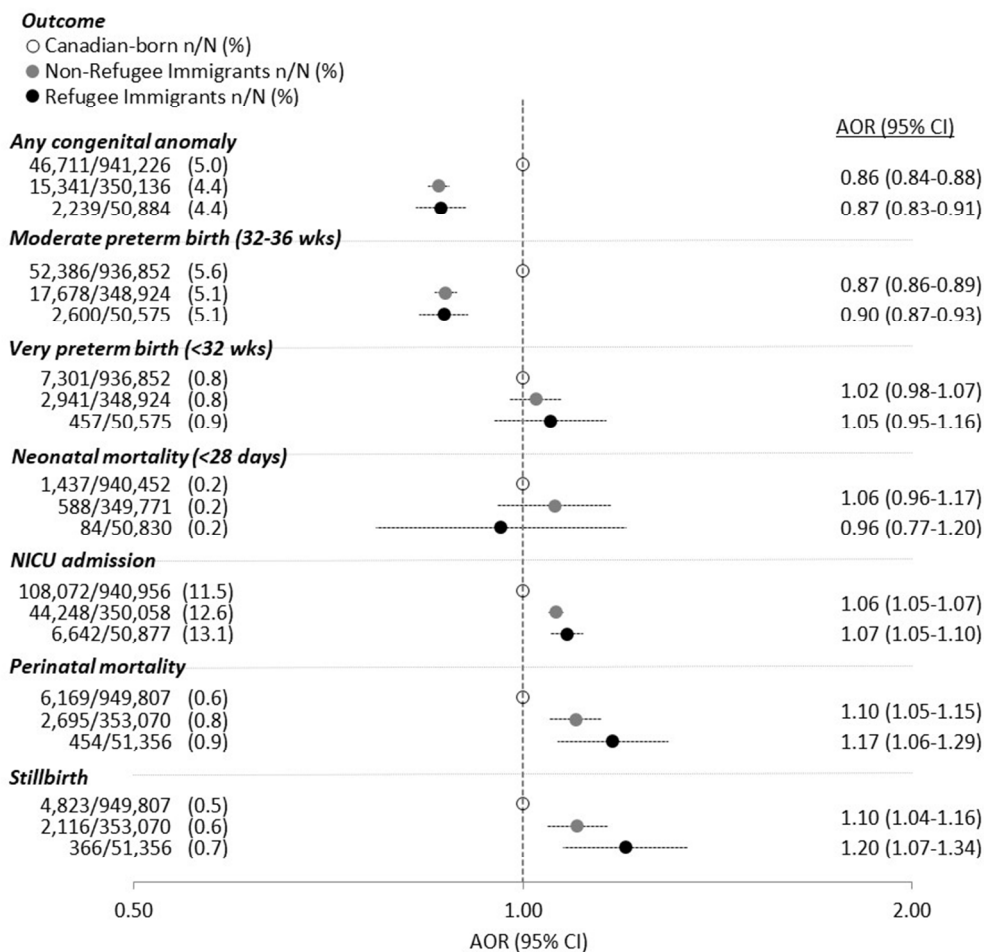**Figure S1b: Adverse perinatal outcomes comparing births to Sri Lankan refugee immigrants (▲triangles) vs. births to Sri Lankan non-refugee immigrants (△triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.**

Outcome n/N (%)		AOR (95% CI)
Any congenital anomaly		
689/16,984 (4.06)	△	
187/5,591 (3.34)	▲	0.85 (0.70-1.01)
Moderate preterm birth (32-36 wks)		
927/16,945 (5.47)	△	
346/5,573 (6.21)	▲	1.04 (0.90-1.20)
Very preterm birth (<32 wks)		
122/16,945 (0.72)	△	
58/5,573 (1.04)	▲	1.20 (0.84-1.71)
Neonatal mortality (<28 days)		
26/16,963 (0.15)	△	
8/5,583 (0.14)	▲	1.02 (0.42-2.47)
NICU admission		
3,496/16,977 (20.59)	△	
1,211/5,590 (21.66)	▲	1.17 (1.08-1.27)
Perinatal mortality		
137/17,128 (0.80)	△	
47/5,640 (0.83)	▲	1.01 (0.70-1.46)
Stillbirth		
112/17,128 (0.65)	△	
37/5,640 (0.66)	▲	1.00 (0.66-1.52)

0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

Figure S2a: Adverse maternal outcomes comparing 2,453 births to Somali refugee immigrants (▲ triangles) vs. 4,499 births to Somali non-refugee immigrants (△ triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		AOR (95% CI)
Complicated urinary tract infection	14 (0.57)	△	
	39 (0.87)	▲	1.41 (0.72-2.74)
Pre-existing hypertension	9 (0.37)	△	
	18 (0.40)	▲	0.98 (0.41-2.36)
Gestational hypertension	51 (2.08)	△	
	109 (2.42)	▲	1.10 (0.75-1.60)
Preeclampsia	28 (1.14)	△	
	46 (1.02)	▲	0.80 (0.47-1.37)
Eclampsia	*	△	
	*		
Pre-pregnancy diabetes	24 (0.98)	△	
	33 (0.73)	▲	0.86 (0.48-1.57)
Gestational diabetes	183 (7.46)	△	
	379 (8.42)	▲	1.20 (0.98-1.48)
Caesarean section	583 (23.77)	△	
	1,124 (24.98)	▲	0.97 (0.85-1.11)
Postpartum hemorrhage	98 (4.00)	△	
	173 (3.85)	▲	1.00 (0.75-1.32)
Maternal ICU admission	13 (0.53)	△	
	23 (0.51)	▲	1.19 (0.55-2.55)
Severe maternal morbidity (SMM)	42 (1.71)	△	
	68 (1.51)	▲	0.82 (0.53-1.26)
SMM excluding HIV	36 (1.47)	△	
	36 (0.80)	▲	0.89 (0.56-1.42)

0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S2b: Adverse perinatal outcomes comparing births to Somali refugee immigrants (▲triangles) vs. births to Somali non-refugee immigrants (△triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome n/N (%)		AOR (95% CI)
Any congenital anomaly		
111/2,370 (4.68)	△	
199/4,375 (4.55)	▲	1.01 (0.77-1.31)
Moderate preterm birth (32-36 wks)		
81/2,311 (3.50)	△	
198/4,272 (4.63)	▲	1.31 (0.98-1.76)
Very preterm birth (<32 wks)		
16/2,311 (0.69)	△	
34/4,272 (0.80)	▲	0.99 (0.51-1.95)
Neonatal mortality (<28 days)		
*/2,368 *	△	
12/4,374 (0.27)		
NICU admission		
344/2,369 (14.52)	△	
665/4,375 (15.20)	▲	1.02 (0.87-1.20)
Perinatal mortality		
34/2,408 (1.41)	△	
51/4,432 (1.15)	▲	0.55 (0.34-0.89)
Stillbirth		
32/2,408 (1.33)	△	
42/4,432 (0.95)	▲	0.48 (0.29-0.80)

0.10   1.00   10.00
AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S3a: Adverse maternal outcomes comparing 4,210 births to Afghan refugee immigrants (▲ triangles) vs. 3,905 births to Afghan non-refugee immigrants (△ triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		AOR (95% CI)
Complicated urinary tract infection	21 (0.54)		
	12 (0.29)		0.60 (0.28-1.28)
Pre-existing hypertension	*		
	10 (0.24)		
Gestational hypertension	61 (1.56)		
	87 (2.07)		1.18 (0.83-1.69)
Preeclampsia	26 (0.67)		
	38 (0.90)		1.26 (0.74-2.15)
Eclampsia	*		
	*		
Pre-pregnancy diabetes	11 (0.28)		
	29 (0.69)		1.72 (0.84-3.52)
Gestational diabetes	248 (6.35)		
	426 (10.12)		1.29 (1.09-1.54)
Caesarean section	788 (20.18)		
	1,159 (27.53)		1.28 (1.15-1.44)
Postpartum hemorrhage	96 (2.46)		
	123 (2.92)		1.14 (0.85-1.52)
Maternal ICU admission	9 (0.23)		
	22 (0.52)		1.72 (0.76-3.92)
Severe maternal morbidity	41 (1.05)		
	47 (1.12)		0.92 (0.59-1.45)

0.10   1.00   10.00
AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S3b: Adverse perinatal outcomes comparing births to Afghan refugee immigrants (▲triangles) vs. births to Afghan non-refugee immigrants (△triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome n/N (%)	AOR (95% CI)
Any congenital anomaly	
183/3,824 (4.79)	
200/4,115 (4.86)	1.03 (0.83-1.29)
Moderate preterm birth (32-36 wks)	
148/3,814 (3.88)	
171/4,094 (4.18)	1.01 (0.80-1.29)
Very preterm birth (<32 wks)	
23/3,814 (0.60)	
35/4,094 (0.85)	1.21 (0.69-2.15)
Neonatal mortality (<28 days)	
10/3,820 (0.26)	
10/4,112 (0.24)	0.98 (0.38-2.49)
NICU admission	
520/3,822 (13.61)	
617/4,115 (14.99)	1.07 (0.93-1.23)
Perinatal mortality	
28/3,856 (0.73)	
47/4,159 (1.13)	1.41 (0.86-2.33)
Stillbirth	
23/3,856 (0.60)	
37/4,159 (0.89)	1.35 (0.78-2.35)

0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S4a: Adverse maternal outcomes comparing 2,613 births to Iraqi refugee immigrants (▲ triangles) vs. 4,239 births to Iraqi non-refugee immigrants (Δ triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)		AOR (95% CI)
Complicated urinary tract infection	30 (0.71)	Δ	
	24 (0.92)	▲	1.32 (0.74-2.34)
Pre-existing hypertension	11 (0.26)	Δ	
	13 (5.00)	▲	1.36 (0.58-3.17)
Gestational hypertension	70 (1.65)	Δ	
	60 (2.30)	▲	1.43 (0.98-2.08)
Preeclampsia	24 (0.57)	Δ	
	11 (0.42)	▲	0.80 (0.37-1.72)
Eclampsia	*	Δ	
	*		
Pre-pregnancy diabetes	17 (0.40)	Δ	
	15 (0.57)	▲	1.29 (0.61-2.72)
Gestational diabetes	239 (5.64)	Δ	
	200 (7.65)	▲	1.22 (0.99-1.50)
Caesarean section	1,011 (23.85)	Δ	
	722 (27.63)	▲	1.26 (1.12-1.42)
Postpartum hemorrhage	115 (2.71)	Δ	
	77 (2.95)	▲	1.15 (0.84-1.57)
Maternal ICU admission	10 (0.24)	Δ	
	6 (0.23)	▲	0.98 (0.34-2.87)
Severe maternal morbidity	44 (1.04)	Δ	
	28 (1.07)	▲	0.88 (0.53-1.45)

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0.10                    1.00                    10.00
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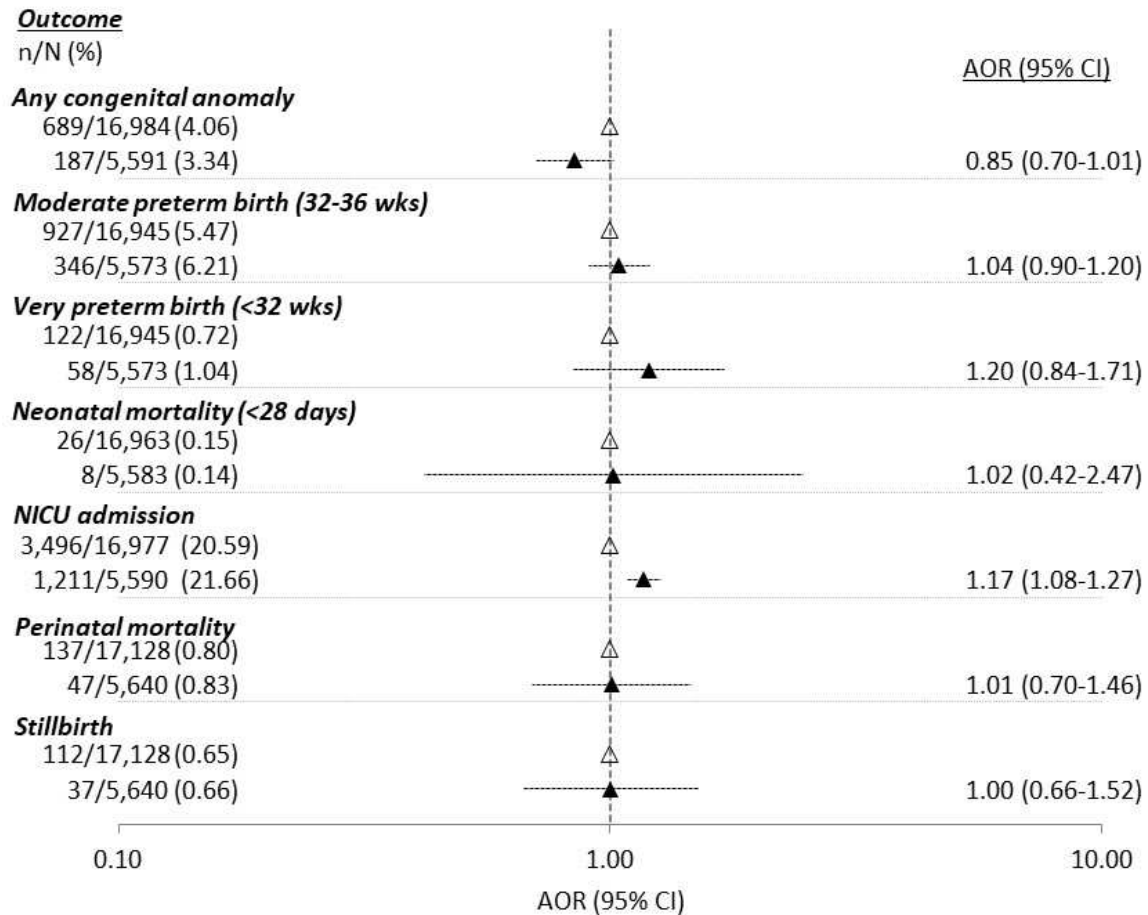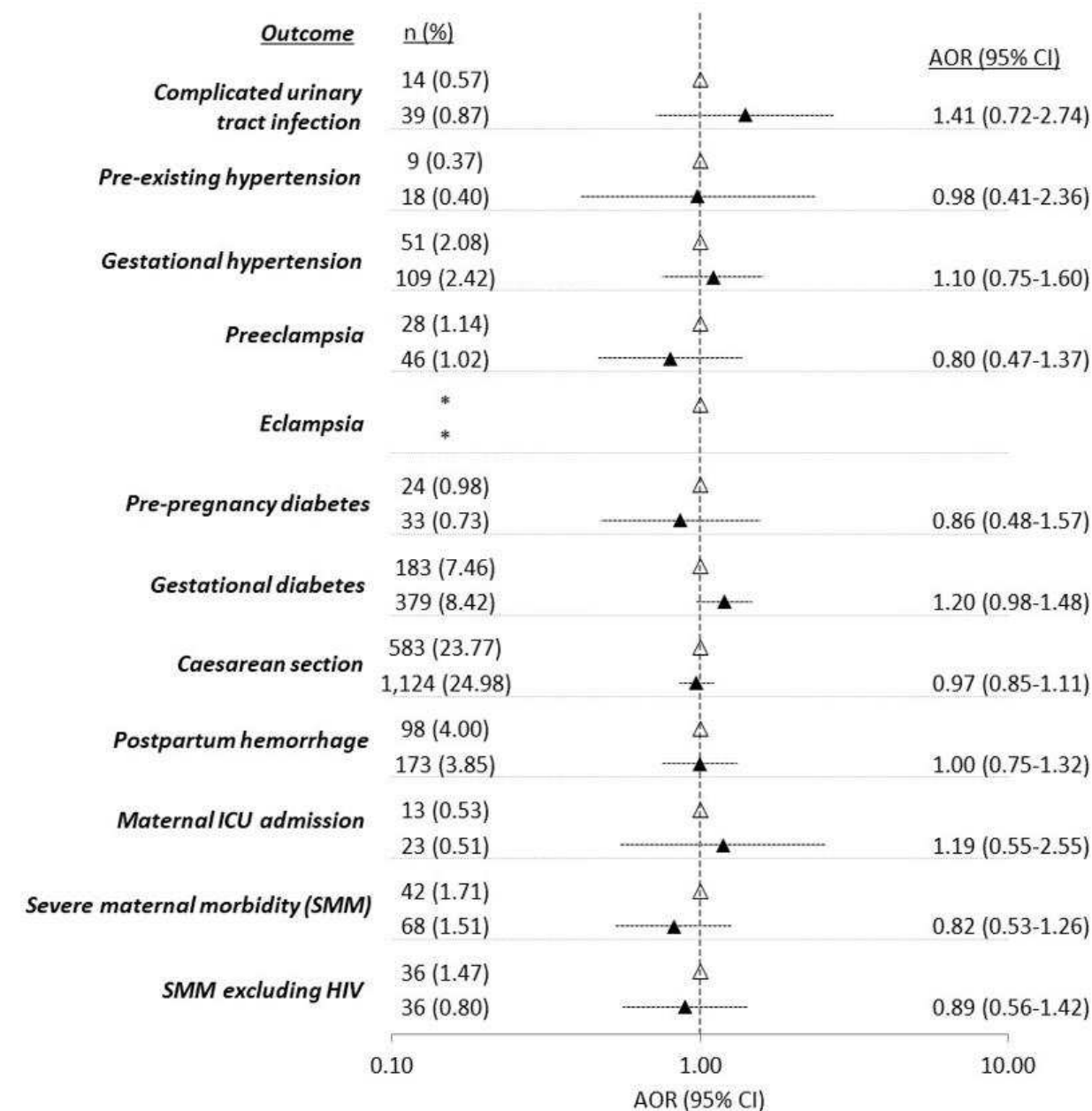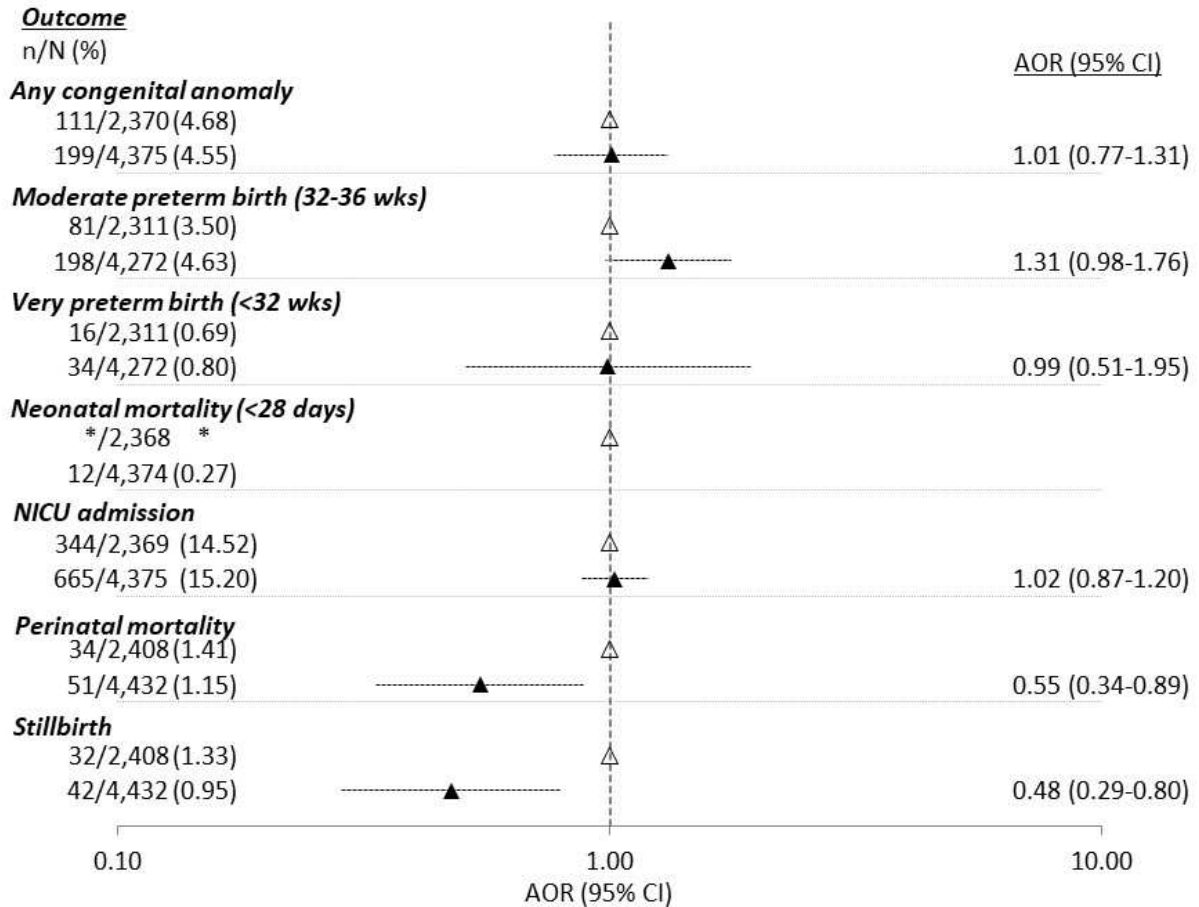
AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S4b: Adverse perinatal outcomes comparing births to Iraqi refugee immigrants (▲triangles) vs. births to Iraqi non-refugee immigrants (△triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome
n/N (%)   AOR (95% CI)
Any congenital anomaly
    181/4,133(4.38)
    107/2,533 (4.22)   0.91 (0.70-1.18)
Moderate preterm birth (32-36 wks)
    179/4,114(4.35)
    119/2,529 (4.71)   0.98 (0.76-1.26)
Very preterm birth (<32 wks)
    30/4,114(0.73)
    17/2,529 (0.67)   0.83 (0.44-1.56)
Neonatal mortality (<28 days)
    9/4,127(0.22)
    */2,533   *
NICU admission
    431/4,132 (10.43)
    279/2,533 (11.01)   1.01 (0.85-1.20)
Perinatal mortality
    34/4,165(0.82)
    21/2,561 (0.82)   0.87 (0.49-1.56)
Stillbirth
    22/4,165(0.53)
    21/2,561 (0.82)   1.37 (0.72-2.58)

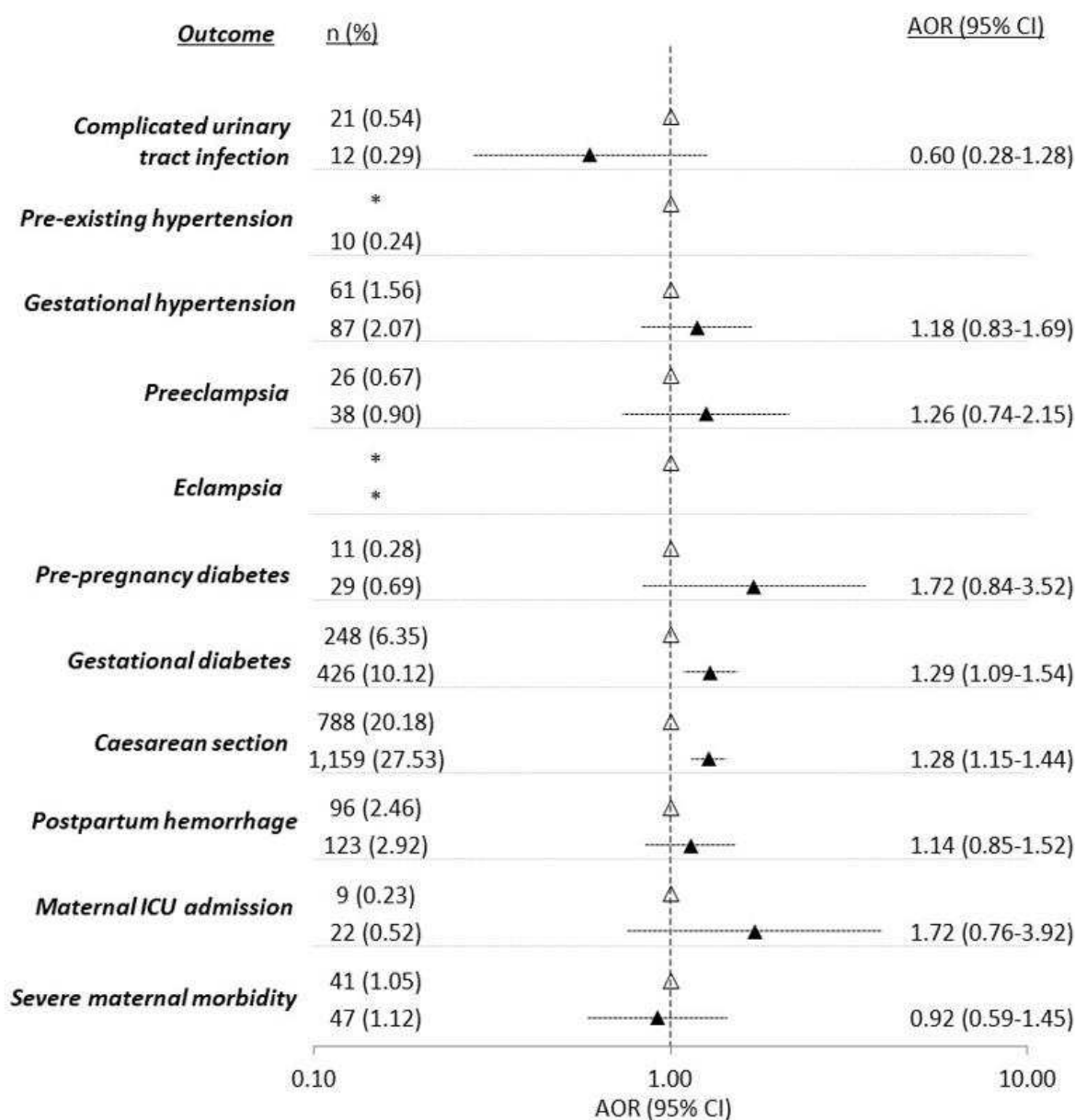0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

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Figure S5a: Adverse maternal outcomes comparing 2,527 births to Chinese refugee immigrants (▲ triangles) vs. 37,093 births to Chinese non-refugee immigrants (△ triangles). Odds ratios adjusted for maternal age, parity, income quantile, official language ability, education and duration of residence.

Outcome	n (%)		AOR (95% CI)
Complicated urinary tract infection	347 (0.94)		
	14 (0.55)		0.67 (0.38-1.17)
Pre-existing hypertension	64 (0.17)		
	6 (0.24)		1.65 (0.67-4.11)
Gestational hypertension	480 (1.29)		
	33 (1.31)		1.38 (0.95-2.02)
Preeclampsia	145 (0.39)		
	9 (0.36)		1.14 (0.56-2.31)
Eclampsia	18 (0.05)		
	*		
Pre-pregnancy diabetes	63 (0.17)		
	*		
Gestational diabetes	2,850 (7.68)		
	174 (6.89)		1.16 (0.98-1.37)
Caesarean section	9,950 (26.82)		
	544 (21.53)		1.03 (0.93-1.15)
Postpartum hemorrhage	1,446 (3.90)		
	94 (3.72)		1.08 (0.86-1.35)
Maternal ICU admission	88 (0.24)		
	6 (0.24)		0.90 (0.37-2.18)
Severe maternal morbidity	384 (1.04)		
	18 (0.71)		0.77 (0.47-1.26)

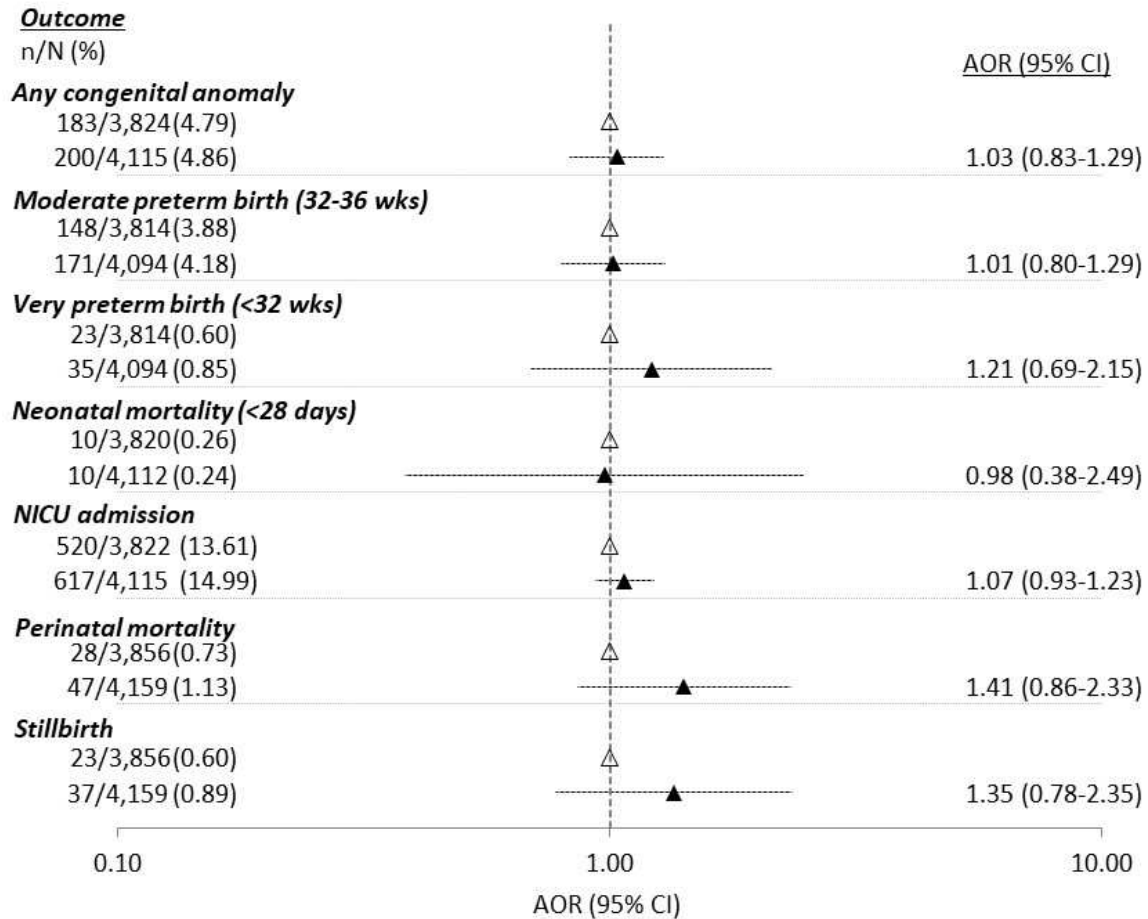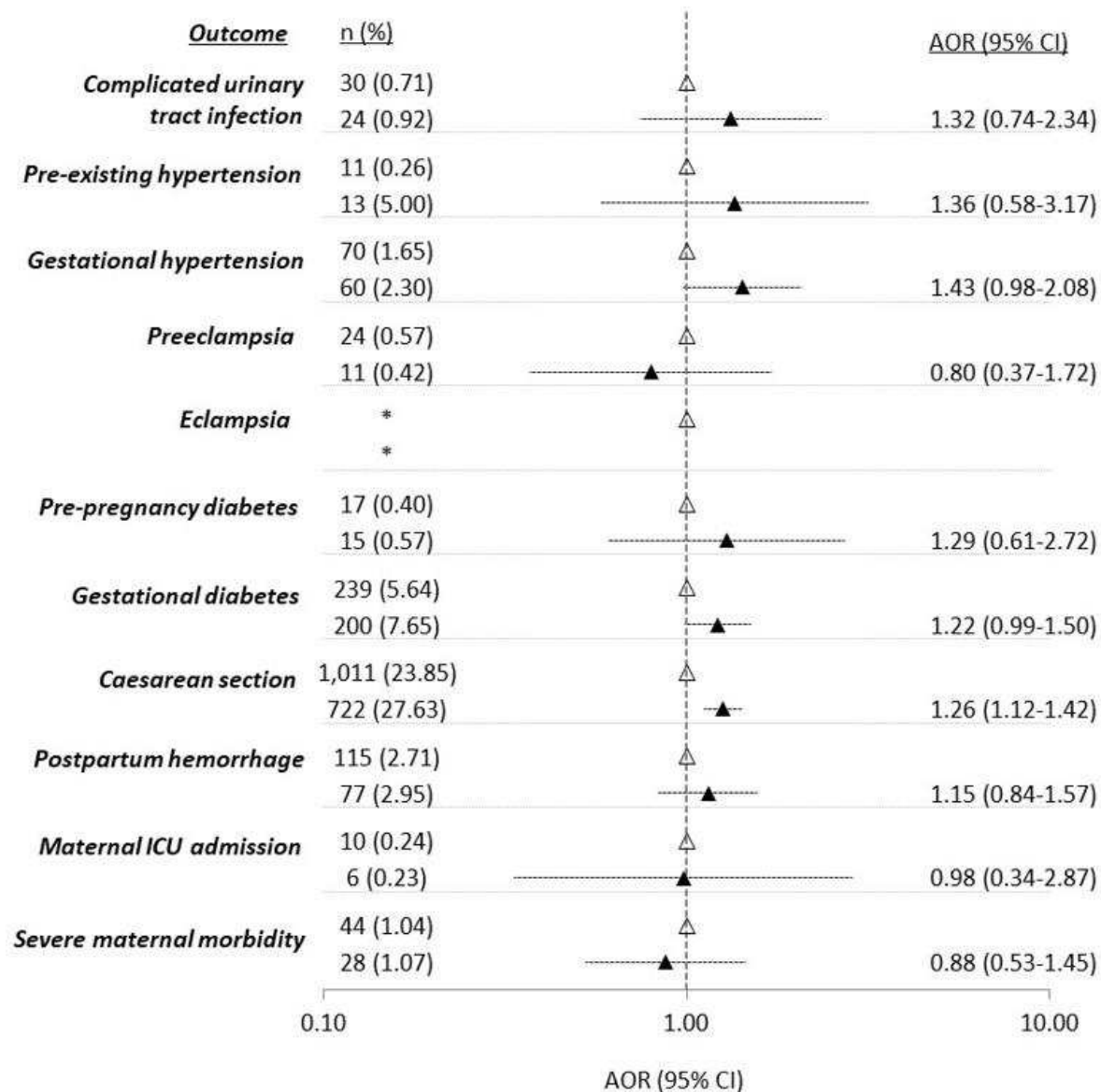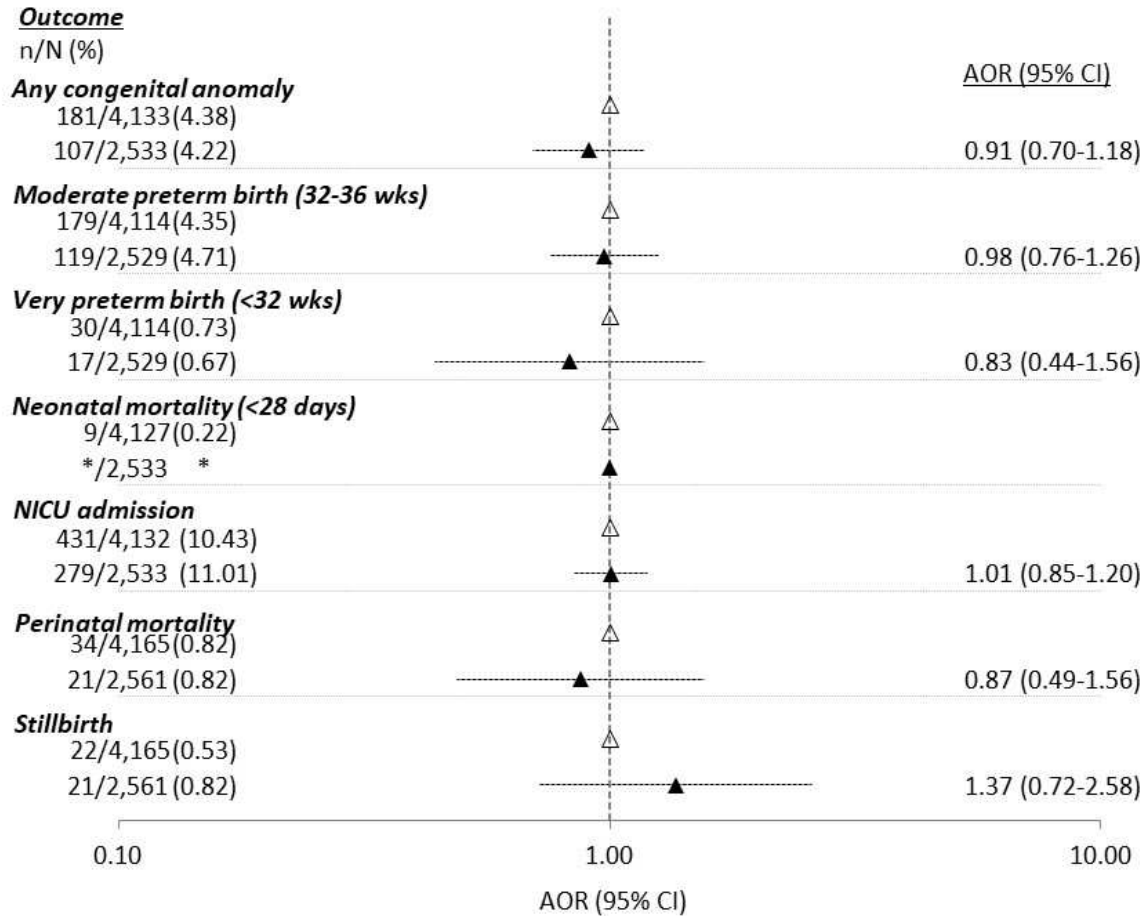0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S5b: Adverse perinatal outcomes comparing births to Chinese refugee immigrants (▲triangles) vs. births to Chinese non-refugee immigrants (△triangles). Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
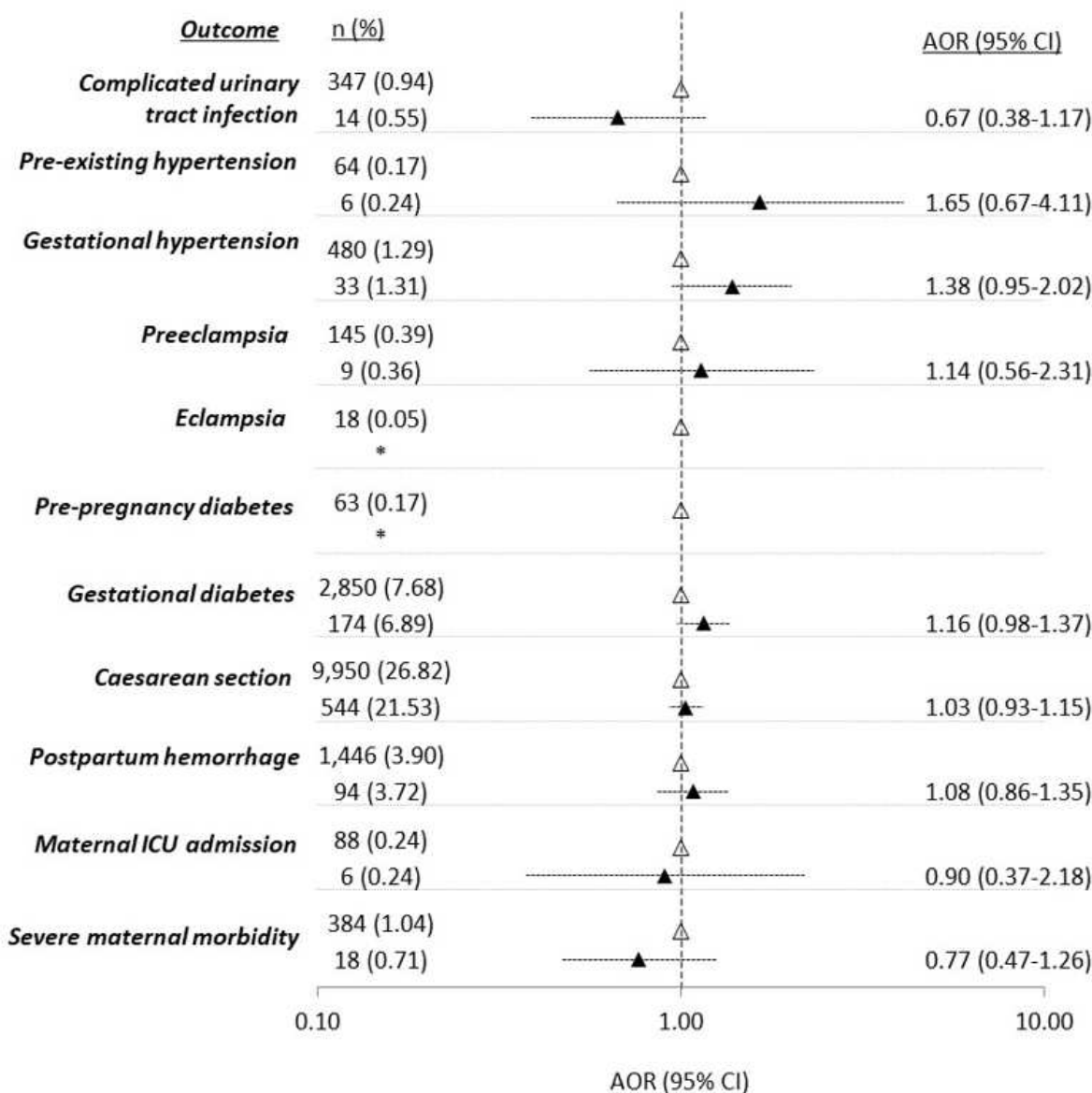
Outcome n/N (%)		AOR (95% CI)
Any congenital anomaly		
1,788/36,499 (4.90)		
104/2,487 (4.18)		0.96 (0.78-1.19)
Moderate preterm birth (32-36 wks)		
1,316/36,406 (3.61)		
99/2,480 (3.99)		1.06 (0.85-1.32)
Very preterm birth (<32 wks)		
182/36,406 (0.50)		
16/2,480 (0.65)		1.30 (0.75-2.25)
Neonatal mortality (<28 days)		
31/36,471 (0.08)		
*/2,486 *		
NICU admission		
2,961/36,491 (8.11)		
171/2,486 (6.88)		0.91 (0.77-1.07)
Perinatal mortality		
147/36,647 (0.40)		
12/2,498 (0.48)		1.00 (0.53-1.88)
Stillbirth		
113/36,647 (0.31)		
10/2,498 (0.40)		1.03 (0.51-2.08)

0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

Refugee maternal and perinatal health in Ontario, Canada: a retrospective population-based study

Figure S6: Adverse maternal outcomes comparing 52,158 births to ALL refugee immigrants (■ squares) vs. 358,589 births to ALL non-refugee immigrants (☐ squares), UNMATCHED. Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.

Outcome	n (%)	AOR (95% CI)
Complicated urinary tract infection	3,335 (1.0)	
	421 (0.8)	0.97 (0.86-1.09)
Pre-existing hypertension	1,734 (0.5)	
	266 (0.5)	1.05 (0.87-1.27)
Gestational hypertension	10,615 (3.0)	
	1,513 (2.9)	1.07 (1.00-1.14)
Preeclampsia	3,036 (0.9)	
	511 (1.0)	1.12 (1.00-1.26)
Eclampsia	269 (0.1)	
	30 (0.1)	0.86 (0.61-1.21)
Pre-pregnancy diabetes	1,706 (0.5)	
	309 (0.6)	1.09 (0.91-1.31)
Gestational diabetes	26,559 (7.4)	
	3,826 (7.3)	1.06 (0.99-1.14)
Caesarean section	101,863 (28.4)	
	14,622 (28.0)	1.07 (1.02-1.12)
Postpartum hemorrhage	11,318 (3.2)	
	1,688 (3.2)	1.02 (0.96-1.09)
Maternal ICU admission	1,060 (0.3)	
	183 (0.4)	1.17 (0.99-1.38)
Severe maternal morbidity (SMM)	3,971 (1.1)	
	759 (1.5)	1.24 (1.07-1.43)
SMM excluding HIV	3,811 (1.1)	
	602 (1.2)	1.08 (0.98-1.19)
HIV	220 (0.1)	
	229 (0.44)	2.72 (1.76-4.21)

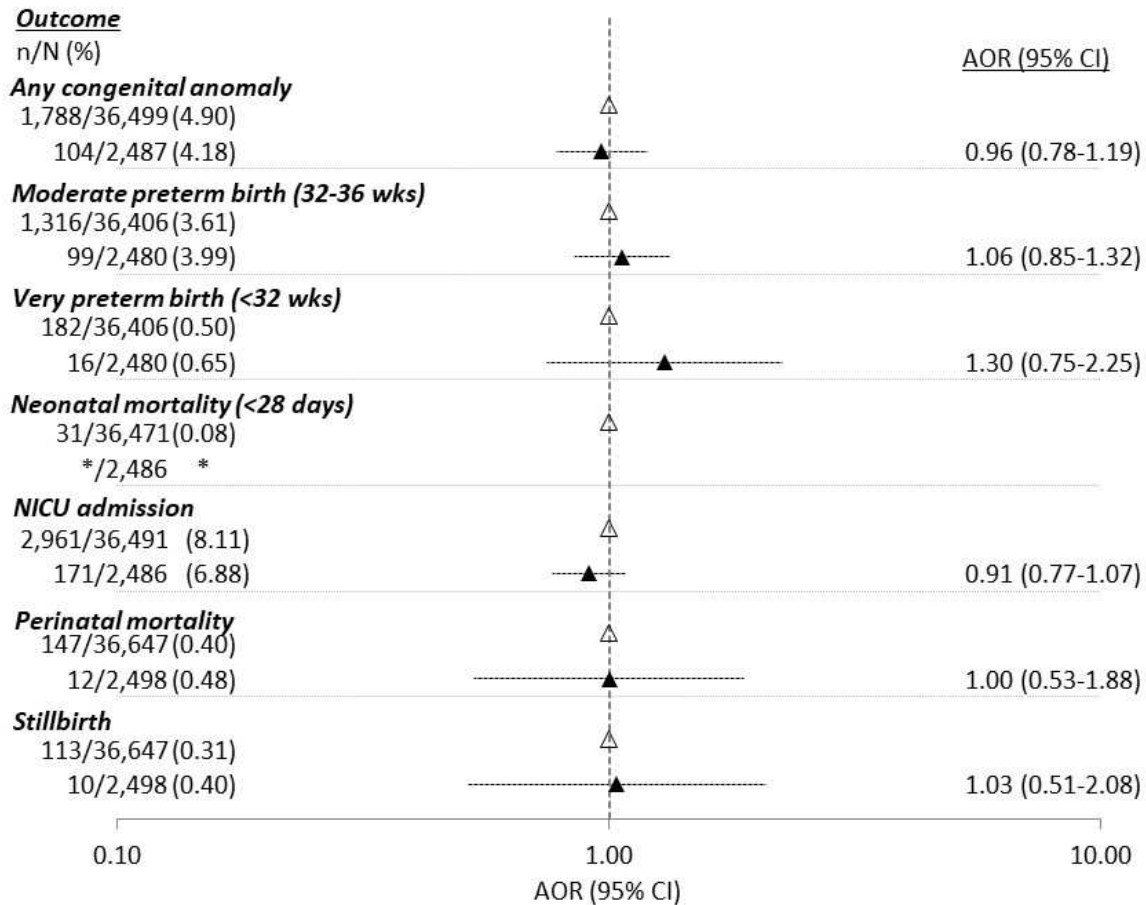0.10   1.00   10.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; ICU – intensive care unit; HIV – human immunodeficiency virus

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Figure S7: Adverse perinatal outcomes comparing births to ALL refugee immigrants (■ squares) vs. births to ALL non-refugee immigrants (□ squares), UNMATCHED. Odds ratios adjusted for maternal age, parity, income quintile, official language ability, education and duration of residence.
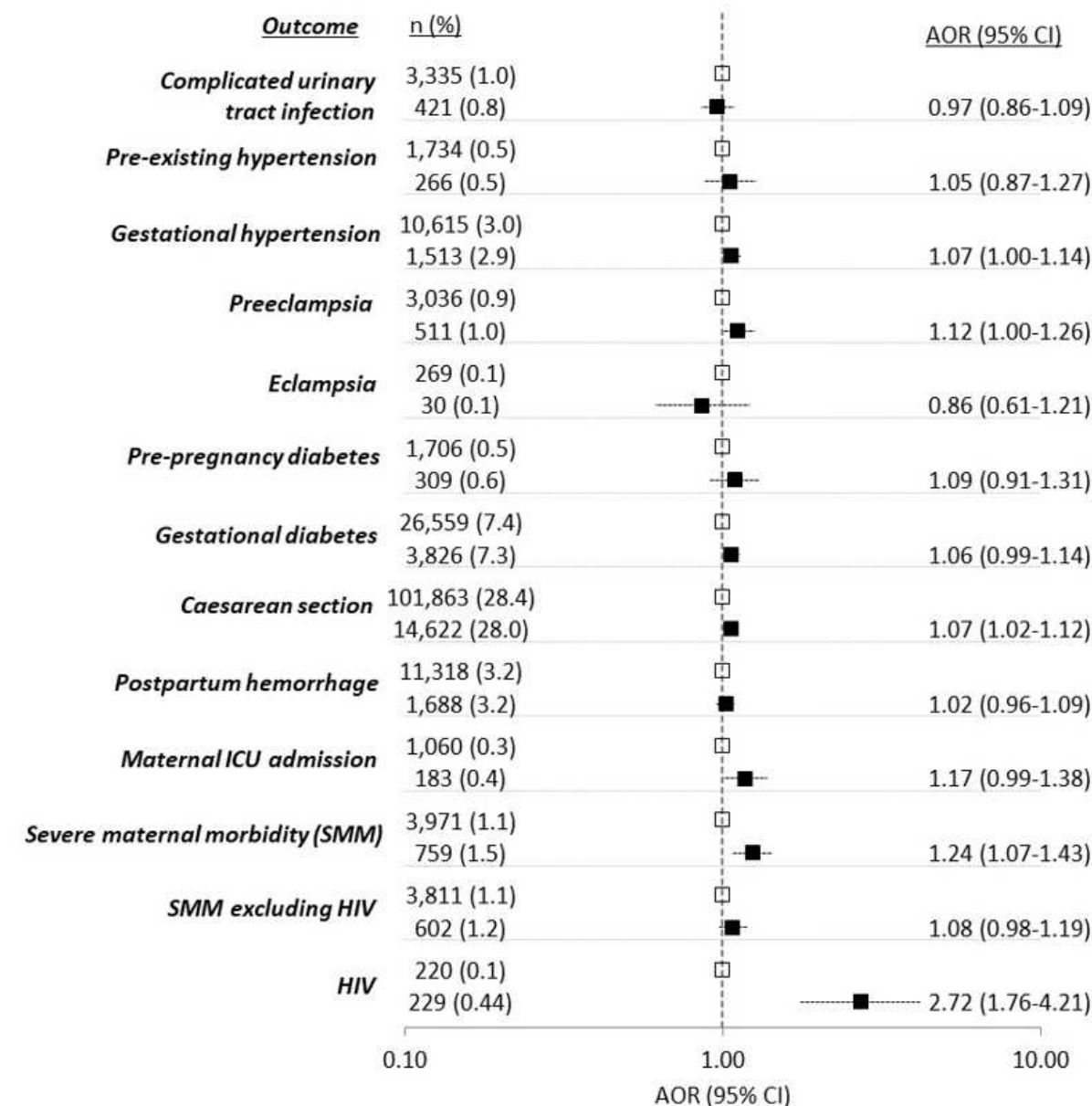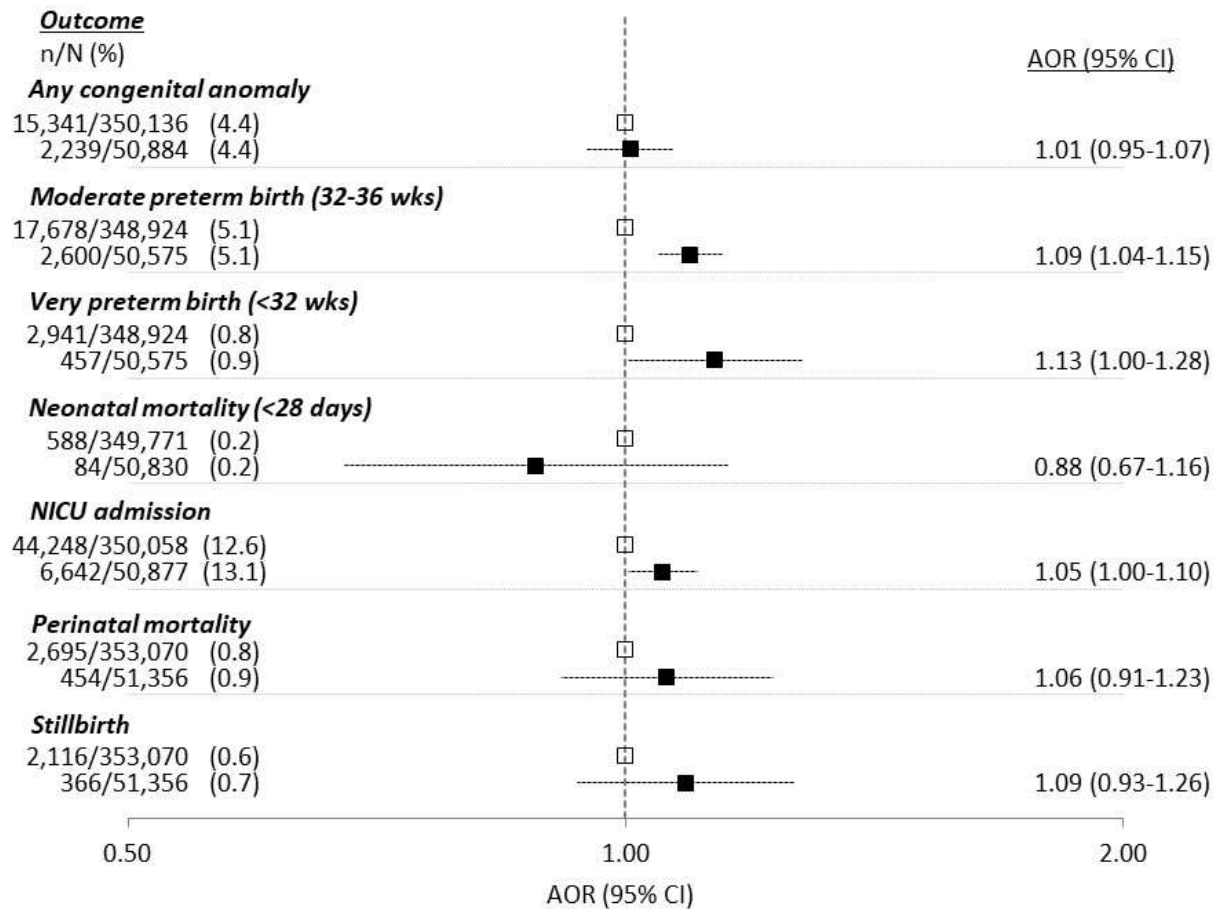

Outcome n/N (%)	AOR (95% CI)
Any congenital anomaly	
15,341/350,136 (4.4)	
2,239/50,884 (4.4)	1.01 (0.95-1.07)
Moderate preterm birth (32-36 wks)	
17,678/348,924 (5.1)	
2,600/50,575 (5.1)	1.09 (1.04-1.15)
Very preterm birth (<32 wks)	
2,941/348,924 (0.8)	
457/50,575 (0.9)	1.13 (1.00-1.28)
Neonatal mortality (<28 days)	
588/349,771 (0.2)	
84/50,830 (0.2)	0.88 (0.67-1.16)
NICU admission	
44,248/350,058 (12.6)	
6,642/50,877 (13.1)	1.05 (1.00-1.10)
Perinatal mortality	
2,695/353,070 (0.8)	
454/51,356 (0.9)	1.06 (0.91-1.23)
Stillbirth	
2,116/353,070 (0.6)	
366/51,356 (0.7)	1.09 (0.93-1.26)

0.50   1.00   2.00

AOR (95% CI)

AOR – adjusted odds ratio; CI – confidence interval; NICU – neonatal intensive care unit

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3-4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	5,6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 16- Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Page 16- Table 1
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	All figures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Unadjusted figures in supplementary tables S2 and S3. Confounder adjusted estimates in all figures.
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-8
Generalisability	21	Discuss the generalisability (external validity) of the study results	9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.