Department of Health

Birth Ratios in Great Britain, 2010-14

A report on gender ratios at birth in Great Britain

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Executive Summary

Aim

The Department of Health made a commitment to publish gender birth ratio analysis annually, in line with the recommendation of the Council of Europe Parliamentary Assembly that member states should collect the gender ratio at birth, monitor its development and take prompt action to tackle possible imbalances' and 'encourage research on sex ratios at birth among specific communities'. If significantly more boys than girls are being born than is expected, this could imply some pregnancies are being terminated with an abortion due to the gender of the fetus. A number of factors can influence the sex of a child including maternal and paternal age, coital rates, number of children and sex of previous children.

The purpose of these Official Statistics is to update and inform the public and Parliament on whether or not there is evidence for gender selective abortions happening at scale within specific communities in Great Britain. Data are sourced from birth registration data in England, Wales and Scotland. This analysis does not use data on abortions as sex of the fetus at termination is not available.

This analysis uses a gender birth ratio upper limit of 107 i.e. we are looking for birth ratios with significantly more than 107 boys born for every 100 girls within a community. Where the ratio of boys to girls for a particular country or ethnicity is significantly greater than 107 (after adjusting for multiple testing and birth order) this may indicate that people in this community could have been involved in gender selective abortions. A lower gender birth ratio limit is not used, as we aren't investigating if there are many more girls born than boys born in Great Britain.

Key Findings

This report presents statistics on the analysis of male to female birth ratios in Great Britain for the period 2010 to 2014:

- There were 3.9 million births registered in Great Britain and a ratio of boys to girls of 105.3. This is not greater than the expected upper limit of 107.

- Latest analyses by **country of birth of mother** for overall birth ratios, and by birth order, shows no ratio was found to be significantly higher than a boy to girl birth ratio of 107.

- Analysis of gender birth ratios by **child's ethnicity** for both overall birth ratio, and birth ratios by birth order, found no ratio to be significantly higher than 107.

- This analysis of gender birth ratios finds **no evidence** for gender selective abortions occurring in Great Britain over the period 2010 to 2014.

1. Introduction

Background

1.1 This report presents statistics on the analysis of male to female birth ratios in Great Britain for the period 2010-2014, using the most recent available finalised data over five years.

1.2 This is the fourth time this analysis has been published in the public domain[1], but the first time these statistics are being released as Official Statistics.

1.3 The purpose of these Official Statistics is to update and inform the Public and Parliament on whether or not there is any evidence for gender selective abortions happening at scale within specific communities in Great Britain.

1.4 Information on the gender of a fetus at a termination is not available. Therefore birth registrations data is used as a proxy to calculate the ratio of male to female births. Any evidence of unusual gender birth ratios might imply gender selective abortions were taking place in the population at scale.

1.5 The Department of Health made a commitment to publish gender birth ratio analysis annually, in line with the recommendation of the Council of Europe Parliamentary Assembly that member states should collect the ratio at birth, monitor its development and take prompt action to tackle possible imbalances' and 'encourage research on sex ratios at birth among specific communities'[2]. If more boys than girls are being born than is expected, this could imply some pregnancies are being terminated with an abortion due to the gender of the fetus. This process is known as a gender selective abortion. However, a number of factors can influence the sex of a child including maternal and paternal age, coital rates, number of children and sex of previous children.

The legal context

1.5 Concern has been raised in some countries about the occurrence of gender selective abortions[3,4.]

1.6 Gender is not itself a lawful ground for abortion in England, Wales and Scotland (Abortion Act 1967). Department of Health guidance, in May 2014, states that abortion on the grounds of gender alone is illegal.

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[1] https://www.gov.uk/government/collections/gender-birth-ratios-for-the-uk
[2] http://assembly.coe.int/Main.asp?link=/Documents/AdoptedText/ta11/ERES1829.htm
[3] Hesketh, T. and Xing, ZW. (2006) Abnormal sex ratios in human populations: Causes and Consequences. Proceedings of the National Academy of Sciences.
[4] Chahnazarian, A. (1988). "Determinants of the sex ratio at birth: Review of recent literature." Biodemography and Social Biology 35 (3-4):214-235

1.7 However, under the Abortion Act, it is lawful to abort a fetus where two registered medical practitioners (RMPs) (i.e. doctors)) are of the opinion, formed in good faith, “that there is a substantial risk that if the child were born it would suffer from such physical or mental abnormalities as to be seriously handicapped, there are some serious conditions which are known to be gender-related.”

1.8 In early 2015 the Serious Crime Act contained a requirement that the Secretary of State should arrange for an assessment to be made, within six months of Royal Assent, of the evidence for gender abortions occurring. A report was subsequently laid before Parliament in August 2015[5], which contained the assessment of evidence of terminations of pregnancy being undertaken on the grounds of the sex of the fetus, and a statement and explanation of why the Secretary of State for Health considered a formal plan under sub-section (3) (a) of the clause was not required.

Identifying the Gender of a Fetus with Technology

1.9 Antenatal sexing of the fetus is not a routine part of antenatal care. Scans are undertaken to support the clinical care of the mother and unborn baby such as: the number of foetuses, the age of the fetus, and screening for fetal anomalies. It is usually only possible to identify the sex of a baby at the second ultrasound scan, which takes place at around 18-21 weeks gestation. Disclosing the sex of a fetus is a local decision, adhering to local policies, and should be based on clinical judgment about the certainty of the assessment and the individual circumstances of each case.

1.10 Ultrasound Imaging can be used to accurately determine the gender of a fetus where gestational age is over 12 weeks and certain other factors are present. However, where these factors are not present, and gestation is less than 11 weeks and 4 days, it is not possible to accurately identify the gender of a fetus using ultrasound imaging.

1.11 The introduction of new and emerging technologies (such as Non-Invasive Prenatal Testing) provide further context from which the monitoring of gender birth ratios needs to be considered. Further details on NIPT are available in the August 2015 report on the evidence for gender selective abortions[5].

1.12 The majority of abortions take place in the first trimester of pregnancy (92% at under 13 weeks; 80% under 10 weeks gestation), whilst NHS antenatal sexing of a fetus typically takes place much later in the pregnancy at weeks 18-21 gestation. The majority of abortions are therefore taking place nearly two months before most women could have been told the gender of the fetus in the antenatal screening pathway.

[5] https://www.gov.uk/government/publications/abortion-on-grounds-of-sex-of-the-foetus

Trends in Gender Birth Ratios

1.6 Within large populations, we can expect the gender birth ratio to vary, due to external factors[6], which includes wars, economic crises and other major exogenous stressors. Figure 1 shows the fluctuation within England and Wales for the past 110 years. The chart shows that the gender birth ratio has never been above 107 over that period. The minimum ratio was 103.5 in 1914 and the maximum ratio was 106.5 in 1944. The male to female birth ratio has been consistently around 105 since 1980.

1.7 Figure 2 shows the birth ratios in all 34 OECD countries. This shows male to female birth ratios for the period 2010-15[7] ranging from nearly 104 in Iceland to 107 in Republic of Korea and Ireland.

1.8 The issue of gender ratios of new born babies is the subject of numerous academic articles, where there is mixed evidence. There is a general consensus that a male to female birth ratio of around 105 (that is 105 male births per 100 female) is normal[8]. Evidence suggests that a number of factors can influence the sex of a child, including maternal and paternal age, coital rates, number of children and sex of previous children[9]. It is important to note that the interaction between factors that could influence the sex of the child has not been controlled for, or taken into account in the analysis. However some consider that a birth ratio above 107 cannot occur naturally.

1.9 This analysis uses a birth ratio upper limit of 107 boys to 100 girls as a threshold for comparisons. This is based on a review of available literature[2,3], advice from academic experts and on examination of data on birth ratios in more developed countries. Figure 1 shows that the male to female birth ratio has never been above 107 over the last 110 years.

Results over Time

1.10 Previous analysis was published in May 2013, May 2014 and August 2015[1], on each occasion using the most recent data available and covering birth registration data over a five year period.

1.11 All reports looked at male to female birth ratios broken down by the mother's country of birth. Reports from 2014 onwards also looked at the gender birth ratios by the child's ethnicity and birth order of the child, in addition to mother's country of birth.

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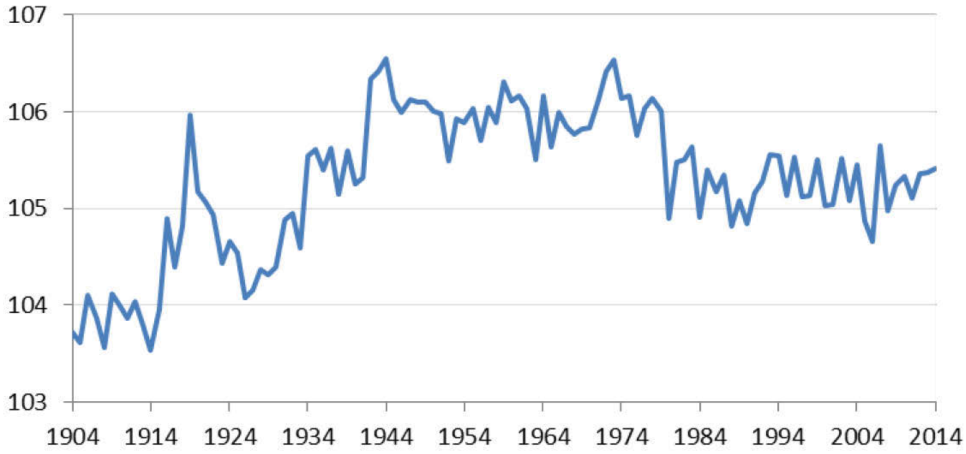
[6] Helle, S., Helama, S., & Lertola, K. (2009). Evolutionary ecology of human birth sex ratio under the compound influence of climate change, famine, economic crises and wars. Journal of Animal Ecology, 78(6), 1226–1233. doi:10.1111/j.1365-2656.2009.01598.x

[7] OECD use some modelled data for 2015 births based on previous years figures, including for UK.

[8] Eberstadt, N. (2011) The Global War against Baby Girls. The New Atlantis

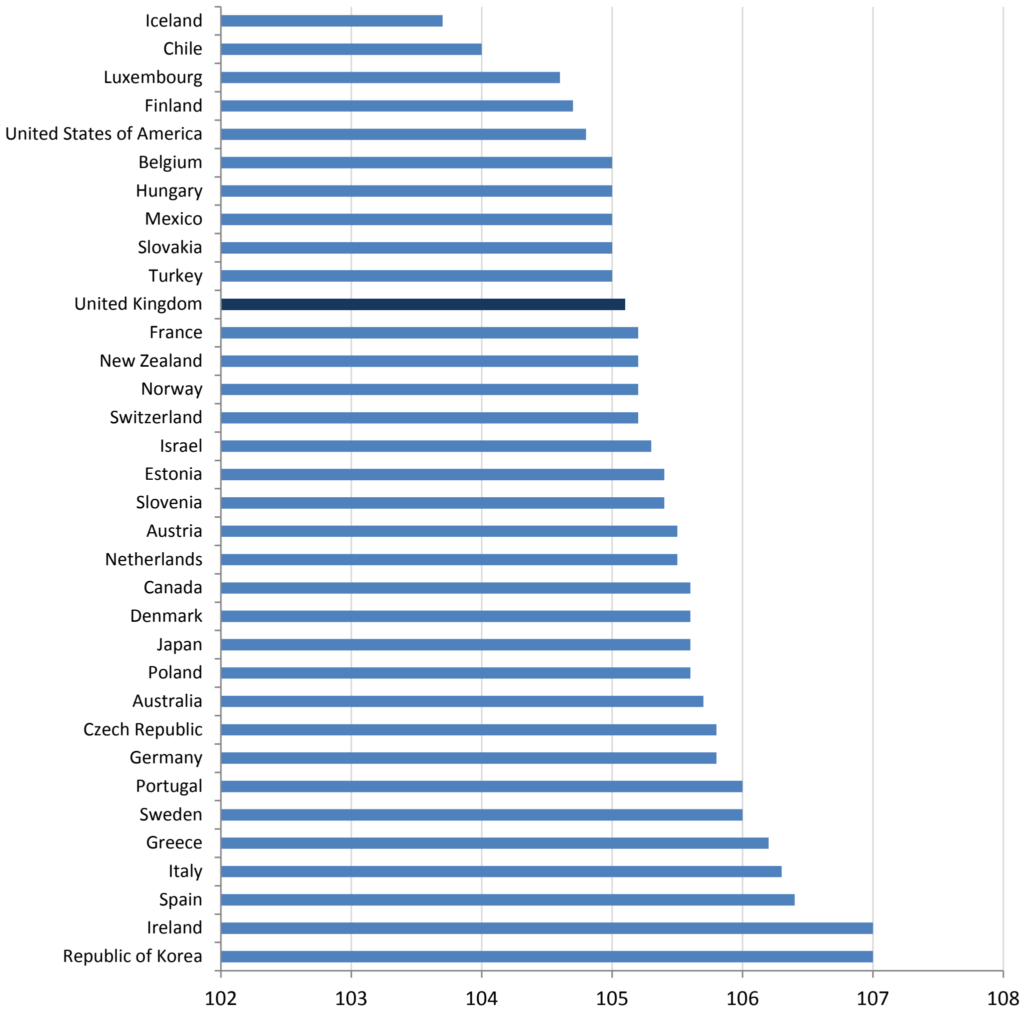
[9] Jacobosen, R. et al (1999). Natural variation in the human sex ratio. Human Reproduction vol.14 no.12.

Figure 1 – Live male births per 100 live female births, England and Wales



Source: Office for National Statistics

Figure 2 Live male births per 100 live female births, OECD countries, 2010-2015[1]



[1]*Source: United Nations, World Population Prospects: The 2015 Revision. 2015 data is modelled on previous years.*

1.12 The May 2013 and May 2014 reports published showed no group analysed to be statistically significant.

1.13 In the August 2015 publication, for the period 2009-2013 in Great Britain, the analysis by country of birth of mother for overall birth ratios and by birth order found no ratio to be statistically significantly higher than a boy to girl birth ratio of 107, except for Nepalese-born mothers giving birth to their third or more child.

1.14 The chances of getting a false positive result (ie a positive result that is not real) in at least one of a large number of tests is quite high. The statistical technique used to assess whether a result is statistically significant or not (the Benjamini-Hochberg procedure) reduces the chance of these false positive results happening randomly, however it does not completely eliminate it. To further test this result of Nepalese born mothers, another statistical technique, (a chi square test) was applied which did not find a statistically significant result, implying the initial result using the Benjamini-Hochberg procedure was a false positive result.

1.15 Following publication of these results in August 2015, an independent review of the methodology was carried out by The Office for National Statistics (paragraph 2.32 and Appendix C). This review recommended some changes to the existing Benjamini-Hochberg procedure and the inclusion of an additional statistical technique – the Storey technique. Retrospective application of the modified Benjamini-Hochberg procedure and Storey technique on to the birth gender ratio data analysis published in August 2015 did not find any evidence for a statistically significant group.

Users and Uses of Birth Ratio Statistics

1.16 The gender birth ratio statistics are of interest to the European Council who originally requested their collation. Following the amendment in the Serious Crime Act 2015, Parliament used the statistics within their remit to assess the legality of the Abortion Act and assess the gender birth ratio within the population in Great Britain. Academics and journalists reviewing evidence for gender selective abortions also have an interest in these statistics. Hospital trusts and screening midwives may also have an interest in these statistics when making local decisions for releasing information about the gender of a fetus during routine scans to the public. The United Nations Population Fund review birth ratios at a global level.

1.17 The purpose of these Official Statistics are to update and inform the public and Parliament on whether or not there is any evidence for gender selective abortions happening at scale within specific communities in Great Britain.

Limitations

1.13 Using birth registration data to calculate birth ratios is only a proxy measure for investigating evidence for gender selective abortions.

1.14 The relatively small number of births within many of the groups in this analysis, are such that large differences between birth ratios and the expected upper limit of 107 would need to be observed for the ratio to be identified as statistically significantly higher than the expected upper limit of 107. Therefore evidence would only be identified through this means if sex selection were taking place on a significant scale.

1.15 Any differences in the birth ratios seen could be due to a number of factors, not just gender selective abortions. There is evidence that paternal and maternal age, coital rates and the number and sex of previous children can influence the sex of a child.

2. Method

2.1 A summary of the methodology is provided below. More detail on the methods are provided in the **Appendices** (**A** – Benajmini-Hochberg procedure; **B** – Power Calculations; **C** – Independent Review of Methodology, 2016)

Background

2.2 Birth registrations data are used to calculate the ratio of male to female births. Any evidence of unusual gender birth ratios might imply gender selective abortions were taking place in the population at scale.

Birth Registration Data and Country of Birth Data

2.3 Analysis is presented by country of birth of the mother for Great Britain.

2.4 The Office of National Statistics provided data for England and Wales for country of birth of mother and birth order[10] using birth registration data. The registration of births in England and Wales is a service carried out by the Local Registration Service in England and Wales in partnership with the General Register Office[11].

2.5 The National Records of Scotland were used as the source data for Scottish births, by country of mother, and birth order.

Ethnicity Data

2.6 Analysis is presented by nine ethnic groups of the babies born for England and Wales.

2.7 Information on the child's ethnicity is routinely collected from mothers as a part of the birth notification data from the NHS Number for Babies (NN4B) system within England and Wales[12]. The ethnicity information included on the birth notification records are linked to the birth registrations; over 99% of birth registration records are successfully linked to their corresponding birth notification record each year[13].

2.8 The Scottish birth record system does have the capability to record babies' ethnicity. However the level of completeness is very poor with high levels of

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[10] Data taken from 'Live births by sex, parity and country of birth of mother, England and Wales, 1010-14.

[11] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/adhocs/005566livebirthsbysexparityandcountryofbirthofmotherenglandandwales2010to2014

[12] The Office for National Statistics carried out an assessment of the quality of these ethnicity data for 2005 to 2008. The data at that time were assessed as being of sufficient quality at national level, but not consistently robust sub-nationally. The proportion of 'not stated' were higher than country of birth, although that is not expected to affect male and female births differently. In this report, we have reduced the ethnic groupings from 13 to 9, so that for coherence we follow the ethnic breakdowns used by The Office for National Statistics.

[13] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/adhocs/005575livebirthsbyethnicityandparityenglandandwales2008to2014

missing or ‘not known’ entries. We therefore exclude Scotland from the gender birth ratio analysis for ethnicity of child.

Birth Order

2.9 The data on birth order relates to the first, second, third child or more that a woman has had, or birth order unknown.

2.10 Information on previous children by birth order is only available for all births from May 2012 in England and Wales and from January 2013 in Scotland. Prior to these time periods, there was no requirement for birth order data to be collected for children born outside of marriage. Therefore data on birth order was only available for births within marriage. However, due to a policy change in May 2012 in England and Wales and January 2013 in Scotland, all birth orders of all children born (both inside and outside of marriage) were recorded. Where birth order data is unavailable, (for example before the policy changes on data collection), these births have been allocated into the unknown category in the tables.

2.11 Following advice from the Office for National Statistics in their 2016 methodological review, unknown birth order has been included as a separate category within this analysis.

Data Coverage

2.12 Birth registration data for the most recent 5 year time period (2010 to 2014) are aggregated for our analysis to ensure sufficiently large sample sizes are used. The sample reflects the most recent five year time period for which finalised data are available.

2.13 Even though five years’ data have been used in our analysis, the sample sizes for some countries and ethnic groups are still very small. To address this issue, countries with fewer than 100 births in the five year period have been excluded. On this basis, 65 countries were excluded for the time period 2010 to 2014.

Birth Ratios Calculations

2.14 The birth ratios were calculated by dividing the number of male births by the number of female births and multiplying this value up by 100 to achieve a ratio of the number of boys born per 100 girls. This calculation was applied to:

- All births in Great Britain
- All births, by country of birth, and birth order, in Great Britain
- All births, by ethnicity of child, and birth order, England and Wales

2.15 For example, the gender birth ratio for babies born from French mothers over the period 2010 to 2014 was 106 for 1st born babies and 105 for the second born babies (Table 2).

Decision on what to compare birth ratios against: Threshold of 107

2.16 This analysis uses an upper value for the natural birth ratio of 107. This is based on a review of academic literature[14, 15], advice from academic experts, and an examination of data on birth ratios in more developed countries. The aim of this analysis is to investigate if any birth ratios are statistically significantly higher than 107, i.e. if any group or community has statistically significantly more than 107 boys born for every 100 girls.

2.17 A lower birth ratio limit was not used, as we are not investigating whether there are many more girls born than boys born in Great Britain than would be expected.

Testing for Birth Ratios that are statistically significant to the threshold

2.18 Birth ratios are examined for all births and by birth order (so whether a child is first born, second born, third born or more) by the mother's country of birth and by the child's ethnicity.

2.19 Differences between birth ratios and the 107 threshold do occur, but could be due to sampling error or chance, rather than a real difference. Statistical significance testing is carried out to determine whether any differences observed between the birth ratios and the 107 threshold are "real" or whether they are simply due to chance.

2.20 In order to identify whether differences are statistically significant, we calculated the probabilities ('p values') that the differences observed are the result of chance rather than a real difference. We have used the common acceptable level of 5% significance level in this analysis, which means that a statistically significant result is found for any p values less than 0.05 (5%) – in other words, for statistically significant results we are 95% sure that it is a real difference and not down to chance. The actual method of statistical significance testing we carried out needed to be modified due to the nature of our analysis. This is further explained below.

The Multiple Testing Problem

2.21 The 'country of mother's birth' analysis involved testing the significance level for 172 countries and five birth orders (all, 1st born, 2nd born, third born or more, unknown), equivalent to 860 statistical tests. The 'ethnicity of child' analysis

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[14] Hesketh, T. and Xing, ZW. (2006)Abnormal sex ratios in human populations: Causes and consequences. Proceedings of the National Academy of Sciences

[15] Chahnazarian, A. (1988). "Determinants of the sex ratio at birth: review of recent literature". Bioemography and Social Biology 35 (3-4): 214-235

involved testing the significance level for 9 ethnic groups and five birth orders (all, 1st born, 2nd born, third born or more, unknown), equivalent to 45 statistical tests

2.22 When undertaking so many statistical tests, as already explained, due to random variation it would be expected that some results appear statistically significant due to chance alone. This could lead users to incorrectly identifying a result as being significant and thus incorrectly inferring evidence about gender selective abortions.

2.23 To try and solve this problem, also known as the 'multiple testing problem', a statistical technique called the Benjamini-Hochberg procedure was applied using the p values already calculated as part of our method to assess statistical significance. See Appendix A and C for more details.

2.24 A limitation of using this Benjamini-Hochberg procedure is that the groups being tested need to have a large number of births for relatively small difference in birth rates to be found to lie outside the expected range, and therefore to be identified as being statistically significant. Many of the groups in this analysis are small and so would require large differences in birth rates to be identified as different from the expected range.

Sensitivity analysis: Storey Technique

2.25 This is a new technique used by The Department of Health for the 2016 publication of the gender birth ratio analysis.

2.26 Given the limitations of the Benjamini-Hochberg procedure, an alternative statistical analysis was conducted to check the validity of the results. The alternative statistical technique was recommended by the ONS and called the Storey technique (Appendix C)[16].

2.27 The Storey technique was applied to the same probabilities (p values) used in the Benjamini-Hochberg procedure to test for the likelihood of any statistically significant results. The Storey technique was used to estimate how many of the statistical tests performed (the 860 for 'country of birth' and 45 for 'ethnicity of child') were 'true positives' at the 5% significance level.

Independent Review of Methodology

2.28 The Office for National Statistics (ONS) quality assured the original methodology for this analysis in 2013.

2.29 In 2016, following continued interest in these statistics, the decision was made to publish gender birth ratios as Official Statistics. The Department of Health asked the Methodology Advisory Service at the ONS to review the methodology

[16] Storey, J.D. (2002) A direct approach to false discovery rates. *Journal of the Royal Statistical Society, Series B* **64** 479–498.

and provide assurance that it was a robust approach for reviewing evidence of extreme gender birth ratios.

2.30 The 2016 ONS methodological review, which was completed in April 2016, advised that the Benjamini-Hochberg method is an appropriate way to analyse birth sex ratios data to assess whether they show any evidence of sex selective abortion, with some small changes to the method which have been applied in this analysis. The ONS also advised supplementing the analysis with the introduction of the Storey Technique, which we have now included. See Appendix C for further information about the outcome of the methodological review.

3. Results

Coverage of Analysis

3.1 This report presents statistics on the analysis of male to female birth ratios in Great Britain for the period 2010-2014.

3.2 Birth ratios are examined for:

- All mothers for 2010-2014 for Great Britain
- The mother of the child's county of birth for 2010-2014 for Great Britain
- Ethnicity of child for 2010-2014 for England and Wales.

3.3 In each case, the analysis looks at:

- Overall gender birth ratios
- Birth ratios by birth order (that is for first born children, second born children etc).

All Births

3.4 In the period 2010 to 2014, there were 3.9 million live births[17] in Great Britain and an overall ratio of boys to girls of 105.3. This is not greater than the expected upper limit of 107.

3.5 The gender birth ratio across the different birth orders did not vary significantly (see Table 1 below). The gender birth ratio among the 1.2 million first born children was 105.4, among the 1.1 million second born children was 105.5 and among the third born or more children was 104.9.

Table 1: Gender Birth Ratios, by birth order, Great Britain, 2010-2014

Birth order	Number of births	Birth ratio
All births	3,856,062	105.3
1st born	1,179,565	105.4
2nd born	1,068,944	105.5
3rd born or more	709,035	104.9
Unknown[18]	898,518	105.2

[17] The analysis only covered countries where the total number of births for 2010-14 was 100 or more, to ensure adequate sample sizes were used, so excluding some countries from the analysis.
[18] Unknown birth order represents those babies whose birth order was unknown. See paragraph 2.14.

Births by mother's country of birth

3.6 The majority of births in Great Britain were to mothers born in England, Wales and Scotland (74%). This analysis focuses on the countries of mother's birth for the 26% of babies born to mothers from countries outside of England, Wales or Scotland.

3.7 The analysis of gender birth ratios by the mother's country of birth for Great Britain for the overall gender birth ratio and by birth order, showed no ratio to be significantly higher than 107. Table 2 shows the gender birth ratios for the countries analysed.

3.8 When interpreting the gender birth ratios in Table 2, it is important to keep in mind that this analysis covers 172 country of birth groups for 5 categories of birth order (all, 1st born, 2nd born, 3rd born or more, and unknown birth order). We might therefore expect to see high birth gender ratios for some groups simply as a result of random variation and small sample sizes. For example, during 2010 to 2014 for women born in Burundi, there were 167 babies who were the 1st born with a gender birth ratio of 160.9, whilst 215 babies were the 2nd born with a gender birth ratio of 93.7.

3.9 Although some gender birth ratios were higher than 107, such as 1st born in Burundi, following statistical tests (see Chapter 2. Methodology), no country and birth order was found to be statistically significant. That is to say, there was no evidence that the gender birth ratio was significantly higher than 107 for any country or birth order.

Births by Ethnicity of Child

3.10 Data on ethnicity of the child is not available for Scotland and therefore this component of the analysis is limited to England and Wales only.

3.11 There were 3.6 million births included in the analysis of birth ratios by ethnicity of the child and birth order, for England and Wales. The majority of births in England and Wales were for children in the White British ethnic group (65%).

3.12 An analysis of gender birth ratios by the ethnicity of the child for England and Wales both for overall birth ratio and by birth order, showed no ratio to be significantly higher than 107. Table 3 shows the results.

3.13 When interpreting the gender birth ratios in Table 2, it is important to keep in mind that this analysis covers 9 ethnic groups for 5 categories of birth order (all, 1st born, 2nd born, 3rd born or more, and unknown birth order). We might therefore expect to see high birth ratios for some groups simply as a result of random variation and small sample sizes. For example, there were 112,229 births of children with Indian ethnicity in 2010-14, of which those babies which were 2nd born had a gender birth ratio of 105.4 and 3nd born or more had a gender birth ratio of 110.8.

3.14 Although some gender birth ratios were higher than 107, such as 3rd born or more born babies of Indian ethnicity, following statistical tests (see Chapter 2. Methodology), no ethnicity and birth order were found to be statistically significant. That is to say, there was no evidence that the gender birth ratio was significantly higher than 107 for any ethnicity or birth order.

Results of sensitivity analysis: Storey Technique

3.15 For both the 'mother's country of birth' and 'ethnicity' analysis, there was no evidence for any true positives amongst any of these statistical tests at the 5% significance level using the Storey Technique. This evidence corroborates the Benjamini-Hochberg conclusion that there is no evidence for unusual sex ratios amongst the 'mother's country of birth' or 'ethnicity of child' data by birth order.

Conclusion

3.16 This analysis of gender birth ratios finds **no evidence** for gender selective abortions occurring in Great Britain over the period 2010 to 2014.

Abortions by Gestation and Ethnicity

3.17 Data on the gender of the fetus at an abortion is not available, which is why gender birth ratios from birth registrations data are used in this analysis. We can however analyse abortions data ethnicity and gestation to provide wider context around the gender birth ratio analysis. Any evidence for unusual gender birth ratios might imply gender selective abortions were taking place in the population at scale.

3.18 The majority of abortions take place in the first trimester of pregnancy (92% at under 13 weeks; 80% under 10 weeks gestation), whilst NHS antenatal sexing of a fetus typically takes place much later in the pregnancy at weeks 18-21 gestation. The majority of abortions are therefore taking place nearly two months before most women could have been told the gender of the fetus in the antenatal screening pathway.

3.19 To supplement the gender birth ratio analysis, further research will be done for the 2017 publication to investigate the relationship between gestation (and thus when gender can be identified) and abortion rates, by ethnic group of the woman.

Table 2: Gender birth ratios by mother's country of birth, births registered in Great Britain 2010-2014

Great Britain — *Totals and ratios*

Country of mother's birth[1]	Total number of births	Gender birth ratio (number of males to 100 female births): All births	1st child	2nd child	3rd child or more	Unknown[1]	Statistically significant result[2]
Total	**3,856,062**	**105.3**	**105.4**	**105.5**	**104.9**	**105.2**	**-**
Africa							
Africa (NOS)[3]	389	110.3	141.5	89.8	111.5	102.3	-
Eastern Africa							
Burundi	856	96.3	160.9	93.7	100.0	63.4	-
Djibouti	130	75.7	87.5	57.1	84.4	60.0	-
Eritrea	4,408	103.1	108.8	115.1	102.1	88.9	-
Ethiopia	3,267	101.0	101.6	96.2	104.6	102.6	-
Kenya	6,433	103.8	100.5	103.8	105.9	110.4	-
Madagascar	103	110.2	142.9	93.8	93.8	133.3	-
Malawi	1,856	100.2	86.5	103.9	112.4	100.0	-
Mauritius	2,872	111.3	104.7	117.1	118.6	108.3	-
Mozambique	575	103.9	111.8	93.9	112.7	100.0	-
Rwanda	766	105.9	118.5	122.1	103.5	90.6	-
Seychelles	245	114.9	113.5	115.8	126.3	105.0	-
Somalia	26,655	103.1	99.0	105.7	104.0	101.3	-
Tanzania	2,149	108.4	108.5	110.8	108.2	102.5	-
Uganda	4,671	101.5	105.0	105.0	95.7	100.7	-
Zambia	2,663	112.5	117.9	106.3	113.6	114.5	-
Zimbabwe	13,887	101.3	104.6	100.9	103.0	96.2	-
Middle Africa							
Angola	2,488	99.8	101.3	105.7	99.5	95.7	-
Cameroon	2,362	109.6	101.3	106.9	113.0	120.9	-
Congo	1,380	112.0	114.3	153.5	100.4	104.8	-
Congo (Democratic Republic)	5,303	105.0	119.5	93.3	100.2	112.1	-
Sao Tome and Principe	404	119.6	140.5	130.9	105.8	102.5	-
Northern Africa							
Algeria	4,919	105.4	108.6	100.4	106.3	111.0	-
Canary Islands	110	111.5	121.1	100.0	120.0	109.1	-
Egypt	1,971	107.0	112.5	107.1	102.4	100.0	-
Libya	4,133	106.7	102.2	103.3	111.8	103.3	-
Morocco	3,933	100.6	105.0	104.4	94.3	86.8	-
Sudan	3,591	106.1	110.9	105.2	102.9	114.3	-
Tunisia	718	113.1	115.2	112.1	98.7	300.0	-
Southern Africa							
Botswana	411	107.6	90.8	98.3	151.4	110.5	-
Namibia	471	99.6	88.0	93.6	92.1	145.9	-
South Africa	21,674	106.7	102.4	108.8	112.3	109.0	-
Swaziland	173	143.7	205.3	87.0	93.3	207.1	-
Western Africa							
Benin	128	141.5	312.5	120.0	95.2	133.3	-
Cape Verde	153	93.7	55.0	166.7	100.0	70.0	-
The Gambia	3,115	105.7	101.4	106.1	105.7	112.4	-
Ghana	17,166	102.0	101.4	100.9	102.5	103.3	-
Guinea	922	106.7	100.0	120.8	99.4	111.1	-
Guinea-Bissau	662	101.8	121.3	97.5	91.2	106.8	-
Ivory Coast	1,794	108.1	127.7	103.8	98.9	109.7	-
Liberia	519	101.9	113.3	96.1	88.4	114.7	-
Nigeria	38,747	103.2	101.4	101.9	107.0	103.4	-
St Helena and Dependencies	156	102.6	129.4	121.4	65.2	108.7	-
Senegal	461	91.3	67.2	84.6	111.0	107.4	-
Sierra Leone	3,298	102.8	101.6	110.4	101.4	98.4	-
Togo	278	93.1	92.9	86.8	108.5	77.4	-

Country of mother's birth[1]	Total number of births	Gender birth ratio (number of males to 100 female births) All births	1st child	2nd child	3rd child or more	Unknown[1]	Statistically significant result[2]
Americas							
Caribbean							
Antigua and Barbuda	101	146.3	138.5	185.7	200.0	118.8	-
Bahamas	164	115.8	93.3	118.5	214.3	108.3	-
Barbados	275	105.2	74.1	120.6	128.6	132.0	-
Cuba	242	142.0	190.3	127.8	111.8	112.5	-
Dominica	197	111.8	133.3	116.7	75.0	113.6	-
Dominican Republic	231	108.1	128.1	105.1	145.5	33.3	-
Grenada	237	95.9	103.1	77.4	88.9	112.9	-
Jamaica	10,403	102.6	107.3	102.6	101.4	101.1	-
Montserrat	487	121.4	118.4	123.1	101.9	133.7	-
St Lucia	489	94.8	104.0	73.9	104.4	100.0	-
St Vincent	306	114.0	102.3	102.2	124.0	141.4	-
Trinidad and Tobago	1,462	104.2	117.7	100.4	97.1	94.4	-
Central America							
El Salvador	105	90.9	123.5	69.6	33.3	166.7	-
Guatemala	108	100.0	92.0	138.5	58.3	150.0	-
Mexico	1,355	111.7	116.0	104.2	135.5	79.5	-
South America							
Argentina	1,189	115.4	121.4	115.0	103.5	110.9	-
Bolivia	528	101.5	81.5	113.1	113.3	109.8	-
Brazil	7,610	107.8	107.7	109.5	94.9	117.1	-
Chile	616	101.3	106.3	96.1	131.3	63.3	-
Colombia	2,730	110.3	111.1	110.4	111.9	106.6	-
Ecuador	1,223	100.8	105.0	107.0	88.7	100.0	-
Guyana	747	108.7	94.2	115.7	91.6	143.7	-
Peru	932	109.9	124.2	94.6	90.5	145.5	-
Uruguay	133	87.3	69.0	80.8	128.6	150.0	-
Venezuela	1,278	103.5	93.3	113.0	109.0	111.5	-
Northern America							
Bermuda	313	110.1	85.7	131.4	137.0	112.5	-
Canada	6,479	105.0	104.7	101.2	112.3	109.0	-
United States	17,731	104.5	103.9	104.8	105.9	103.7	-
Asia							
Asia (Except Middle East) (NOS)[3]	359	109.9	85.5	111.5	193.1	64.3	-
Central Asia							
Kazakhstan	735	110.0	118.8	109.1	97.7	87.1	-
Kyrgyzstan	255	117.9	106.0	119.5	173.3	90.9	-
Turkmenistan	201	111.6	182.4	47.7	175.0	100.0	-
Uzbekistan	593	124.6	123.5	128.6	113.0	136.4	-
Eastern Asia							
China	20,519	106.9	108.2	103.8	104.7	111.7	-
China (Taiwan)	852	104.3	95.4	121.6	125.7	65.0	-
China)	4,951	106.4	103.6	108.1	108.5	110.3	-
Japan	4,291	108.0	110.4	111.3	94.6	87.3	-
Korea (South)	1,512	111.5	119.5	107.1	92.4	115.4	-
Mongolia	461	113.4	115.9	111.1	124.3	104.5	-
Southern Asia							
Afghanistan	14,022	104.4	97.9	105.9	107.7	88.9	-
Bangladesh	41,086	103.7	105.7	101.7	103.9	103.1	-
India	73,177	107.2	105.0	107.9	112.5	111.3	-
Iran	4,963	103.0	101.0	104.5	107.1	102.2	-
Nepal	4,919	109.5	105.7	110.5	134.6	87.5	-
Pakistan	95,519	103.2	105.7	103.6	101.7	94.6	-
Sri Lanka	17,124	102.1	99.1	102.0	106.3	108.4	-
South-Eastern Asia							
Brunei	308	108.1	90.5	116.7	129.2	162.5	-
Burma	646	124.3	102.8	164.5	123.1	133.3	-
Cambodia	139	131.7	140.0	145.5	107.7	100.0	-
East Timor	283	92.5	103.0	85.0	84.4	97.6	-
Indonesia	1,251	104.1	102.9	97.4	130.3	85.7	-
Malaysia	4,893	103.6	97.1	108.4	104.2	129.1	-
Philippines	13,722	108.9	112.9	104.0	110.8	109.4	-
Singapore	1,359	107.8	97.0	120.9	97.9	138.3	-
Thailand	5,506	106.6	104.4	109.9	112.8	95.3	-
Vietnam	4,321	111.1	112.6	106.0	116.9	112.0	-

Country of mother's birth[1]	Total number of births	Gender birth ratio (number of males to 100 female births)					Statistically significant result[2]
		All births	1st child	2nd child	3rd child or more	Unknown[1]	
Western Asia							
Armenia	254	91.0	83.3	100.0	106.3	72.7	-
Azerbaijan	455	105.0	104.9	105.3	103.1	108.3	-
Bahrain	447	107.9	105.2	128.4	83.3	93.8	-
Cyprus	2,041	106.4	107.9	110.2	105.4	99.0	-
Georgia	567	98.9	94.2	107.7	116.2	83.7	-
Iraq	12,406	106.0	110.8	102.4	103.8	114.3	-
Israel	2,296	109.7	99.7	102.0	120.9	131.6	-
Jordan	734	100.0	98.4	116.4	88.7	75.0	-
Kuwait	1,917	109.7	119.7	114.5	104.2	93.1	-
Lebanon	1,908	104.1	101.6	93.4	120.6	90.0	-
Oman	265	126.5	156.4	137.9	91.1	150.0	-
Palestine	281	116.2	133.3	130.3	103.2	75.0	-
Qatar	270	101.5	125.6	97.4	84.4	85.7	-
Saudi Arabia	3,840	107.8	113.8	99.3	110.7	93.1	-
Syria	1,645	111.4	114.3	110.7	108.9	116.7	-
Turkey	12,075	111.7	113.0	112.6	109.7	107.6	-
United Arab Emirates	1,710	103.3	99.4	108.5	104.6	98.0	-
Yemen	2,562	114.6	112.8	133.6	109.1	81.8	-
Europe							
Eastern Europe							
Belarus	938	108.4	103.7	107.4	128.3	114.3	-
Bulgaria	7,725	110.8	111.0	110.1	115.2	109.3	-
Czech Republic	8,850	104.9	102.4	104.1	102.4	111.0	-
Hungary	7,871	107.1	105.0	111.0	109.2	105.8	-
Kosova	3,266	110.7	103.6	115.0	113.6	107.9	-
Poland	114,447	105.2	106.6	105.0	102.2	104.4	-
Moldova	1,230	111.3	98.1	112.7	125.8	161.7	-
Romania	22,586	104.0	103.8	102.3	104.4	109.6	-
Russia	6,087	104.6	106.7	102.4	107.6	99.0	-
Slovakia	12,729	108.2	110.8	106.5	107.1	106.6	-
Ukraine	3,824	103.3	102.2	100.9	110.9	108.5	-
Union of Soviet Socialist States	260	100.0	105.6	83.7	108.3	166.7	-
Northern Europe							
Channel Islands	1,320	106.9	103.2	107.1	86.9	128.8	-
Denmark	1,847	110.6	113.5	106.2	106.7	118.0	-
England	2,473,291	105.3	105.2	105.4	105.0	105.5	-
Estonia	1,451	103.8	120.2	93.7	95.5	95.2	-
Finland	1,508	101.3	114.7	89.5	80.4	112.4	-
Iceland	203	93.3	93.8	78.1	100.0	109.5	-
Ireland	16,325	105.5	103.2	108.7	104.3	106.1	-
Isle of Man	676	97.1	103.3	97.0	82.0	97.3	-
Latvia	12,927	105.9	107.6	101.4	109.3	107.1	-
Lithuania	21,733	104.5	100.7	106.5	108.5	106.1	-
Northern Ireland	13,607	107.7	112.3	107.6	102.8	102.2	-
Norway	1,231	98.9	105.6	95.2	91.4	97.2	-
Scotland	250,124	105.1	105.6	105.1	104.5	104.9	-
Sweden	3,564	108.2	104.1	105.8	120.2	113.2	-
Wales	148,577	105.5	108.0	106.0	103.7	103.8	-
Southern Europe							
Albania	5,091	112.4	113.8	109.0	122.2	105.5	-
Bosnia and Herzegovina	857	99.3	92.7	109.9	105.0	87.7	-
Croatia	752	121.8	105.0	150.5	143.2	104.3	-
Gibraltar	744	106.1	98.2	119.4	98.6	106.6	-
Greece	2,652	107.5	106.6	113.8	105.2	93.7	-
Italy	7,230	105.1	102.3	106.6	113.5	104.9	-
Macedonia	600	99.3	116.2	100.9	89.7	52.8	-
Malta	681	102.1	106.3	123.1	86.3	82.0	-
Portugal	8,938	103.5	98.2	111.6	108.5	98.3	-
Serbia	735	107.6	116.0	109.4	68.9	135.5	-
Slovenia	253	116.2	92.9	92.5	161.5	325.0	-
Spain	7,463	101.2	98.4	101.9	101.9	107.4	-
Yugoslavia	166	112.8	139.3	86.4	121.4	92.9	-

Great Britain							*Totals and ratios*
		Gender birth ratio (number of males to 100 female births)					
Country of mother's birth[1]	**Total number of births**	**All births**	**1st child**	**2nd child**	**3rd child or more**	**Unknown[1]**	**Statistically significant result[2]**
Western Europe							
Austria	835	102.2	111.7	98.4	101.5	84.2	-
Belgium	2,238	109.9	102.8	128.6	96.9	117.8	-
France	13,299	105.2	106.0	105.4	100.7	107.7	-
Germany	26,948	105.4	105.4	106.4	105.0	104.7	-
Luxembourg	138	102.9	100.0	115.8	100.0	88.9	-
Netherlands	3,943	100.6	103.0	113.5	93.0	81.9	-
Switzerland	1,502	102.7	108.1	97.6	90.9	139.7	-
Oceania							
Australia and New Zealand							
Australia	11,233	106.1	105.0	109.8	112.4	95.9	-
New Zealand	5,663	105.7	103.2	112.2	110.4	95.9	-
Melanesia							
Fiji	939	98.9	112.7	96.9	92.0	94.4	-
Papua New Guinea	169	98.8	78.6	104.3	111.1	112.5	-
Not Stated	120	73.9	33.3	43.8	55.0	138.1	-

[1] The information on previous children born to mothers in England and Wales was only available for all live births from May 2012 onwards and for Scotland from January 2013 onwards. Prior to this, information about previous live births was only available for births within marriage. Where birth order data is unavailable, these births have been out in this 'ratio unknown' category.

[2] A dash (-) indicates that there was no statistically significant results found for all births and/or births by any birth order for a particular country after applying the Benjamini-Hochberg procedure. An asterisk (*) indicates that the result is significantly significant for all births and/or births by any birth order, for a particular country, after applying the Benjamini-Hochberg procedure.

[3] NOS refers to countries 'not otherwise stated' within a Continent

Source: Office for National Statistics and the National Records of Scotland

Table 3: Gender birth ratios and test result by child's ethnicity, births registered in England and Wales, 2010-2014[1]

England and Wales							*Totals and ratios*
		Gender birth ratio (number of males to 100 female births)					
Ethnicity of the child	**Total number of births**	**All births**	**1st child**	**2nd child**	**3rd child or more**	**Unknown[1]**	**Statistically significant result[2]**
Total	**3,560,029**	**105.3**	**105.4**	**105.5**	**104.9**	**105.2**	-
White British	2,306,053	105.4	105.6	105.5	105.0	105.4	-
White Other	317,025	105.6	105.9	105.6	105.6	105.1	-
Indian	112,229	105.6	104.1	105.4	110.8	101.9	-
Pakistani	141,927	104.0	105.4	104.7	102.8	101.5	-
Bangladeshi	49,283	102.5	103.2	103.1	102.2	98.9	-
Black African	121,034	103.9	105.1	102.9	104.4	103.0	-
Black Caribbean	33,739	103.6	100.9	105.3	102.7	104.6	-
Other	352,421	105.9	105.5	106.6	106.2	105.4	-
Not Stated	126,318	105.2	104.2	105.4	105.7	106.1	-

[1] The information on previous children born to mothers in England and Wales was only available for all live births from May 2012 onwards and for Scotland from January 2013 onwards. Prior to this, information about previous live births was only available for births within marriage. Where birth order data is unavailable, these births have been out in this 'ratio unknown' category.

[2] A dash (-) indicates that there was no statistically significant results found for all births and/or births by any birth order for a particular country after applying the Benjamini-Hochberg procedure. An asterisk (*) indicates that the result is significantly significant for all births and/or births by any birth order, for a particular ethnic group, after applying the Benjamini-Hochberg procedure.

Source: Office for National Statistics

Appendix A: Benjamini-Hochberg procedure

In testing whether a result is statistically significant, it is common practice to determine whether the likelihood of an extreme observation occurring by chance is less than 5%. This is known as the alpha (α) value.

As this analysis involves doing multiple tests for the mother's country of birth and the ethnicity of the child, this leads to a 'multiple testing problem'. This is because the probability of getting a significant result increases with the more tests that are run. The significance level that is set for a single test, α, which measures the probability that a significant result is detected under the assumption that there isn't one, is not a valid way of detecting significant result, when multiple tests are being run. To assist in the detection of results which are still significant when lots of tests are run, a correction needs to be made to α. Many approaches have been developed, and in this case, the Benjamini-Hochberg procedure is used in the analyses presented here.

The Benjamini-Hochberg procedure (B-H step-up procedure) is a way of setting α where it takes into account the fact that there are multiple tests. The procedure is as follows:

1. Find the significance level (p-value) for each individual test

2. Order the tests in descending order of p-values, and give all of the values a rank, called *k*, with 1 being applied to the biggest p-value.

3. For a given α find the smallest *k* such that

$$p_k < \frac{(m - k + 1)\alpha}{m}$$

4. Then say that for all tests which have a value of i where $i = k, \ldots, m$ that they are significant results.

Appendix B: Power Calculations

This information on power calculations has been included for illustration purposes only.

In testing whether a result is statistically significant, it is common practice to determine whether the likelihood of an extreme observation occurring by chance is less than 5% (that is, the odds are less than 1 in 20). This is known as the alpha (α) value.

A consequence and a limitation of using this technique for multiple testing is that the groups being analysed will generally need to be large (that is, have a high number of births) for relatively small differences in birth rates to be found to lie outside the expected range. Many of the groups in this analysis are small and so would require large differences in birth rates to be identified as different from the expected range.

Calculations were conducted to determine the birth ratio that would need to be observed for a particular country of birth or ethnic group in order to have a good chance (i.e. 80%) of correctly concluding that the true value lies above the expected upper limit of 107 boys for every 100 girls. The required ratio depends on the number of births registered for that country or ethnic group. The fewer the number of births, the greater the observed ratio needs to be to ensure this chance is maintained. The levels of power and significance were set to 5% and the calculation carried out for a one-tailed test, i.e. results greater than 107:100.

Use of the Benjamini-Hochberg (B-H) procedure cannot easily be factored into a power calculation. A minimum level of power was deduced by using the critical value of (i/N) * α that is associated with the 860th country/parity group and the 45th ethnicity/parity group, rather than the α that is used when calculating the effect size for a single hypothesis test.

- In the case of the 860th country/parity group, i=1, N=860 and α=0.05, giving a critical value of 0.000058.

- In the case of the 45th ethnicity/parity group, i=1, N=45 and α=0.05, giving a critical value of 0.001111.

The required effect size for groups of varying size is shown in the table below.

For example, an ethnic group with 10,000 registered births would need a birth ratio of 114 or more; and a country associated with 10,000 registered births would need a birth ratio of 116 or more.

Table 4: Required Effect Sizes by Sample Size of Groups

	Ratio of Boys: 100 Girls		
Sample Size	**Single Test**	**Ethnic Group (45 tests)***	**Country of Birth (860 tests)****
500	124	141	152
1000	119	130	137
5000	112	117	119
10000	111	114	116
50000	109	110	111
100000	108	109	110

* The analysis was based on data from 9 ethnic groups, by five lots of parity tests (All, 1st born, 2nd born, 3rd born or more, unknown), total 45 tests.

** The analysis was based on data from 172 country of birth groups, by five lots of parity tests (All, 1st born, 2nd born, 3rd born or more, unknown), total 860 tests.

Appendix C: Independent Review of Methodology

The recommendations following from the independent methodology review led by the Office of National Statistics in April 2016 have all been included in this analysis and are presented below:

- When implementing the Benjamni-Hochberg procedure, the process should involve calculating the probabilities and then rank all these results is descending order in one operation, rather than doing separate tests by all births and birth order.

- The Benjamni-Hochberg procedure may be supplemented with an analysis using Storey (2001's) approach to estimate the local positive False Discovery Rate (pFDR).

- Continue to aggregate 5 years of data in the analysis, to ensure that the sample size is adequate to be able to detect a specified difference.

- In this analysis, the Department of Health uses a birth ratio of 107 males to 100 females. This is based on a review of available literature, advice from academic experts and on examination of data on birth ratios in more developed countries. ONS advised, that on this basis, one-sided tests against a ratio of 107 are appropriate.

- Previously, the Department of Health analysis has reported on male to female birth ratios for two or more children. However as the birth order data for two or more children is closely related to three or more children, the recommendation is to no-longer report the birth ratios for birth orders of for two or more children.

- There are a large number of births where birth order is unknown. It is possible that any evidence of sex selection could show up in this category. Therefore, given that birth order is of primary policy interest, the methodology review recommended reporting birth ratios and analyses for the unknown birth order.

Appendix D: Further Information

Enquiries

Enquiries about the data or requests for further information should be addressed to:

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Links

This bulletin for birth ratio analysis for 2010-2014, and previous reports, can be found on the Department of Health website:

Previous reports:
- https://www.gov.uk/government/collections/gender-birth-ratios-for-the-uk

Related links:
- See abortion statistics, 2015

- https://www.gov.uk/government/statistics/report-on-abortion-statistics-in-england-and-wales-for-2015