**Ethnicity is a risk factor for permanent brachial plexus birth injury: A population study in Southern Finland**

Petra Grahn1, Mika Gissler2,3,4, Yrjänä Nietosvaara1,5, Marja Kaijomaa6

1. Department of Pediatric Orthopedics and Traumatology, New Children’s Hospital, Helsinki University Hospital, University of Helsinki, Finland
2. THL Finnish Institute for Health and Welfare, Department of Knowledge Brokers, Helsinki, Finland
3. Region Stockholm, Academic Primary Health Care Centre, Stockholm, Sweden
4. Karolinska Institutet, Department of Molecular Medicine and Surgery, Stockholm, Sweden
5. Department of Pediatric Surgery, Kuopio University Hospital, University of Eastern Finland
6. Department of Obstetrics and Gynaecology, Women’s Hospital, Helsinki University Hospital, University of Helsinki, Finland

**Corresponding author:**

Petra Grahn, MD

HUS, New Children’s Hospital

Stenbäckinkatu 9, 00029 HUS, Helsinki, Finland

[petra.grahn@hus.fi](mailto:petra.grahn@hus.fi)

Word count manuscript **3167/3500**

Word count abstract **244/250**

**Abstract**

**Objective:** To calculate the incidence and assess risk factors leading to permanent brachial plexus birth injury (BPBI) in Southern Finland

**Design:** Retrospective population-based study

**Setting:** Helsinki University Women’s Hospital and Helsinki University New Children’s Hospital, Finland

**Sample:** All children born from 2006 to 2022 in Southern Finland with a permanent BPBI and their mothers

**Methods:** Birth information of all mothers and their children born from 2006 to 2022 in Southern Finland were gathered from the national database and compared to prospectively collected data from mothers and their children with a permanent BPBI delivered within the same period. Permanent injury was defined as limited active or passive range of motion or decreased strength in the affected limb detected at one year of age. The severity of the injury was assessed using the 3-month Toronto test score.

**Main outcome measures:** Permanent brachial plexus birth injury

**Results:** Altogether, 298 428 children were born within the study period, of which 100 acquired a permanent BPBI. The incidence of a permanent BPBI was 0.4 per 1000 vaginal live births (0.34 all births), with a declining trend. Children born to immigrant mothers and women of Black ethnicity had a higher incidence of permanent injury (0.85 and 1.52 per 1000). Non-white background and immigrant status correlated with a more severe injury (β=-1.12 range, -2.17 to -0.07, p=0.004), with children to Black mothers having the least favorable outcome (β= -1.64 range, -2.79 to -0.49, p=0.005).

**Conclusion:** The overall incidence of permanent BPBI is declining. Immigrant status and Black ethnicity increase the risk of a permanent BPBI.

**Keywords:** birth injury; permanent brachial plexus birth injury; brachial plexus birth injury; incidence; ethnicity; immigrant mother

**Funding:** Research grant from Finska Läkaresällskapet and Pediatric Research Center

**Introduction**

Brachial plexus birth injury (BPBI) is the most common severe birth injury in Finland, with an overall incidence of 2.5 per 1000 live births.1 Most children who fully recover do so during the first three months.2–4 A permanent injury causes a lifelong disability in varying degrees.5–7 In the most dire cases, the affected limb is short and painful, with a limited range of motion and diminished sensation.8,9 Incidence for a permanent BPBI lies between 0.1 and 1.6. 2,3,10–12 National and international studies have reported declining overall incidences, with racial and geographical variations.1,13–15 Possible explanations can be the rising rate of cesarean sections and differences in the availability of antenatal care.13–15

Shoulder dystocia is the most important risk factor for a BPBI, followed by instrumental delivery and factors leading to fetal macrosomia, such as diabetes mellitus type I (DM I).13,14,16 Moreover, socioeconomic factors seem to affect the incidence, with studies showing that women in poorer areas or areas with lower availability of health care have an increased risk of delivering a child with a BPBI.12–15 Ethnic background has been linked to an increased risk of a BPBI, with children born to non-white women reportedly having a higher risk of acquiring one.13–15 However, half of BPBIs still occur without any identified risk factor.13 Many centers have strived to educate the delivery staff on timely identifying and managing shoulder dystocia to minimize BPBIs and other birth-related complications, leading to a decline in the prevalence of permanent BPBIs and other delivery complications.16,17

This study aimed to calculate the incidence and assess risk factors leading to a permanent BPBI in Southern Finland.

**Patients and methods**

This retrospective population-based study analyzes risk factors for a permanent BPBI by combining prospectively collected research data and registry data. With its three satellite units, Helsinki University Hospital (HUS) Women’s Hospital represents the only birth center in South Finland, serving nearly two million inhabitants. HUS New Children’s Hospital is the only primary care center for patients with BPBIs in this area. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were used to report the results of this study, which the HUS Regional Committee on Medical Research Ethics (registration number 79/E7/2001 and HUS/3082/2023) approved.

*Reference population*

Since 1987, The Finnish Institute for Health and Welfare (THL) ([www.thl.fi](http://www.thl.fi)) has gathered standardized essential information on all pregnancies, including data on antenatal maternal well-being, delivery characteristics, and information regarding the newborn. Ethnicity is not gathered. For this study, the following maternal data was collected: personal identity code, residential area, maternal parity, possible comorbidities and type of delivery, maternal and gestational age at delivery, mode and characteristics of delivery, and complications during pregnancy and delivery. Assisted deliveries (considerable majority vacuum deliveries) are documented by the performing obstetrician, and data regarding the procedure duration (minutes) and difficulty, number of pulls, and the difficulty in delivering shoulders (1=easy, 2=mediocre, 3=hard) is collected. Data collected from the newborn includes personal identity code, sex, weight, length and head circumference at birth, Apgar points, birth injuries, and congenital conditions.

Statistics Finland ([www.stat.fi](http://www.stat.fi)) collects information regarding Finland’s immigrant population, including the country of birth, fertility rate, parity, and maternal age at delivery. The data from the Statistics Finland database are only available in aggregated format; thus, the data cannot be combined with the data compiled by the Finnish Institute for Health and Welfare.

*Study population*

All women giving birth between 2006 and 2022 and their live born children with a permanent BPBI were included in the study (**Table 1**). Maternal and delivery characteristics were collected from the prospective HUS Helsinki Women’s Hospital patient database, and information regarding the child from the prospective BPBI registry of HUS New Children’s Hospital.

Any child presenting with BPBI (ICD-10 codes P14.0, P14.1, P14.3) in Southern Finland is examined by the referral center’s pediatrician at 0 to 2 days of age. All children with an injury that does not resolve itself during the first month are referred to the HUS New Children’s Hospital’s BPBI clinic for further evaluation by a specialized team consisting of a hand surgeon with a minimum level 4 expertise, an occupational therapist, a physiotherapist, and a nurse.18,19 The same team regularly examines patients at set intervals from one month to 18 years. The 3-month Toronto test score (3MTS) is calculated to assess the injury’s severity.7 A score of 3.5 or lower indicates a severe type of permanent injury where the child may benefit from plexus reconstruction. A permanent BPBI is defined as clinically evident limited active or passive range of motion or decreased strength of the affected limb that is still detectable at one year. Since 1995, the prospective BPBI registry has stored information on all children with a permanent BPBI. This registry includes data on maternal ethnicity, knowledge of the national language (Finnish or Swedish), possible immigrant status, and data on newborn birth weight, sex, side of injury, and the result of 3MTS. Ethnicity is described as the US National Institutes of Health suggests (Black, Asian, Caucasian, Hispanic).

*Background information*

During the study period, 298 428 live births occurred. The rate of cesarean deliveries increased from 18.3% (2006) to 22.7% (2022), with an overall frequency of 18.5% (n=54 788). The fertility rate in all women was 1.57 over the study period (women born in Finland 1.55, women from outside the European continent including Russia 2.24, and women from Africa 3.45). The mean rate of the immigrant population in South Finland between 2006 to 2022 was 7.1% ([www.stat.fi](http://www.stat.fi)).

Of all newborns, 600 had a BPBI, of which 100 (51 girls) were permanent (16.7%). Of the 100 children with a permanent injury, 98 were born vaginally (six breech) and two via emergency cesareans (breech 1, placental ablation 1). All except two deliveries (both breech at 28 and 29 gestational weeks) were full-term with a mean pregnancy duration of 39.9 weeks (range, 28.9–42.1, SD 2.1). The injury was right-sided in 54 (two bilateral, both breech). The mean 3MTS was 5.6 (range, 0–9.3, SD 2.2). Thirty-two (32%) of the children with a permanent injury were born to immigrant mothers, of which half (n=18, 56%) were Black African immigrants. The remaining 14 children were born to immigrants from Europe (n=8, Caucasian), Asia (n=5, Asian), and South America (n=1, Hispanic). All native mothers (n=68) were Caucasian. An interpreter was used in 22/32 initial evaluations at the Helsinki Children’s Hospital as the parent(s) spoke neither Finnish, Swedish, nor English. Tables 1 and 2 present further birth and maternal characteristics.

**Data analysis and statistics:**

Maternal and delivery characteristics were compared using the chi-square and t-tests. A similar comparison detected differences between women and children of different ethnic backgrounds. Associations with the severity of the injury was investigated by fitting linear regression models for the 3MTS score. Univariate and multivariate models were used. The level of significance was set at p<0.05. Odds ratios (OR) with 95% confidence intervals (CI) for having a severe injury (3MTS ≤ 3.5) were calculated.

**Results:**

The mean calculated risk for a permanent BPBI in Southern Finland over the study period was 0.40 per 1000 vaginal live births, while the same for all deliveries was 0.34. The incidence showed a decreasing trend with considerable annual variation (**Figure 1**). Interestingly, the overall incidence was higher in the migrant vs. the native population (0.63 vs. 0.26, p=0.01), with immigrants from the African and Asian continents having the highest incidence (0.85 both, 1.52 Africa, p=0.002 and 0.006) (**Table 3**). In the last five years of the study, 60% of all children with a permanent injury were born to immigrant mothers (**Figure 2**).

*Factors contributing to a permanent BPBI*

Mothers of children with a permanent BPBI had a higher BMI at the start of pregnancy and more often presented with any type of diabetes (p<0.001 for both). They had a significantly higher occurrence of shoulder dystocia complicated (59% vs. 0.3%) and/or assisted deliveries (10% vs. 45%) (p<0.001 for both). Conversely, there was no difference in maternal age, parity, or gestation at delivery, in the incidence of inducted labor, nor the duration of stage 2 (active labor) (**Table 1**). Children with a permanent injury were heavier at birth (p<0.001); although, there were no changes in the mean birth weight of these children (4.03 kg, range 0.8–5.6, SD 0.7) over the study period (p>0.05).

The immigrant mothers were younger than the native mothers (29.4 vs. 32.1 years, p=0.02); however, there was no difference in BMI, nulliparity, duration of pregnancy, type of delivery, occurrence of shoulder dystocia, or birth weight between the native and the immigrant mothers (p>0.05). Non-white women (n=24) had a higher BMI at the start of pregnancy (28.1 vs. 25.5 kg/m2, p=0.02) and a lower rate of nulliparity (28% vs. 51.5%, p=0.04) (**Table 2**). The difference was more pronounced concerning Black mothers (mean BMI 29.1 kg/m2, p=0.02 and 16.7% nulliparity rate, p<0.01). There was no difference in the gestation at delivery or the incidence of induced deliveries, but the incidence of breech deliveries was higher in the non-white group. Among the 41 assisted deliveries, non-white women had a higher number of reported pulls (mean 4.7) than Caucasians (mean 3.4), and the procedure took slightly longer (mean 7.4 minutes vs. 8.8); however, the differences did not reach statistical significance (p>0.05), although the procedure was categorized as more difficult in the non-white deliveries (p=0.046) (**Table 2**).

*Ethnic differences in injury severity*

The injury’s severity was worse in children born to Black mothers compared to Caucasian (3MTS mean 4.2 range, 0–6.5 SD 1.6 vs. 5.9 range, 0.0–9.3 SD 2.2, p=0.006) (**Figure 3**). No other ethnic group (Caucasian or Asian) showed any statistically significant difference to the native population regarding 3MTS (p=0.7 and 0.3). Neither the duration of delivery stage 2 nor that of the vacuum extraction correlated with the injury’s severity (p>0.05). The OR having a 3MTS of 3.5 or lower was significantly higher for the immigrant population (2.2, 95% CI 1.3, 0.2) compared to the native (0.5, 95% CI: 5.6, 0.8). Regarding ethnicity, Black mothers had the highest OR of having a child with a 3MTS ≤3.5 (2.4, 95% CI 1.3, 0.1), while Caucasians had the lowest (0.4, 95% CI 6.8, 0.8).

Of the 32 immigrant mothers, only ten (31%) spoke one of the national languages at the time of delivery. Knowledge of the national language correlated with the severity of the injury where children of mothers who spoke the national language(s), had a mean 3MTS of 5.9 (range 3.1–6.5, SD 2.2) vs. 4.6 (range 0–8.6, SD 1.9) in the children whose mothers did not. However, this difference did not reach statistical significance (p=0.4).

*Uni- and multivariate models for risk factors*

In the univariate linear regression analysis, a non-white background correlated with a more severe injury (β=-1.12 range, -2.17 to -0.07, p=0.004). For Black women, the correlation was even stronger (β=-1.64 range, -2.79 to -0.49, p=0.005). No other associations between ethnicity and birth characteristics in relation to 3MTS were found in the univariate models. In the multivariate models, a non-white background adjusted for shoulder dystocia and maternal age negatively impacted the 3MTS (β=-1.23, range -3.38 to -0.15, p=0.027). Similarly, Black ethnicity adjusted with shoulder dystocia and maternal age (β=-1.77, range -2.95 to -0.69, p=0.004) as well as shoulder dystocia and BMI (β=-1.42, range -2.64 to -0.20, p=0.023) all negatively impacted the 3MTS. Lastly, DM I combined with Black ethnicity and shoulder dystocia (β=-0.99, range -1.98 to -0.00, p=0.049) correlated with a worse injury.

**Discussion**

*Main findings*

The overall incidence of a permanent BPBI declined from 0.8 in 1000 births in 2006 to 0.4 in 2022. Conversely, the incidence is rising in the immigrant population, with 60% of children with a permanent injury born to immigrant mothers during the last five years of the study. Furthermore, the injury’s severity is worse in infants born to non-white women (p=0.004).

*Strengths and limitations*

We reported the population-based incidence and risk factors for a permanent BPBI with special emphasis on the mothers’ ethnic background. We believe this to be one of the first studies to analyze a defined population for risk factors leading to a permanent BPBI attributing to participating hospitals’ long tradition of prospective data gathering and the registry of THL, which has been shown to have high completeness and validity.20

Since information on ethnicity is not registered in the THL database risk factor analysis mirroring the whole population based on ethnic subgroups could not be done. Instead, we had to use aggravated data as reported by Statistics Finland, assuming that most immigrants from Africa are Black and those from Asian are Asian. Complete subgroup analysis was unachievable due to the low number of patients from some continents. Migrant women had a higher fertility rate, especially African (1.3-fold to native). Even if the incidence is corrected by the fertility rate, it remains significantly higher in the non-white population.

*Interpretation*

BPBI has been declining in Finland, the United Kingdom, and in parts of the United States. 1,13–15 Shoulder dystocia simulation training has yielded excellent results in lowering the prevalence of the injury—nationally and globally and is possibly the main reason for the decline together with the increase in cesarean births.13-17 However, the incidence in the immigrant population is inclining rapidly, especially among Black women. Studies from the UK and the US have previously reported on ethnic variations in the prevalence of BPBI, suggesting socioeconomic factors may play a role. A lack of access to high-quality perinatal care has been suggested as a possible explanation.13–15 The UK National Health Service (NHS) maternity statistics from 2022 showed a prevalence of BPBI in Black women in 0.8 of 1000 live births, while the same for Caucasians was 0.5.21 In Finland, all women are entitled to the same free prenatal care, including regular appointments with a midwife or doctor to monitor maternal and fetal well-being and to screen for various risk factors. All deliveries are treated in public hospitals with highly trained delivery staff; private obstetricians are unavailable for delivery. Thus, variation in maternity care due to socioeconomic status is unlikely to explain the differences in the incidences of this study.

Gestational diabetes is a known risk factor for fetal macrosomia. This study found an association between gestational diabetes, Black ethnicity, and a worse 3MTS. Moreover, mothers to children with a permanent BPBI had a significantly higher frequency of gestational diabetes compared to the control (p<0.001). Dietary acculturation increases the risk of gestational diabetes in non-white women.22 A study analyzing immigrant women’s pregnancies reported the worst outcome in African women who, among other complications, developed gestational diabetes more often.23 A strong inverse association between a woman’s birth weight and her risk of developing gestational diabetes has been found, which appears to be independent of BMI24.24 According to this ‘fetal origin’ hypothesis, the previous intrauterine malnutrition impairs the function of pancreatic beta-cells and due to ‘in utero programming’, the later exposure to a high-energy diet increases the risk of gestational diabetes.24

Previous studies have reported a higher prevalence of severe maternal comorbidities and a higher risk of death in childbirth in non-white women.25-27 Many risk factors for these severe complications are the same for shoulder dystocia—the main known and most important risk factor for BPBI.13,14 As there was no difference in the prevalence of the known risk factors for shoulder dystocia and BPBI between the ethnic groups of this study, the answer to the injury’s predominance in the non-white population may lie in pelvic anatomy. Women from the European gene pool often present with a transversally oval inlet compatible with an android, gynaecoid, or platypelloid pelvic type, while East Asian and sub-Saharan African women, on average, have a rounder inlet, often oval in the anterior–posterior direction, matching the anthropoid pelvic shape.28–30 The delivery progresses slightly differently in different pelvis types, and some argue that an anthropoid pelvis more often leads to a persistent occiput posterior position (OR 1.4 in Black vs. Caucasian women), increasing the risk for maternal and newborn morbidities.31–32 In births complicated by shoulder dystocia, the occiput posterior position has been reported to increase the risk of BPBI.31

According to findings from the UK, Asian and Black women have a significantly higher risk for neonatal deaths (3.0 vs. 1.3 per 1000 live births) and emergency cesarean sections (25% vs. 18%) compared to Caucasians.21,33 The same statistics also show Caucasian women’s deliveries progressing spontaneously slightly more often than other ethnic groups (52.2% vs. 50.0%).21,33 The pulling force and the duration of the traction on the plexus influence the injury’s severity.34 In milder injuries, the nerves have been mildly stretched or compressed (neurapaxia), and the recovery is generally good. However, in a permanent injury, axonal disruption has occurred (axonotmesis)—with or without a complete tear or avulsion from the spinal cord (neurotmesis). The more severe the injury, the more likely the child will require surgery during growth.6,7 In this study, the most severe injuries were diagnosed in the Black (mean 3MTS 4.2 vs. 5.9 in the Caucasian). The number of cases is small (n=18) but significant, especially bearing in mind similar findings by others.12–15 Absence of a common language during the end stages of pregnancy and in the delivery room may have played a role in the injury’s development. As most of the immigrant women (69% 22/32) did not speak either of the two national languages at the time of childbirth, it is possible that lack of a common language influenced the progression of labor, thus resulting in the slightly more severe injury (3MTS=4.6 vs 5.9). Interpreting services could be beneficial during pre-birth evaluation and delivery, especially with mothers from different cultural backgrounds. However, interpreting services are rarely used during childbirth in Finland.

**Conclusion**

The incidence of a permanent BPBI is rising in the non-white population even though the overall incidence is on a decline. We failed to explain the reason for the injury’s predominance in this population as well as the more pronounced injury type in children of Black women. Being non-white should be considered as a risk factor for a birth injury and care should be taken, especially in this population, to prevent and promptly recognize and treat known risk factors leading to severe birth complications.

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**Table 1. Maternal and delivery characteristics**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All** | **BPBI** | **p-value** |
| **Deliveries/newborns** | **298428/299219** | **100/100** |  |
| **Age (years)** | **31.4** (12.3–58.1, SD 5.2) | **31.0** (18.8–41.9, SD 5.2) | **0.399** |
| **BMI** | **24.2** (12.0–68.0, SD 4.7) | **26.9** (17.5–41.5, SD 4.9) | **<0.001** |
| **Nulliparity** | **45.5%** (n=134 553) | **47.0%** (n=47) | **0.770** |
| **Diabetes (all)** | **12.3%** (n=36 379) | **28%** (n=28) | **<0.001** |
| Gestational diabetes | 11.3% (n=33 515) | 24% (n=24) | <0.001 |
| Diabetes type I | 0.6% (n=1784) | 4% (n=4) | <0.001 |
| **Duration of pregnancy (weeks)** | **39.8** (21.6–44.3, SD 1.8) | **39.9** (28.9–42.1, SD 2.1) | **0.648** |
| **Cesarean delivery** | **18.5%** (n=54 788) | **2%\*\*** (n=2) | **<0.001** |
| **Induction of labor** | **24.6%** (67 575/274 893) | **26%** (n=26) | **0.115** |
| **Breech delivery** | **0.7%** (n=2023) | **6.1%** (n=6) | **<0.001** |
| **Stage II duration (minutes)** | **30.5** (0–90, SD 27.7) | **31.2** (4–81, SD 18.6) | **0.07** |
| **Assisted delivery** | **10.1%\*** (29 704 vacuum 26 forceps) | **44.6%\*** (41/92, all vacuum) | **<0.001** |
| **Shoulder dystocia** | **0.3%\*** (663/240 640) | **57.6%\*** (n=53/92) | **<0.001** |
| **Birth weight** | **3477** (400–6150, SD 573) | **4107** (780–5580, SD 677) | **<0.001** |
| **Immigrant mother** | **17.6%** (n=52725) | **32%** (n=32/100) | **<0.001** |
| African | 3.9% (n=11738) | 18% (18/100) | <0.001 |

Birth data from the reference and study population between 2006 and 2022. Body mass index (BMI) as reported at the start of the pregnancy. Comparisons between the groups were made using the chi-square and t-tests. Results are expressed in mean with range and standard deviation (SD) or rate (%) and number (n). \*Breech and cesarean deliveries were excluded; \*\*both were emergency cesarean deliveries (placental abruption and unexpected breech in spontaneously started deliveries).

**Table 2. Differences in delivery characteristics between Caucasian and non-white mothers to children with a permanent brachial plexus birth injury**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Caucasian** | **Non-white** | **p-value** |
| **Number of deliveries** | **76** | **24** | **NA** |
| **Age** **(years)** | **31.7** (19.4–41.9, SD 5.0) | **29.2** (18.8–40.3, SD 5.6) | **0.08** |
| **BMI** | **26.1** (19.3–41.5, SD 4.6) | **28.3** (20.1–40.0, SD 5.3) | **0.03** |
| **Nulliparity** | **47.4%** (n=36) | **25%** (n=6) | **0.012** |
| **Diabetes (all)** | **26.3%** (n=20) | **33.3%** (n=8) | **0.54** |
| Gestational diabetes | 22.3% (n=17) | 29.2% (n=7) | 0.49 |
| Diabetes type I | 3.9% (n=3) | 4,1% (n=1) | 0.9 |
| **Pregnancy duration (weeks)** | **40.0** (28.9–42.3, SD 1.9) | **39.8** (38.0–42.1, SD 2.6) | **0.78** |
| **Induction of labor** | **26.3%** (n=20) | **25%** (n=6) | **0.89** |
| **Cesarean delivery** | **2.6%\*\*** (n=2) | **n=0** | **NA** |
| **Breech delivery** | **5.2%** (n=4) | **8.3%** (n=2) | **0.04** |
| **Assisted delivery** | **46.4%\*** (n=32) | **40.9%\*** (n=9) | **0.69** |
| Duration (minutes) | 7.4 (1–20, SD 4.7) | 8.8 (5–16, SD 3.7) | 0.51 |
| Number of pulls | 3.4 (1–10, SD 2.0) | 4.7 (1–8, SD 2.2) | 0.11 |
| Shoulder delivery difficulty (1–3) | 2.7 (1–3, SD 0.6) | 2.6 (1–3, SD 0.6) | 0.74 |
| Overall difficulty (1–3) | 1.6 (1–3, SD 0.7) | 2.3 (1–3, SD 1.0) | 0.046 |
| **Stage II duration (minutes)** | **32.6** (4–81, SD18.3) | **25.6** (4–65, SD 17.1) | **0.09** |
| **Shoulder dystocia** | **57.9%\*** (n=40) | **59.1%\*** (n=13) | **0.87** |
| **Birth weight (grams)** | **4062.3** (780–5010, SD 656.46) | **3913.1** (1510–5580, SD 743.1) | **0.38** |

The differences in pregnancy and delivery characteristics between Caucasian and non-white mothers. Comparisons between the groups were made using the chi-square and t-tests. Results were expressed in mean with range and standard deviation (SD) or rate (%) and number (n). \*Breech and Cesarean deliveries were excluded; all assisted deliveries were vacuum extractions.

**Table 3. Incidence of permanent brachial plexus birth injury by birth continent**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Native** | **Immigrants** | **European** | **African** | **Non-white\*\*** |
| **2006** | 0,49 | 1,14 | 1,18 | 2,61 | 1,19 |
| **2007** | 0,44 | 1,08 | 0,00 | 4,87 | 2,15 |
| **2008** | 0,19 | 0,98 | 1,06 | 0,00 | 1,00 |
| **2009** | 0,68 | 0,45 | 0,93 | 0,00 | 0,00 |
| **2010** | 0,31 | 0,83 | 0,85 | 0,00 | 0,88 |
| **2011** | 0,38 | 0,38 | 0,00 | 1,74 | 0,77 |
| **2012** | 0,59 | 1,42 | 1,45 | 3,40 | 1,50 |
| **2013** | 0,27 | 0,00 | 0,00 | 0,00 | 0,00 |
| **2014** | 0,42 | 0,30 | 0,66 | 0,00 | 0,00 |
| **2015** | 0,07 | 0,30 | 0,00 | 0,00 | 0,58 |
| **2016** | 0,22 | 0,27 | 0,00 | 1,13 | 0,53 |
| **2017** | 0,24 | 0,54 | 0,00 | 1,18 | 1,01 |
| **2018** | 0,00 | 0,26 | 0,00 | 1,11 | 0,46 |
| **2019** | 0,34 | 0,77 | 0,00 | 2,29 | 1,38 |
| **2020** | 0,42 | 1,24 | 0,63 | 4,31 | 1,77 |
| **2021** | 0,23 | 0,24 | 0,00 | 1,11 | 0,43 |
| **2022** | 0,09 | 0,49 | 0,00 | 2,13 | 0,85 |
| **p-value\*** |  | 0,010 | 0,551 | 0,006 | 0,003 |

The difference in the incidence of permanent brachial plexus birth injury by mothers’ migrant status and background continent. Cesarean deliveries have not been removed as ethnicity is not gathered in the database of the Finnish Institute of Health and Welfare. \*The p-value has been calculated with the native births as the reference. \*\*Non-white=23 mothers (18 from the African continent and five from the continent of Asia). One Hispanic was removed as birth data from South America is combined with Central and North in the Statistics Finland database.

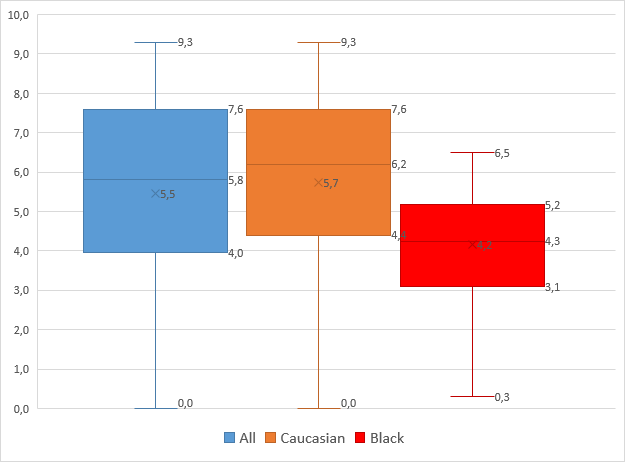
**Figure 1. Incidence of permanent brachial plexus birth injuries in native vs. immigrant births**

The difference in incidence between immigrant (mean 0.8, range; 0–1.8, SD 0.49) and native (mean 0.3, range 0–0.6, SD 0.16) births over the study period and the total incidence (mean 0.3, range 0–1.8, SD 0.18). Cesarean deliveries have not been removed as ethnicity is not collected in the database of the Finnish Institute of Health and Welfare. The difference is statistically significant (p<0.001).

**Figure 2. Rate of permanent brachial plexus birth injury in immigrants**

Rate (%) per year of children born with a permanent brachial plexus birth injury (BPBI) to immigrant mothers and the rate (%) of the immigrant population in Southern Finland during the study period (mean 7.1 %, range, 4.1–9.9, SD 1.8).

**Figure 3. The 3-month Toronto test score in the study population**



Box-plot figure showing the difference in the 3-month Toronto test score between Caucasian and Black (p=0.003).