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COHORT PROFILE

# Cohort Profile: The Born in Bradford multi-ethnic family cohort study

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The Born in Bradford cohort study was established in 2007 to examine how genetic, nutritional, environmental, behavioural and social factors impact on health and development during childhood, and subsequently adult life in a deprived multi-ethnic population. Between 2007 and 2011, detailed information on socio-economic characteristics, ethnicity and family trees, lifestyle factors, environmental risk factors and physical and mental health has been collected from 12 453 women with 13 776 pregnancies (recruited at ~28 weeks) and 3448 of their partners. Mothers were weighed and measured at recruitment, and infants have had detailed anthropometric assessment at birth and post-natally up to 2 years of age. Results of an oral glucose tolerance test and lipid profiles were obtained on the mothers during pregnancy at ~28 weeks gestation, and pregnancy serum, plasma and urine samples have been stored. Cord blood samples have been obtained and stored and Deoxyribonucleic acid (DNA) extraction on 10 000 mother–offspring pairs is nearly completed. The study has a biobank of over 250 000 samples of maternal blood, DNA and urine, cord blood and DNA and paternal saliva. Details of how scientists can access these data are provided in this cohort profile.

## Why was the cohort set up?

Born in Bradford (BiB) was created in response to rising concerns about the high rates of childhood morbidity and mortality in the city of Bradford, the sixth largest city in the UK with a population of about half a million and urban areas that are among the most deprived in the UK. Around 20% of the population of Bradford is of South Asian origin (90% of whom are from Pakistan), and this constitutes a three-generation community that maintains close links with Pakistan.[1] The relatively young age of the population of Pakistani origin and their higher fertility rates, compared with the White British majority population, explain why almost half of babies born in the city have parents of Pakistani origin. Sixty percent of the babies born in the city are born into the poorest 20% of the population of England and Wales based on the British government's residential area Index of Multiple Deprivation.[2] Infant mortality in Bradford has been consistently above the national average, peaking at 9.4 deaths/1000 live births in 2003, when the national average was 5.5 deaths/1000 live births, and levels of congenital anomalies and childhood disability are among the highest in the UK.[3–10]

The cohort was established in 2007 with the broad aims to:

- describe health and ill health within a multi-ethnic (largely bi-ethnic) economically deprived population;
- identify modifiable causal pathways that promote well-being or contribute to ill health;
- develop, design and evaluate interventions to promote health;
- provide a model for integrating operational, epidemiological and evaluative research into practice within the National Health Service and other health-related systems; and
- build and strengthen local research capacity in Bradford.

BiB examines how genetic, nutritional, environmental and social factors impact on health and development during childhood and, with ongoing funding, will also examine long-term effects into adult life. The ultimate goal is to develop hypotheses, which can then be evaluated and tested for health and social interventions to improve childhood and adult health.

Specific research objectives currently being tested are linked to substudies, which include investigations of factors related to differences in birth size and adiposity, infant care practices and sudden infant death, *in utero* renal development, the health effects of environmental and dietary exposures in pregnancy, vitamin D levels and pregnancy outcomes, viral infection exposure on immune response, development and prevention of childhood obesity and understanding the genetic determinants of growth, adiposity and diabetes risk. A number of these studies include a particular emphasis on differences between individuals of White British and those of Pakistani origin. Of relevance to building local research capacity, several of these substudies support postgraduate Masters and PhD students. A full list of substudies and PhD projects is described on the programme's website (www.borninbradford.nhs.uk).

An initial BiB planning and development team undertook a wide consultation with community, neighbourhood and faith groups in the city to make them aware of our plans for a cohort study and to elicit areas of community interest. Our presentations about the patterns of ill health in the city, particularly the high infant mortality rate and high levels of morbidity in children, including obesity, encouraged groups to express strong support for our proposed study. Additionally, community consultation revealed public concern about the effect of environmental toxins, particularly air pollution, on health, with asthma in children identified as an important problem.

An area of considerable sensitivity in the city was that of genetic disease. This was disproportionately present in the Pakistani community and had been linked with the prevailing practice of marriage to first cousins and other blood relations.[11] Although local groups were prepared to discuss what they recognized as an area of justifiable concern, they were keen for future discussions to be culturally sensitive and to be based on sound scientific evidence that included exploration of potential social and well-being benefits, as well as adverse effects of such unions.

During the course of recruitment, we have been successful in obtaining grant funding to allow us to undertake long-term follow up of two subcohorts. We also have funds to link the entire cohort to external data, including long-term follow up of two subcohorts, one over 2000 participants that is concerned with risk factors for allergic disease in infancy and another a different 1700 participants concerned with risk factors for obesity.

## Who is in the cohort?

Bradford has one maternity unit based at Bradford Royal Infirmary. The unit is one of the busiest in the UK with over 6000 new births each year. All women booked for delivery at the Bradford Royal Infirmary are offered an oral glucose tolerance test (OGTT) at 26–28 weeks gestation, requiring a test and retest over 2 h. Around 80% take up this offer. Study information was given to women by their midwife at their booking appointment and they were invited to take part. On attendance at the OGTT clinic, full consent was obtained for recruitment to BiB, and the woman was invited to complete an interviewer-administered questionnaire. Between March 2007 and November 2010, >80% of the women who attended the OGTT took up the invitation, and we recruited 12 453 women with 13 776 pregnancies to the cohort, with OGTT results for 11 442 of them. All babies born to women who agreed to participate in the cohort study were eligible for recruitment. Partners of the women who were recruited to the cohort were also invited to participate. Only a small proportion of fathers attended the OGTT clinic with their partners. Others were approached when they attended the hospital with their partner for other appointments or when a member of the study team visits the family home during follow-up visits to see mother and baby. Figure 1 describes the recruitment figures for the cohort.

Almost half of the South Asian population in Bradford is of Mirpuri origin. Mirpur is a predominantly rural district in the province of Azad Kashmir in Pakistan. Some members of the community do not read or speak English. However, the majority are able to understand Urdu or Mirpuri, although not all are literate in Urdu. To ensure consistency, the baseline questionnaire was transliterated into Urdu and Mirpuri using a standardized process, so that words and phrases corresponded with the original English version. A further complication of translation was that Mirpuri does not have a written form.

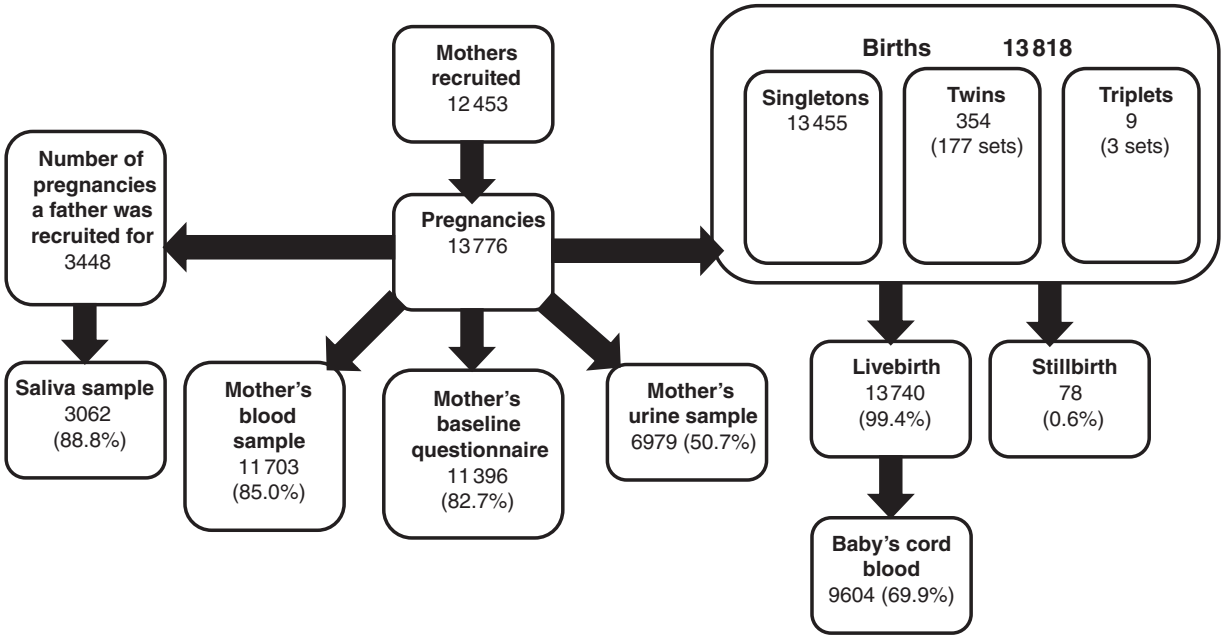


**Figure 1** Recruitment statistics

Bilingual interviewers, trained in use of the transliterated versions, were employed to administer the questionnaires. A total of 9319 (81.9%) women completed the questionnaire interview in English, 1468 (12.9%) in Urdu, 547 (4.8%) in Mirpuri and 11 (0.1%) in other languages. In 32 (0.3%) cases, the language used was not recorded.

A minority of the pregnant women (17.3%) were offered but did not attend the OGTT clinic and were recruited through other contacts such as hospital appointments or during their hospital stay for the birth. As the study is locally based with just one maternity unit, we are able to determine the proportion of women eligible who have been recruited to the study and also to compare the study population data with data on all births in Bradford. Table 1 compares characteristics between these participants with those not recruited (either because they were not approached or declined). There are a number of small differences between the recruited and non-recruited cohorts. We recruited a lower proportion of younger mothers (age: 20–24 years) compared with mothers not in the cohort and a higher proportion of South Asian mothers and nulliparous mothers. Differences in gestational age and preterm delivery may be explained by recruitment to BiB occurring late in pregnancy, and therefore we did not have the potential to recruit those born before 26–28 weeks.

## How often have they been followed up?

Follow up of the cohort is variable and dependent on funding linked to specific substudies. Figure 2 describes the follow up in the whole cohort and the key subcohorts and data collected.

### Follow-up data on the whole cohort

At birth, the details of the delivery, birthweight and a summary record of antenatal information are entered into maternity and radiology information systems, and we are able to link to these data for all study participants. Umbilical cord blood samples were collected and stored in the biobank at −80°C, alongside maternal blood samples taken at recruitment. Study administrators visited the post-natal wards and identified all BiB mothers. Their babies had their abdominal circumference measured, along with head circumference and subscapular and triceps skinfold thickness, before they were discharged.

All babies were visited by a health worker at ∼2 weeks, 7 weeks and 8 months. Growth measurements, breastfeeding and immunization data are recorded on child health record and child health information systems. These data are extracted and imported into the main BiB database, linked by National Health Service numbers. Growth measurements by the school nurse will be collected at 4 and 6 years and we will also link to these data for all participants.

A congenital anomalies register has been established in the city as part of BiB. Details on all children with possible congenital anomalies are reported by paediatricians, geneticists and by other specialists who identify them in clinics, and these are entered into the database that is linked to the main BiB data.

The advent of electronic health records provides new opportunities for cost-effective follow up of health outcomes. We have developed systems for linking

**Table 1** Comparison of BiB cohort with all other births at the maternity department in Bradford Teaching Hospitals Trust—2007–11

| Characteristic | BiB cohort, *n* (%) | Non-cohort births*, *n* (%) | *P*-value |
|---|---|---|---|
| **Mothers age (years)** | | | |
| <20 | 987 (7.2) | 963 (8.2) | |
| 20–24 | 3692 (26.8) | 3413 (29.0) | |
| 25–29 | 4484 (32.6) | 3760 (31.9) | |
| 30–34 | 2985 (21.7) | 2348 (19.9) | |
| 35–39 | 1376 (9.9) | 1030 (8.9) | |
| ⩾40 | 249 (1.8) | 218 (1.9) | |
| Missing | – | 29 (0.2) | |
| Total | 13 773 | 11 761 | <0.001 |
| **Residential deprivation IMD 2010** | | | |
| 1 | 9347 (67.8) | 8212 (69.8) | |
| 2 | 2356 (17.1) | 1689 (14.4) | |
| 3 | 1374 (10.0) | 933 (7.9) | |
| 4 | 312 (2.3) | 216 (1.9) | |
| 5 | 207 (1.5) | 138 (1.2) | |
| Missing/outside Bradford area | 177 (1.3) | 573 (4.8) | <0.001 |
| **Ethnicity** | | | |
| Non-South Asian | 6873 (49.9) | 6150 (52.2) | |
| South Asian | 6900 (50.1) | 5475 (46.6) | <0.001 |
| Missing | – | 136 (1.2) | |
| Birthweight, mean (SD) (kg), all singleton births term | 3.29 (0.48) | 3.26 (0.48) | <0.001 |
| All singleton births (preterm) | 1.97 (0.66) | 1.96 (0.81) | 0.81 |
| Stillbirths (all births) | 75 (0.55) | 129 (1.08) | <0.001 |
| Gestational age, mean (SD) (weeks), all births | 39.04 (1.91) | 38.81 (2.62) | <0.001 |
| Preterm birth (<37 weeks)[a] | 771 (5.8) | 1062 (8.9) | <0.001 |
| **Parity (per mum)** | | | |
| 0 | 5073 (38.4) | 3507 (29.8) | |
| 1 | 3683 (27.9) | 3152 (26.8) | |
| 2 | 2175 (16.4) | 2053 (17.5) | |
| 3 | 1083 (8.2) | 1170 (9.9) | |
| ⩾4 | 736 (5.6) | 823 (7.0) | |
| Missing | 468 (3.5) | 1056 (9.0) | <0.001 |
| Multiple births (%) | 325 (2.3) | 262 (2.2) | 0.59 |
| Percentage low birthweight (<2500 g) (%)[a] | 1019 (7.7) | 1138 (9.8) | <0.001 |
| Baby's sex (M:F) | 6977: 6562 | 6169: 5723 | <0.001 |
| Missing | 4 (0.03) | 7 (0.06) | |
| **Mode of delivery**[a] | | | |
| Caesarean | 2956 (22.4) | 2006 (17.3) | |
| Vaginal | 10 262 (77.6) | 9620 (82.7) | <0.001 |
| Missing | – | 1 (0.0) | |
| Missing records (%)[b] | 394 (2.9) | 137 (1.2) | <0.001 |

*Ethnic groups assigned using Nam Pehchan.
[a]Based on singleton births only.
[b]In the BiB cohort, this consists of records where mothers have given birth outside the BRI.
IMD = Index of Multiple Deprivation; SD = Standard Deviation; BRI = Bradford Royal Infirmary.

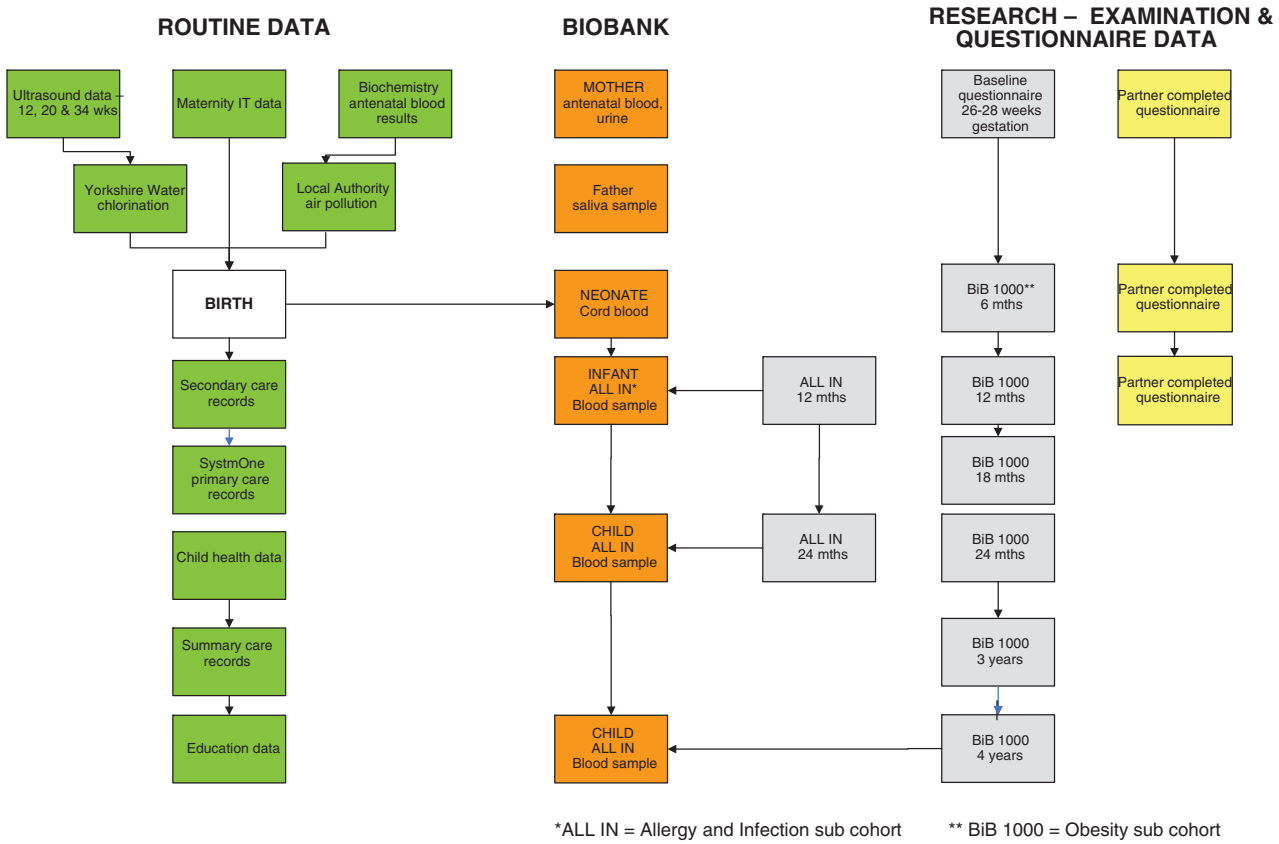


**Figure 2** Data collection—parents and child from birth to 4 years

and capturing routine data from primary and secondary care, such as attendances, diagnoses and prescribing. We have also worked with local education services to link future educational attainment outcomes from the National Pupil Database for BiB children.

From our knowledge and experience with other birth cohorts, for example Avon Longitudinal Study of Parents and Children (ALSPAC),[12] we recognize that a major strength is in detailed examination of all participants as they age through childhood and into adolescence, and we believe that such follow up in BiB would be a major scientific opportunity to research the social, genetic and health characteristics of a multi-ethnic population. We also recognize the resource implications and plan to maintain follow up on the whole cohort via the record linkages described earlier and supplement these with detailed follow up on subgroups (see later) during the children's early years and then seek funding for a more detailed assessment of all participants when the children are older.

## Follow up on subgroups within the cohort

Follow up with research visits occurs in two subgroups. One called BiB1000, because the original plan was to collect data on a subgroup of 1000, is concerned with identifying risk factors for childhood obesity, and the second called ALL IN (ALLergy and INfection) is concerned with the associations between specific viral infections and allergic diseases in infants.

Exceeding the initial recruitment target, BiB1000 has recruited over 1700 families in which the children were born between October 2008 and May 2009. Funding for this subgroup was obtained to investigate the growth trajectories and identify modifiable risk factors for childhood obesity. A community team of bilingual researchers visits families at home when children are aged 6, 12 and 18 months and 2, 3 and 4 years to collect this information. We also offer research clinics based at the hospital as an alternative for mothers who prefer not to have home visits, but most (61%) prefer home visits. We have achieved follow-up rates of ~75% for each sweep, with >92% of the subgroup participating in at least one follow-up visit.

For the ALL IN study, there is funding for a separate subgroup of 2300 families followed up at the ages of 1 and 2 years. This study collects data on exposures that may be linked to risk for asthma and atopy, such as family size, childcare arrangements, household variables, pets, immunizations and infant feeding. Blood is taken and stored for testing for serological and virological measures of herpes virus infections (Epstein-Barr Virus (EBV), Cytomegalovirus (CMV) and

Varicella zoster virus (VZV)). Funding has recently been obtained to undertake a further sweep of this subgroup at the age of 4 years.

Following recruitment at 28 weeks pregnancy, 3749 women were invited for an additional ultrasound scan at 34 weeks as part of a substudy to investigate renal development. Two thousand nine hundred and seventy-nine women (80%) accepted, and this subgroup had ultrasound scan foetal growth measurements on at least three antenatal time points (12, 20 and 34 weeks).

Ethics approval has been obtained for the main platform study and all of the individual substudies from the Bradford Research Ethics Committee.

### Attrition

Levels of collection of different forms of data are high for participants recruited to the study at baseline. We believe this reflects the close link between the study and maternity services in the hospital and community, the high public profile of the study consequent on the wide consultation and publicity that has been in place throughout and the fortuitous need for women to spend 2 h in hospital to undergo the OGTT. It is also achieved by the good organization of the recruitment team and their fluency in key community languages.

The study is still in its early phases and, perhaps not surprisingly, we have seen little drop out. Initial piloting of the use of post-natal postal questionnaires as a method of follow up resulted in poor response rates (30%), and invitations to attend post-natal research clinic appointments were also poorly taken up. We consider that barriers, such as literacy, language and poverty are all contributing factors to the lack of success with these traditional methods of follow up and therefore have adopted different approaches.

## What has been measured?

Limited initial funding, as well as a commitment to the research being relevant to local staff and public, led us to explore how we could embed recruitment and follow up into routine health services. As well as making the study more efficient, we felt that the integration of research and practice could help with subsequent translation of knowledge into practice. Using routine health services data, collected as part of the clinical care and performance monitoring, would present challenges in ensuring its research quality but had considerable potential to embed research in routine practice.

During 2005–06, we developed and piloted recruitment methods and designed the baseline questionnaire. Between 2007 and 2011, detailed information on socio-economic characteristics, ethnicity and family trees, lifestyle factors, environmental toxins (in household water supplies and neighbourhood air pollution) and physical and mental health were collected on women recruited at ~28 weeks pregnancy. A related but more limited data set has been obtained from their partners. Mothers were weighed and measured at recruitment and infants have had anthropometric assessment at birth and post-natally up to 2 years of age. Details about the recruitment and data collection methods are described in a previously published protocol.[13]

Table 2 describes the data collected at baseline and follow up for the full cohort and subgroups. For the BiB1000 subgroup, the focus of data collection is on growth, diet, feeding practices, physical activity, screen viewing and sleep. For the ALL IN subgroup, the focus is on exposures that may be linked to risk for asthma and atopy, such as family size, childcare arrangements, household variables, pets, immunizations and infant feeding.

BiB has a biobank of over 250 000 samples of maternal blood, DNA and urine, cord blood and DNA and paternal saliva (see Supplementary Table, available as Supplementary data at *IJE* online). ALL IN blood samples from the children are stored for testing for serological and virological measures of herpes virus infections (EBV, CMV and VZV).

## What has it found?

Initial recruitment has only recently been completed and so published findings at this stage are limited, and for many of the published conference abstracts, we clearly note that the findings are preliminary. Table 3 describes how the baseline characteristics of the mothers vary by ethnicity. Pakistani origin mothers were on average older, shorter and lighter than White British origin mothers. More Pakistani mothers were likely to be married but fewer were likely to be employed than White British mothers. Few Pakistani mothers reported smoking during pregnancy, and none reported having consumed alcohol while pregnant, in contrast to a high prevalence of smoking and alcohol use in White British mothers. Pakistani origin mothers reported similar patterns of financial coping to White British mothers, though fewer reported they were worse off compared with a year ago (16% vs 26%). Fewer Pakistani origin mothers took an annual holiday, and more were in receipt of financial welfare benefits than White British mothers. The majority of Pakistani-origin mothers were related to the father of their child, and this was a more common practice than for their parents (64% vs 55%).

Babies born to women of Pakistani ancestry were lighter (mean difference: 235 g) than White babies and this difference persists over generations.[14,15] Our research on child growth has shown that health workers are reliable in their routine antenatal[16,17] and post-natal anthropometric measurements.[18] We have also shown that the growth of infants in

**Table 2** Born in Bradford data collection

| | $n = 13\,776$ | BiB1000 cohort ($n = 1763$) | | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | 6 months | 12 months | 18 months | 2 years | 3 years | 4 years |
| **Mother** | | | | | | | |
| Weight at booking | ✓ | | | | | | |
| Height | ✓ | | | | | | |
| Weight | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Arm circumference | ✓ | | | | | | |
| Skinfolds—triceps | ✓ | | | | | | |
| Age of menarche | ✓ | | | | | | |
| Housing status | ✓ | | | | | | |
| Marital status | ✓ | ✓ | ✓ | | ✓ | | |
| Household structure | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| Migration history | ✓ | | | | | | |
| Family relationships | ✓ | | | | | | |
| Education—mother and father | ✓ | | | | | | |
| Employment status—mother and father | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| Financial status (income, benefits etc.) | ✓ | | | | | | |
| Deprivation | ✓ | | | | | | |
| Social network information | | | | | | | |
| Smoking status | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| Alcohol and drug use | | | | | | | |
| Diet/FFQ | ✓ | ✓ | | ✓ | | ✓ | |
| Caffeinated drinks | ✓ | | | | | | |
| Use of supplements—vitamin C, D, E, iron multivitamins | ✓ | | | | | | |
| Home food availability | | | | ✓ | | ✓ | |
| Water consumption | ✓ | | | | | | |
| Mental health | ✓ | ✓ | ✓ | ✓ | | | |
| General health | ✓ | | | | | | |
| Physical activity | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Screen time | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Body image | | ✓ | | | ✓ | | |
| Parenting practices | | ✓ | ✓ | | ✓ | | ✓ |
| Caregivers' feeding style | | ✓ | ✓ | | ✓ | | |
| **Maternity data set** | | | | | | | |
| BP at booking | ✓ | | | | | | |
| BP at 28/40 weeks | ✓ | | | | | | |
| BP at 38/40 weeks | ✓ | | | | | | |
| Diabetes | ✓ | | | | | | |
| Gestational diabetes | ✓ | | | | | | |
| Gravida and parity | ✓ | | | | | | |
| Pre–eclampsia | ✓ | | | | | | |
| Delivery information | ✓ | | | | | | |
| Ultrasound data, 12, 20, 32 weeks | ✓ | | | | | | |

(continued)

**Table 2** Continued

| | $n = 13\,776$ | BiB1000 cohort ($n = 1763$) | | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | 6 months | 12 months | 18 months | 2 years | 3 years | 4 years |
| **Child** | | | | | | | |
| Length | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weight | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Head circumference | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Abdominal circumference | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Skinfolds—subscapular, triceps, thigh | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| General health | | ✓ | | ✓ | ✓ | ✓ | |
| Childhood illness | | ✓ | | ✓ | ✓ | ✓ | |
| Breastfeeding | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Diet | | | ✓ | ✓ | ✓ | ✓ | |
| Sleep duration | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Infant characteristics | | ✓ | | | | | ✓ |
| Growth perception | | ✓ | | | ✓ | | ✓ |
| Physical activity* | | | | | ✓ | ✓ | ✓ |
| Screen time | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Strengths and difficulties quest | | | | | | ✓ | |

| | $n = 3448$ | BiB1000 cohort ($n = 438$) | |
|---|---|---|---|
| | Baseline | 6 months | 12 months |
| **Father** | | | |
| Height | ✓ | ✓ | ✓ |
| Weight | ✓ | ✓ | ✓ |
| Ethnicity | ✓ | ✓ | ✓ |
| Date of birth | ✓ | | |
| Age completed education | ✓ | | |
| Country of birth | ✓ | | |
| Age of migration | ✓ | | |
| Employment | ✓ | | |
| Lifestyle smoking/alcohol | ✓ | ✓ | ✓ |
| General health | | ✓ | ✓ |
| Parenting | | ✓ | ✓ |
| Mental health | | ✓ | ✓ |
| Saliva sample | | | |

| | Allergy and Infection Study ($n = 2300$ at 12 months) | | |
|---|---|---|---|
| | 1 year | 2 years | 3 years |
| **Mother** | | | |
| Mother's weight | ✓ | ✓ | ✓ |
| Abdominal circumference | ✓ | ✓ | |
| Maternal mental health | ✓ | ✓ | |
| General health | ✓ | | |

(continued)

**Table 2** Continued

| | Allergy and Infection Study ($n = 2300$ at 12 months) | | |
|---|---|---|---|
| | 1 year | 2 years | 3 years |
| Family history of asthma, hay fever, eczema | ✓ | ✓ | |
| Childcare | ✓ | ✓ | |
| Activities outside the home | ✓ | ✓ | |
| Environment (pets, flooring, heating, bedding, damp, etc.) | ✓ | ✓ | |
| Travel abroad | ✓ | ✓ | |
| Smoking | ✓ | ✓ | ✓ |
| Passive smoking | ✓ | ✓ | ✓ |
| **Child** | | | |
| Childs' weight | ✓ | ✓ | ✓ |
| Child's length | ✓ | ✓ | |
| Childhood illness | ✓ | | |
| Breastfeeding duration | ✓ | | |
| Childs' physical activity | | | ✓ |
| Child symptoms—asthma. allergic rhinitis, eczema | | | ✓ |
| Child allergic reactions—food, medicines, vaccines | | | ✓ |
| Strengths and difficulties questionnaire | | | ✓ |
| Hospital episodes/immunizations | ✓ | ✓ | |
| Skin prick test | | | ✓ |
| SCORAD | | | ✓ |

SCORAD—Assessment of atopic dermatitis. BP = Blood Pressure. SCORAD = SCORing Atopic Dermatitis.

Bradford differs from the WHO standards, with current growth charts having the potential to cause mislabelling in this population.[16]

Infants of South Asian origin have been shown in other studies to have a lower risk of sudden infant death syndrome.[19] Our research on infant care practices has identified that infants of Pakistani origin were less likely to be exposed to risk factors for sudden infant death syndrome (smoking, alcohol and solitary sleep) than White British infants.[20] With regard to co-sleeping, we found that bed- and sofa sharing were almost mutually exclusive. Pakistani families avoided sofa sharing and hazardous bed sharing, whereas White British parents were more likely to sofa share with their baby.[21]

Our emphasis on the application of research into practice has led to organizational changes to the local health services, such as the development of a paperless maternity system (to aid data collection for BiB), the establishment of a regional congenital anomalies register and better links between health information systems. The study has also supported the introduction of routine vitamin D supplementation for pregnant women and the introduction of offering OGTT to all pregnant women. We have demonstrated how embedding research in practice can lead to improved quality and an expansion of growth data collected.[22]

Importantly, for a city in which popular discourse epitomizes multi-ethnic Britain, we have found low levels of perceived discrimination. In a consecutive subsample of 4308 women from the cohort, only 5.5% ($n = 92$) of the South Asian women and 1.9% ($n = 33$) of the White British women reported that they considered themselves to be a member of a group that is discriminated against in this country (analyses conducted for this cohort profile).

## What are the main strengths and weaknesses?

BiB has a number of strengths. It is a largely bi-ethnic cohort of families of White British and Pakistani origin, which has the advantage of relative homogeneity in the composition of each of these ethnic groups. This will allow a detailed assessment of the associations and causal analyses for differences between these ethnic groups in regard to key health outcomes such as obesity, diabetes and congenital anomalies. However, the cohort also includes large samples from other ethnic groups (e.g. Indian and

**Table 3** Baseline characteristics of mothers in BiB cohort by ethnic group

| Socio-demographic characteristics | Total sample ($n = 11\,396$) *n* (%) | Pakistani ($n = 5127$) *n* (%) | Indian ($n = 438$) *n* (%) | Asian other ($n = 326$) *n* (%) | White British ($n = 4488$) *n* (%) | White other ($n = 303$) *n* (%) | Black ($n = 249$) *n* (%) | Mixed ($n = 217$) *n* (%) | Other ($n = 199$) *n* (%) |
|---|---|---|---|---|---|---|---|---|---|
| Mother's age, mean (SD) (years) | 27.8 (5.6) | 28.2 (5.2) | 29.1 (4.5) | 28.7 (5.3) | 27.2 (6.1) | 26.9 (4.7) | 29.4 (5.3) | 24.8 (6.0) | 31.0 (5.4) |
| Maternal height, mean (SD) (cm) | 161.6 (6.5) | 159.7 (5.7) | 158.5 (6.3) | 156.2 (6.3) | 164.1 (6.2) | 165.6 (6.6) | 163.5 (6.3) | 163.6 (6.1) | 159.9 (7.0) |
| Maternal weight, mean (SD) (kg) | 74.0 (15.5) | 71.2 (14.1) | 67.8 (13.0) | 67.5 (13.1) | 77.9 (16.5) | 73.6 (13.7) | 78.6 (16.2) | 77.8 (16.5) | 69.4 (12.2) |
| Social and economic circumstances | | | | | | | | | |
| Marital status | | | | | | | | | |
| Married | 7367 (64.7) | 4708 (91.8) | 415 (94.8) | 308 (94.5) | 1386 (30.9) | 157 (51.8) | 140 (56.2) | 63 (29.0) | 163 (81.9) |
| Remarried | 396 (3.5) | 291 (5.7) | 17 (3.9) | 12 (3.7) | 62 (1.4) | 4 (1.8) | 1 (0.4) | 1 (0.4) | 5 (2.5) |
| Single | 3372 (29.6) | 60 (1.2) | 4 (0.9) | 4 (1.2) | 2881 (64.2) | 133 (43.9) | 99 (39.8) | 145 (66.8) | 29 (14.6) |
| Separated, divorced or widowed | 251 (2.2) | 65 (1.3) | 2 (0.5) | 2 (0.6) | 157 (3.5) | 9 (3.0) | 9 (3.6) | 4 (1.8) | 2 (1.0) |
| Maternal education | | | | | | | | | |
| Less than five GCSEs | 2453 (21.5) | 1323 (25.8) | 40 (9.1) | 70 (21.5) | 896 (20.0) | 23 (7.60) | 24 (9.6) | 50 (23.0) | 15 (7.5) |
| Five GCSE equivalent | 3488 (30.6) | 1596 (31.1) | 71 (16.2) | 92 (28.2) | 1531 (34.1) | 43 (14.2) | 51 (20.5) | 80 (36.9) | 14 (7.0) |
| A level equivalent | 1644 (14.4) | 643 (12.5) | 55 (12.6) | 54 (16.6) | 762 (17.0) | 52 (17.2) | 29 (11.7) | 33 (15.2) | 12 (6.0) |
| Higher than A level equivalent | 2912 (25.6) | 1329 (25.9) | 228 (52.1) | 88 (27.00) | 861 (19.2) | 98 (39.4) | 98 (39.40) | 33 (15.2) | 132 (66.3) |
| In which ways does this household occupy this address? | | | | | | | | | |
| Buying it with mortgage/loan | 5150 (45.2) | 2341 (45.7) | 222 (50.7) | 156 (47.9) | 2160 (48.1) | 61 (20.1) | 48 (19.3) | 61 (20.1) | 73 (36.7) |
| Owns outright | 1590 (14.0) | 1231 (24.0) | 94 (21.5) | 46 (14.1) | 183 (4.1) | 7 (2.3) | 1 (0.4) | 7 (2.3) | 10 (5.0) |
| Rents it | 3641 (31.9) | 907 (17.7) | 80 (18.3) | 97 (29.8) | 1899 (42.3) | 228 (75.2) | 187 (75.10) | 228 (75.2) | 106 (53.3) |
| Lives here rent free | 869 (7.6) | 552 (10.8) | 32 (7.3) | 24 (7.4) | 214 (4.8) | 6 (2.0) | 12 (4.8) | 6 (2.0) | 10 (5.0) |
| Total number of household members, mean (SD) | 4.1 (2.5) | 5.3 (2.5) | 3.9 (1.8) | 4.7 (2.5) | 3.0 (1.3) | 2.9 (1.3) | 2.8 (1.1) | 3.2 (1.4) | 3.2 (1.3) |
| Are you/your partner managing financially? | | | | | | | | | |
| Living comfortably | 3022 (26.5) | 1363 (26.6) | 168 (38.4) | 74 (22.7) | 1187 (26.4) | 82 (27.1) | 34 (13.7) | 45 (20.7) | 58 (29.1) |
| Doing alright | 4706 (41.3) | 2129 (41.5) | 195 (44.5) | 138 (42.3) | 1803 (40.2) | 140 (46.2) | 93 (37.3) | 89 (41.0) | 99 (49.7) |
| Just getting by | 2727 (23.9) | 1210 (23.6) | 53 (12.1) | 84 (25.8) | 1175 (26.2) | 48 (15.8) | 62 (24.9) | 53 (24.4) | 32 (16.1) |
| Quite difficult | 651 (5.7) | 309 (6.0) | 15 (3.4) | 22 (6.8) | 226 (5.0) | 19 (6.3) | 30 (12.0) | 23 (10.6) | 5 (2.5) |
| Very difficult | 216 (1.9) | 85 (1.7) | 4 (0.9) | 4 (1.2) | 79 (1.8) | 10 (3.3) | 25 (10.0) | 5 (2.3) | 3 (1.5) |
| How you and your partner are doing financially now compared with a year ago? | | | | | | | | | |
| Better off | 3333 (29.2) | 1543 (30.1) | 141 (32.2) | 76 (23.3) | 1226 (27.3) | 104 (34.3) | 92 (36.9) | 60 (27.7) | 78 (39.2) |
| Worse off | 2385 (20.9) | 824 (16.1) | 66 (15.1) | 69 (21.2) | 1183 (26.4) | 73 (24.1) | 65 (26.1) | 67 (30.9) | 29 (14.6) |
| About the same | 5555 (48.8) | 2688 (52.4) | 226 (51.6) | 176 (53.9) | 2057 (45.8) | 124 (40.9) | 87 (34.9) | 88 (40.6) | 88 (44.2) |

(continued)

**Table 3** Continued

| Socio-demographic characteristics | Total sample ($n = 11\,396$) *n* (%) | Pakistani ($n = 5127$) *n* (%) | Indian ($n = 438$) *n* (%) | Asian other ($n = 326$) *n* (%) | White British ($n = 4488$) *n* (%) | White other ($n = 303$) *n* (%) | Black ($n = 249$) *n* (%) | Mixed ($n = 217$) *n* (%) | Other ($n = 199$) *n* (%) |
|---|---|---|---|---|---|---|---|---|---|
| Do you have a hobby or a leisure activity? | | | | | | | | | |
| Yes | 6127 (53.8) | 2750 (53.6) | 298 (68.0) | 204 (67.3) | 2289 (51.0) | 204 (67.3) | 166 (66.7) | 95 (43.8) | 123 (61.8) |
| Cannot afford | 666 (5.8) | 249 (4.90) | 8 (1.8) | 14 (4.6) | 332 (7.4) | 14 (4.6) | 61 (24.5) | 16 (7.4) | 6 (3.0) |
| Do not want/need | 4516 (39.6) | 2084 (40.7) | 131 (29.9) | 84 (27.7) | 1841 (41.0) | 84 (27.7) | 21 (8.4) | 104 (47.9) | 69 (34.7) |
| Do you have a holiday at least once a year? | | | | | | | | | |
| Yes | 4465 (39.2) | 1255 (24.5) | 210 (48.0) | 106 (32.5) | 2393 (53.3) | 204 (67.3) | 94 (37.8) | 77 (35.5) | 110 (55.3) |
| Cannot afford | 4112 (36.1) | 1960 (38.2) | 101 (23.1) | 117 (35.9) | 1606 (35.8) | 58 (19.1) | 106 (42.6) | 95 (43.8) | 50 (25.1) |
| Do not want/need | 2716 (23.8) | 1857 (36.2) | 120 (27.4) | 97 (29.8) | 472 (10.5) | 39 (12.9) | 45 (18.1) | 43 (19.8) | 34 (17.1) |
| Do you receive means tested benefits? | | | | | | | | | |
| Yes | 4639 (40.7) | 2405 (46.9) | 101 (23.1) | 157 (48.2) | 1701 (37.9) | 57 (18.8) | 63 (25.3) | 103 (47.5) | 37 (18.6) |
| No | 6718 (59.0) | 2708 (52.8) | 335 (76.5) | 167 (51.2) | 2772 (61.8) | 246 (81.2) | 186 (74.7) | 112 (51.6) | 162 (81.4) |
| Relatedness | | | | | | | | | |
| Are you related to the father of your baby? | | | | | | | | | |
| Yes | 3412 (29.9) | 3262 (63.6) | 48 (11.0) | 63 (19.3) | 11 (0.2) | 2 (0.7) | 3 (1.2) | 9 (4.2) | 9 (4.5) |
| No | 7972 (70.0) | 1858 (36.2) | 390 (89.0) | 263 (80.7) | 4475 (99.7) | 301 (99.3) | 246 (98.8) | 208 (95.9) | 190 (95.5) |
| Are your (the mother of the baby) parents related by blood? | | | | | | | | | |
| Yes | 2973 (26.1) | 2837 (55.3) | 55 (12.6) | 31 (9.5) | 11 (0.2) | 3 (1.0) | 6 (2.4) | 7 (3.2) | 18 (9.0) |
| No | 8251 (72.4) | 2140 (41.7) | 380 (86.8) | 294 (90.2) | 4467 (99.5) | 299 (98.7) | 243 (97.6) | 210 (96.8) | 178 (89.4) |
| Do not know | 157 (1.4) | 143 (2.8) | 3 (0.7) | 1 (0.3) | 5 (0.1) | 1 (0.3) | 0 (0) | 0 (0) | 3 (1.5) |
| Are the father's parents related by blood? | | | | | | | | | |
| Yes | 2730 (24.0) | 2563 (50.0) | 38 (8.7) | 30 (9.2) | 38 (0.8) | 12 (4.0) | 4 (1.6) | 25 (11.5) | 12 (6.0) |
| No | 7975 (70.0) | 2043 (39.8) | 390 (89.0) | 284 (87.1) | 4356 (97.1) | 280 (92.4) | 240 (96.4) | 170 (78.3) | 179 (89.9) |
| Do not know | 676 (5.9) | 517 (10.1) | 10 (2.3) | 12 (3.7) | 88 (2.0) | 11 (3.6) | 5 (2.0) | 21 (9.7) | 8 (4.0) |
| Self-reported health behaviours | | | | | | | | | |
| Mother smoked during pregnancy | | | | | | | | | |
| Yes | 1871 (16.4) | 171 (3.3) | 5 (1.1) | 16 (4.9) | 1513 (33.70 | 62 (20.50 | 11 (4.4) | 76 (35.0) | 8 (4.0) |
| No | 9504 (83.4) | 4943 (96.4) | 433 (98.9) | 309 (94.8) | 2974 (66.2) | 241 (79.5) | 237 (95.2) | 141 (65.0) | 191 (96.0) |
| Mothers drank alcohol 3 months before/during pregnancy | | | | | | | | | |
| Yes | 3481 (30.6) | 15 (0.3) | 56 (12.8) | 7 (2.2) | 3025 (67.4) | 155 (51.2) | 63 (25.3) | 114 (52.5) | 31 (15.6) |
| No | 7882 (69.2) | 5096 (99.4) | 380 (86.8) | 318 (97.6) | 1456 (32.4) | 147 (48.5) | 184 (73.9) | 103 (47.5) | 168 (84.4) |

GCSE = General Certificate School Education.

Bangladeshi), and we hope our results will help to inform interventions aimed at reducing health inequalities and improving health in South Asian populations locally, nationally and internationally, as well as demonstrating that improving our understanding of disease processes benefits everyone irrespective of ethnic group. Recruitment for the study has been successful and the cohort population is representative of the population of Bradford, indicating minimal selection bias.

Bradford is unusual in the high levels of poverty and diversity; hence, it is not representative of the rest of the country, although there are similarities with other UK cities and with cities with high levels of ethnic minority and immigrant communities across the world. About half of all mothers of Pakistani origin in the cohort were born in Pakistan; therefore, the cohort provides the opportunity to compare populations by country of birth (Pakistan and UK) and by ethnicity. The cohort contains populations of particular interest and importance for health research, for example, in relation to infant growth and later health and in relation to community customs and practices and genetic illness.

The cohort is embedded in routine clinical practice and relies on the support from clinical staff. We have demonstrated that routine measurements taken by clinical staff are valid and reliable.[17,18] The close links between research and practice provide a strong foundation for future translation of research findings into practice. The main focus for the majority of the substudies is on applied epidemiology, which we hope will promote the generation of findings that will lead to health improvement.

A key strength of the study is the broad multidisciplinary background of the researchers involved with the study, including clinicians, paediatricians, social scientists, epidemiologists, statisticians and laboratory scientists and close links with other national and international birth cohorts. BiB has provided a platform for collaboration between local health professionals and academics from 10 universities in the UK and international partners through The European Child Cohort Network (EUCCONET).[23] The study has already been successful in achieving its aim of increasing research capacity and attracting talented new researchers to the city through the development of substudies.

The use of photographs in health research is increasingly recognized as a valid tool for revealing more and greater details than other methods alone would have generated.[24] In BiB, several photographic projects have been completed, which have provided popular methods of promoting public awareness, engagement and understanding about the programme.[25,26] In addition to photography, the poet Ian McMillan has written a number of poems both for the birthday cards sent to the children in the cohort and for the project more generally.[27]

Local engagement in health issues, in general, and BiB, in particular, was promoted by the establishment of an Advocacy and Scrutiny Group as a subcommittee of BiB. This group included parents, members of the public and locally based people with a relevant expertise, for example, in the law and in ethics. The Advocacy and Scrutiny Group advised on issues of acceptability of both research questions and data collection methods and considered issues of potential participant burden. This was particularly useful during the establishment of the cohort and the development of the baseline questionnaire. Now the cohort has been recruited, the Advocacy and Scrutiny Group has been replaced by more direct contact with cohort participants via a Family Liaison Officer, employed by BiB. She keeps in touch with the cohort through birthday cards, newsletters, the website and through the BiB Facebook page. She works closely with children's centres, schools and nurseries, faith groups and local politicians to ensure that both the cohort members and the people of Bradford are kept informed about the progress of the study. Community-based meetings provide parents the chance to hear about the project's first findings, to comment on them and to make recommendations, which will help to shape future research. This programme of activities encourages the continuing participation of both cohort members and the people of Bradford in the developing project.

There are also a number of weaknesses. Recruitment at the end of the second trimester means that we are unable to collect early pregnancy exposures. Variation in language and literacy in the cohort may lead to differences in exposures being related to the data collection methods and differences in measurement error, which we will aim to explore in future analyses.

Long-term follow up of the cohort has a number of potential difficulties. Follow-up data are collected for subgroups, but this is dependent on specific grant funding and therefore can be patchy and incomplete. We have tried to overlap as many nested studies as possible with the BiB1000 study to provide a common sample with detailed repeat measurements. However, this has not always been feasible and it also risks creating participant fatigue through making considerable demands on a relatively small number of families. The study has the participant's permission to access routine medical and education information, which offers great opportunities for collecting long-term outcomes, but presents challenges in relation to the quality of these data and the data linkage.

Despite our efforts to engage with fathers and partners, first in the hospital and then by running community events and getting the backing of community leaders including representatives from local mosques, only 20% enrolled into the study. This disappointing response reflects the lack of opportunities to approach

men, who for the most part do not attend the clinic for their partner's appointments and are not in the house during home visits to the family. Once approached, >90% of the partners consented to take part. This level of participation is not dissimilar to that for other birth cohorts based on specific geographical areas, including the ALSPAC cohort. The cohort of fathers who consented to involvement will provide some opportunities both to study them in their own right and to look at wider family groups, hence addressing a gap evident in many other birth cohort studies.

## Where can I find out more, and what is the potential for collaboration?

The BiB website[26] contains further details about the research team, study protocols, questionnaires and news about the study. Photographs from Ian Beesley and poems from Ian McMillan are also included.

We welcome collaboration with other researchers. The BiB website[26] has details of how to submit expressions of interest and has short proformas for these. All suggestions will be reviewed by the BiB Executive Group on a monthly basis, and we aim to get back to potential collaborators within 8 weeks.

## Supplementary Data

Supplementary data are available at *IJE* online.

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**Conflict of interest:** None declared.

**KEY MESSAGES**

- Half of all the families recruited are in the poorest fifth of deprivation for England and Wales, and 45% are of Pakistani origin. This provides a relatively homogeneous ethnic minority group with a known predisposition to diabetes and cardiovascular disease and with a high prevalence of recessive genetic disorders.
- We have collected detailed ancestry and relationship history for all families in the study, with questionnaires completed by trained multi-lingual interviewers. Additionally, family trees were completed with mothers who answered that they were related to the father of their baby. This means that BiB can make a unique contribution to understanding the role of intergenerational migration patterns and consanguineous marriages on health and development.
- The characteristics of mothers and of babies vary by ethnicity. This is evident in mothers' and babies' weights where both were lower in Pakistanis, in family characteristics where a majority of Pakistani origin mothers were related to the father of their child, in marriage patterns and engagement in the labour market where Pakistanis were more likely to be married but less likely to be employed and in health-related behaviours where fewer Pakistanis smoke and none consumed alcohol during pregnancy.
- The study has demonstrated that birth and early childhood anthropometric measurements collected routinely in clinical practice are reliable; the lower birthweight in Pakistani origin infants compared with White British origin infants is similar whether the Pakistani origin parents were born in the UK or in the Indian subcontinent; growth of infants in this population (of both of the key ethnic groups) differs markedly from that predicted by WHO growth standards.
- BiB has been able to link hospital, laboratory, radiology, community, primary care systems and education records to provide follow-up data. Importantly, it has brought together the worlds of research and practice and provides a strong bridge for translation of research findings into clinical care, with tangible examples of how research can change practice.

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