Department of Health

Gender Ratios at Birth in Great Britain, 2011-15

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 generally accepted 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 2011 to 2015:

- There were 3.8 million births registered in Great Britain and a ratio of boys to girls of 105.3, which is below the expected upper limit of 107.

- Latest analyses by **country of origin 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 **ethnicity of the child** 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 2011 to 2015.

1. Introduction

Background

1.1 This report presents Official Statistics on the analysis of male to female birth ratios in Great Britain using the most recently available finalised data for the period 2011-2015.

1.2 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. This analysis has been published since 2013. [1]

1.3 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.

1.4 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.

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

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[1] https://www.gov.uk/government/collections/gender-birth-ratios-for-the-uk
[2] http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-EN.asp?fileid=18020&lang=en
[3] Hesketh, T., & Xing, Z. W. (2006). Abnormal sex ratios in human populations: causes and consequences. *Proceedings of the National Academy of Sciences, 103*(36), 13271-13275.
[4] Chahnazarian, A. (1988). Determinants of the sex ratio at birth: Review of recent literature. *Social biology, 35*(3-4), 214-235.

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[6].

1.12 The majority of abortions take place in the first trimester of pregnancy (92% at under 12 weeks; 58% under 7 weeks gestation), whilst NHS antenatal sexing of a fetus typically takes place much later in the pregnancy, usually between 18-21 weeks 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

1.13 Within large populations, we can expect the gender birth ratio to vary, due to external factors[6], including wars and economic crises. Figure 1 shows the fluctuation within England, Wales and Scotland since 1905. 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 106.7 in 1973. The male to female birth ratio has been consistently around 105 since 1980.

1.14 Figure 2 shows the birth ratios in all 34 OECD countries. This shows male to female birth ratios for the period 2010-15 ranging from 104 in Chile to 107 in Republic of Korea. However, there are a range of countries outside the OECD where male to female birth ratios have exceed 107 in recent years, such as China, India and several countries in the Caucasus region [7].

1.15 The issue of gender ratios of new born babies is the subject of numerous academic articles, where there is a range of evidence. A 2011 World Health Organisation report stated a biologically normal sex ratio at birth ranges from 102 to 106 male births, per 100 female births[8]. Although other studies have stated that 105 or lower is a more "normal" ratio of boys to girls[7]. 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 this analysis.

1.16 For this publication a birth ratio upper limit of 107 boys to 100 girls is used as a threshold for comparisons. 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.

Results over Time

1.17 All previous reports (published each year from 2013) looked at male to female birth ratios broken down by the mother's country of origin. 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 origin.

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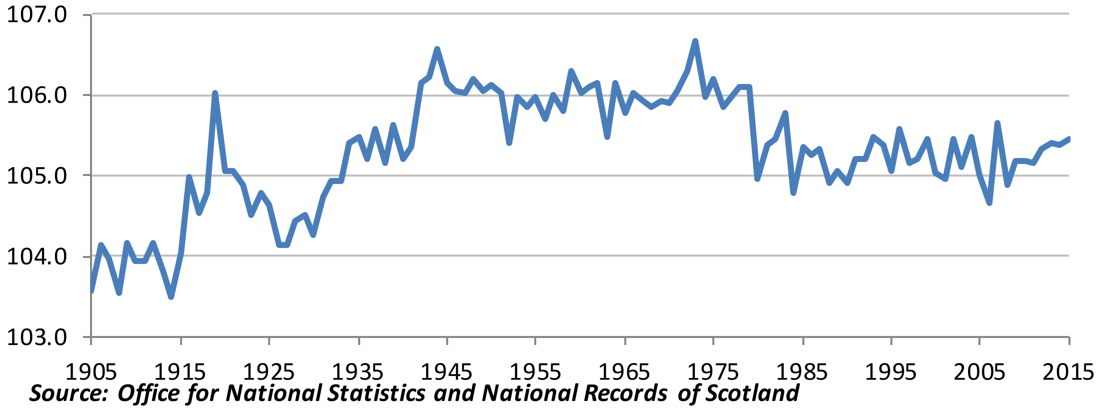
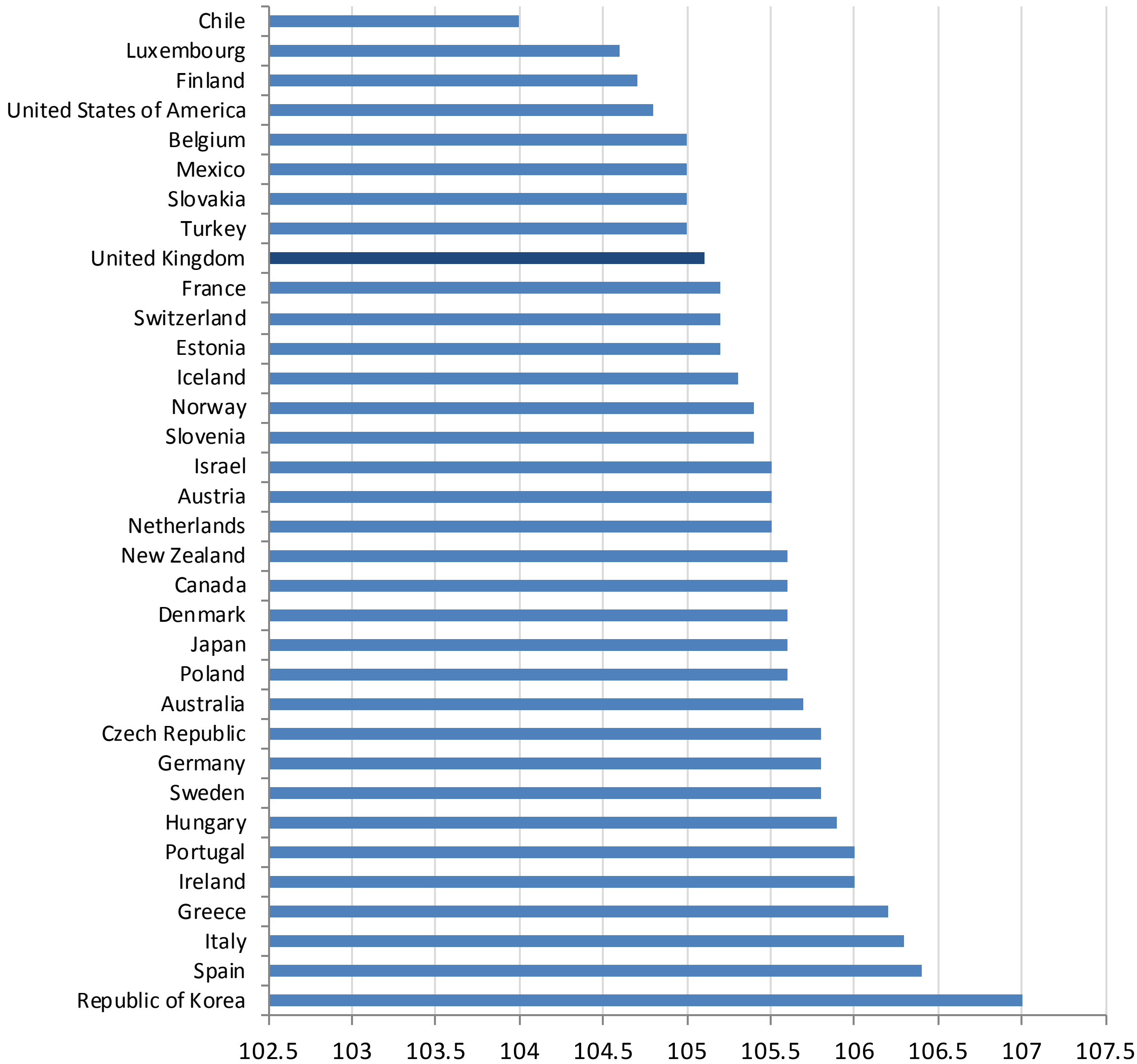
[6] Helle, S., Helama, S., & Lertola, K. (2009). Evolutionary ecology of human birth sex ratio under the compound influence of climate change, famine, economic crises and wars. *Journal of Animal Ecology*, *78*(6), 1226-1233.
[7] Eberstadt, N. (2011). The global war against baby girls. *The New Atlantis*, 3-18.
[8] World Health Organization. (2011). Preventing gender-biased sex selection: an interagency statement-OHCHR, UNFPA, UNICEF, UN Women and WHO.
[9] Jacobsen, R., Møller, H., & Mouritsen, A. (1999). Natural variation in the human sex ratio. *Human reproduction, 14*(12), 3120-3125.

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



Source: Office for National Statistics and National Records of Scotland

Figure 2 – Live male births per 100 live female births, OECD countries, 2010-2015



Source: United Nations, World Population Prospects: The 2017 Revision

1.18 The 2013, 2014 and 2016 reports showed no statistically significant results in any of the groups analysed.

1.19 In the 2015 publication there was one statistically significant result, for Nepalese-born mothers giving birth to their third or later child.

1.20 The chances of getting a false positive result (i.e. 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 likely to be a false positive result.

1.21 Following publication of these results in August 2015, an independent review of the methodology was carried out by The Office for National Statistics (paragraph 2.29 and Appendix D). 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

1.22 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.

Limitations

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

1.24 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.

1.25 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** (**- B** – Analytical Techniques; **C**– Power Considerations; **D–** Independent Review of Methodology, 2016)

Birth Registration Data and Country of Origin Data

2.2 Analysis is presented by country of origin of the mother for Great Britain.

2.3 The Office of National Statistics provided data for England and Wales for country of origin 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].

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

Ethnicity Data

2.5 Analysis is presented by nine ethnic groups of the babies born in England and Wales, in line with the ethnic groupings used by the Office for National Statistics.

2.6 Information on ethnicity of the child 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].

2.7 The Scottish birth record system does record babies' ethnicity. However, there are high levels of missing or 'not known' entries. We therefore exclude Scotland from the gender birth ratio analysis for ethnicity of child.

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[10] Data taken from 'Live births by sex, parity and country of origin of mother, England and Wales, 2011-15.

[11] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/adhocs/007189livebirthsbysexparityandcountryofbirthofmotherenglandandwales2011to2015

[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 origin, although that is not expected to affect male and female births differently. .

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

Birth Order

2.8 The data on birth order relates to the first, second and third or later born child that a woman has had. There is also a category for where the birth order is unknown.

2.9 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, all birth orders of all children born (both inside and outside of marriage) are now 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.

2.10 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

2.11 Birth registration data for the most recent 5 year time period (2011-2015) 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.

2.12 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, 74 countries with fewer than 100 births in the five year period have been excluded.

Birth Ratios Calculations

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

2.14 For example, the gender birth ratio for babies born from French mothers over the period 2011-2015 was 103 males to 100 females for first born babies and 106 males to 100 females for the second born babies (Table 2).

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

2.15 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.

2.16 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

2.17 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 origin and by the child's ethnicity.

2.18 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.

2.19 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 due 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

2.20 The 'country of mother's origin' analysis involved testing the significance level for 173 countries and five birth orders (all, 1st born, 2nd born, third born or later and unknown), equivalent to 865 statistical tests. The

[14] Hesketh, T., & Xing, Z. W. (2006). Abnormal sex ratios in human populations: causes and consequences. *Proceedings of the National Academy of Sciences, 103*(36), 13271-13275.
[15] Chahnazarian, A. (1988). Determinants of the sex ratio at birth: Review of recent literature. *Social biology, 35*(3-4), 214-235.

‘ethnicity of child’ analysis involved testing the significance level for 9 ethnic groups and five birth orders (all, 1st born, 2nd born, third born or later and unknown), equivalent to 45 statistical tests.

2.21 When undertaking so many statistical tests, due to random variation it would be expected that some results appear statistically significant due to chance alone. For example, at the 5% significance level used here, you would expect 1 in 20 results to be significant. When applied across the 865 and 45 statistical tests carried out here, there is a high chance of incorrect identification of a significant result, leading to inferring evidence about gender selective abortions incorrectly.

2.22 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 B and C for more details.

2.23 A limitation of using this Benjamini-Hochberg procedure is that the groups being tested need to have a large number of births for a 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

2.24 This technique was first used by The Department of Health for the 2016 publication of the gender birth ratio analysis. (Appendix B).

2.25 Given the limitations of the Benjamini-Hochberg procedure, an alternative statistical analysis was conducted to check the validity of the results. Following a review of the methodology in conjunction with the ONS, a supplementary test, known as the Storey technique was recommended (Appendix D[16]).

2.26 The Storey technique is a further test concerned with controlling the rates of false positives and is applied to the same probabilities (p values) calculated from the single testing procedure and used in the Benjamini-Hochberg procedure to test for the likelihood of statistically significant results. The Storey technique was used to estimate how many of the statistical tests performed (865 for ‘country of origin’ and 45 for ‘ethnicity of child’) were ‘true positives’ at the 5% significance level.

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[16] Storey, J. D. (2002). A direct approach to false discovery rates. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, *64*(3), 479-498.

Independent Review of Methodology

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

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

2.29 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 now include in publications from 2016 onwards. See Appendix D 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 2011-2015.

3.2 Birth ratios are examined for:

- All mothers for 2011-2015 for Great Britain
- The mother of the child's county of birth for 2011-2015 for Great Britain
- Ethnicity of child for 2011-2015 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 2011-2015, there were 3.8 million live births[17] in Great Britain and an overall ratio of boys to girls of 105.3, which is below the 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 1.3 million first born children was 105.5, among the 1.2 million second born children was 105.3 and among the third born or more children was 105.0

Table 1: Gender Birth Ratios, by birth order, Great Britain, 2011-2015

Birth order	Number of births	Birth ratio
All births	3,827,170	105.3
1st born	1,302,845	105.5
2nd born	1,188,764	105.3
3rd born or more	802,042	105.0
Unknown[18]	533,519	105.4

[17] The analysis only covered countries where the total number of births for 2011-15 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 2.10.

Births by mother's country of origin

3.6 The majority of births in Great Britain were to mothers born in England, Wales and Scotland (74%). This analysis focuses on the mother's country of origin 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 origin 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 all of the countries included in the analysis.

3.8 However, initial testing using the Benjamini-Hochberg and Storey techniques did produce significant results for Slovenia, for children where the birth order is unknown and also Asia (except middle east, not otherwise stated (NOS)) for the third born or later children. However, further investigation did not find these results to be valid in terms of checking for sex selective abortion for the following reasons.

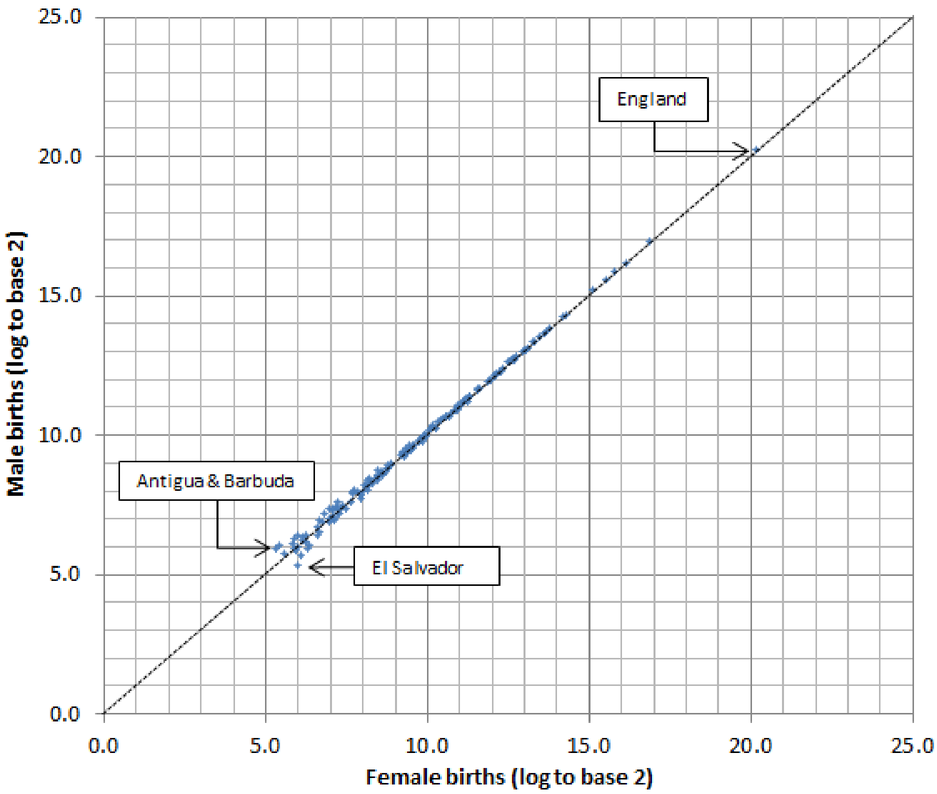
3.9 Firstly considering Slovenia, the male to female birth ratios for first, second, third born or later children are low relative to the male to female birth ratio for the unknown birth order. So by adding the males and females within the unknown category consisting of a very small number of children to the corresponding male and female totals in each birth order in turn, did not produce a significant result when applying both the Benjamini-Hochberg and Storey techniques. Therefore no matter how the unknowns are distributed across the first born, second born, third born or later categories, we fail to find a significant result. Therefore from these findings we can conclude that the high proportion of males for the unknown category was likely to have occurred by chance.

3.10 Secondly, the Asia (except Middle East) (NOS), consists of a number of countries within Asia which have not been accounted for elsewhere due to lack of precise information on the country of origin of the mother. Due to the uncertain and disparate nature of this grouping, along with the relatively small sample size for the third born or later child, we cannot consider this as a meaningful significant result. Most of the third born births from countries in Asia were properly attributed to specific countries and none of these countries showed significant results. The "Asia (except Middle east, NOS))" is likely to include births from these countries but the lack of information on the precise country of origin of the mother meant they have had to be combined into this 'Not otherwise stated' category

3.11 When interpreting the gender birth ratios in Table 2, it is important to keep in mind that this analysis covers 173 country of origin groups for 5 categories of birth order (all, 1st born, 2nd born, 3rd born or later, 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 2011-2015 for women born in Cuba, there were 102 babies who were the first born with a gender birth ratio of 168.4 whilst 95 babies were the second born with a gender birth ratio of 115.9. This wide variation exists, particularly where sample sizes are smaller (see Figure 3 and 4 below).

3.12 Although some gender birth ratios were higher than 107, such as first and second born from Cuba, 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.

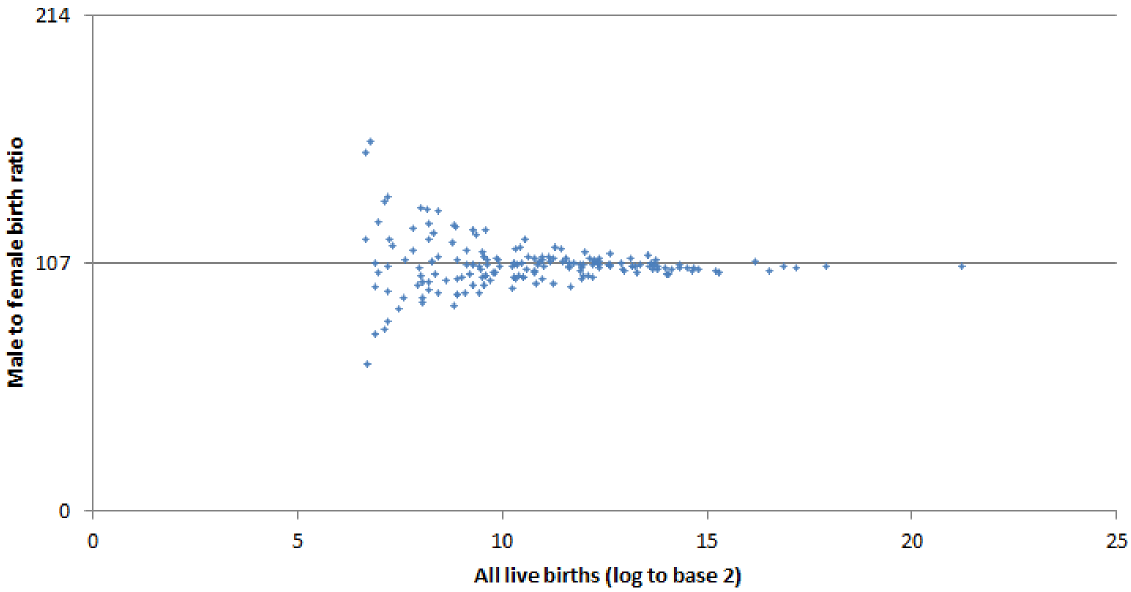
Figure 3: Plot of Male & Female births by country of origin of the mother: All births, England, 2011 – 2015



3.13 The chart above shows a plot of all male to female births by country of origin of the mother. Note that a logarithmic scale (base 2) has been applied to this data for presentation of large values (e.g. England) within the chart.

3.14 The ratio of male to female births for most countries of origin are slightly above the central line, reflecting that more males than females are born (105.3 males to 100 females from 2011 to 2015). There is some variation towards the bottom of the chart, where the number of babies born to mothers from specific countries is lower. For example, in babies born to mothers from Antigua & Barbuda there are more boys than girls, whereas for those from El Salvador, more girls were born.

Figure 4: Plot of Male to Female birth ratio by country of origin of the mother: All births, England, 2011 – 2015



3.15 The greater variation in countries with lower numbers of live births is shown in Figure 4 in relation to the unadjusted birth ratios, and compared to the 107 boys to 100 girls ratio used as the threshold for comparisons. Most countries (64 per cent) are below the 107 ratio threshold, with most of those that are higher having low sample sizes, for example Tajikistan and Antigua & Barbuda where the ratio is 160 and 155 boys to 100 girls respectively. Similar variation is seen below the 107 line, with El Salvador where there were 63 boys born for every 100 girls. As noted above, when testing using the Benjamini-Hochberg technique, there were no countries found to be significantly higher than the 107 ratio.

Births by Ethnicity of Child

3.16 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.

3.17 There were 3.5 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 (64%).

3.18 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.

3.19 When interpreting the gender birth ratios in Table 3 it is important to keep in mind that this analysis covers 9 ethnic groups for 5 categories of birth order (all, first born, second born, third born or later, and unknown birth order). As with the country of origin analysis, 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 112,499 births of children with Indian ethnicity in 2011-15, of which those babies which were second born had a gender birth ratio of 104.4, while the third born or more category had a gender birth ratio of 110.7.

3.20 Although some gender birth ratios were higher than 107, such as third born or later babies of Indian ethnicity, following the statistical testing, 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

3.21 For both the 'mother's country of origin' and 'ethnicity' analysis, there was no evidence for any true positives, i.e. underlying rates exceeding 107, 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 origin' or 'ethnicity of child' data by birth order.

Conclusion

3.22 This analysis of gender birth ratios finds **no evidence** for gender selective abortions occurring in Great Britain over the period 2011-2015.

Abortions by Gestation and Ethnicity

3.23 Data on the gender of the fetus at an abortion is not available, which is why 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.

3.24 The majority of abortions take place in the first trimester of pregnancy (92% at under 12 weeks; 58% under 7 weeks gestation), whilst NHS antenatal sexing of a fetus typically takes place much later in the pregnancy at 18-21 weeks 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. It is acknowledged that some people may seek information on gender through tests available on the internet and private clinics however data is not available on the extent to which this is happening.

3.25 To supplement the gender birth ratio analysis, further analysis has been done to investigate the relationship between gestation (and thus when gender can be identified) and abortion rates, by ethnic group of the woman. See Annex A.

Table 2: Gender birth ratios by mother's country of origin, births registered in Great Britain 2011-2015

Great Britain | *Totals and Ratios*

Country of mother's origin[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]
Total	**3,827,170**	105.3	105.5	105.3	105.0	105.4
Africa						
Africa (NOS)[2]	350	109.6	151.3	69.6	117.6	119.0
Eastern Africa						
Burundi	778	101.6	164.5	94.4	107.3	51.9
Djibouti	120	76.5	78.6	72.2	78.8	66.7
Eritrea	4,696	106.5	106.3	119.5	104.0	88.3
Ethiopia	3,263	96.7	102.3	89.5	104.7	86.3
Kenya	6,188	106.0	105.9	103.5	108.6	111.8
Madagascar	102	117.0	115.8	115.4	114.3	200.0
Malawi	1,794	98.0	92.9	97.4	98.8	115.8
Mauritius	2,745	112.8	105.8	118.1	129.6	83.3
Mozambique	553	112.7	130.2	109.8	107.8	96.4
Rwanda	720	104.5	102.8	115.6	96.2	108.2
Seychelles	224	121.8	112.1	125.0	119.0	145.5
Somalia	25,391	103.6	99.2	105.0	104.5	103.3
Tanzania	2,000	109.4	106.9	117.8	108.5	88.4
Uganda	4,423	101.6	104.0	104.7	96.9	101.2
Zambia	2,426	108.6	117.1	100.2	108.2	115.7
Zimbabwe	13,180	101.9	101.6	103.7	103.8	93.4
Middle Africa						
Angola	2,420	97.9	97.4	102.7	96.2	95.3
Cameroon	2,430	108.9	100.5	110.3	112.9	121.0
Congo	1,271	112.9	106.1	150.5	104.1	103.8
Congo (Democratic Republic)	5,081	106.7	119.7	90.0	103.2	125.2
Sao Tome and Principe	458	123.4	145.8	142.2	98.6	100.0
Northern Africa						
Algeria	4,844	107.8	112.8	101.4	108.8	111.0
Canary Islands	120	106.9	120.0	94.7	100.0	100.0
Egypt	1,994	100.4	102.3	107.8	91.0	105.6
Libya	3,805	106.3	103.9	103.8	109.0	107.4
Morocco	3,999	101.3	104.5	104.7	96.0	87.0
Sudan	3,805	103.3	106.7	103.6	100.5	112.5
Tunisia	774	121.1	124.5	123.8	100.0	350.0

Country of mother's origin[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]
Southern Africa						
Botswana	401	99.5	88.7	86.4	132.6	109.5
Namibia	474	93.5	87.8	89.9	84.0	145.8
South Africa	20,764	106.2	102.5	107.3	112.1	109.9
Swaziland	161	114.7	159.1	85.2	61.1	212.5
Western Africa						
Benin	126	125.0	233.3	95.0	115.0	100.0
Cape Verde	180	87.5	62.1	150.0	81.3	53.8
The Gambia	3,177	105.8	107.3	106.8	104.2	105.1
Ghana	16,901	101.9	104.2	100.4	101.2	102.9
Guinea	968	105.5	91.1	129.2	97.7	115.9
Guinea-Bissau	778	101.6	113.3	102.8	95.9	95.9
Ivory Coast	1,743	103.1	112.2	96.2	97.1	117.6
Liberia	512	100.8	105.4	101.8	90.1	119.5
Nigeria	38,242	103.9	101.7	103.1	106.5	105.6
St Helena and Dependencies	146	105.6	150.0	114.3	61.5	123.1
Senegal	457	88.8	60.3	83.3	117.6	88.9
Sierra Leone	3,167	105.2	104.3	109.2	103.6	102.9
Togo	265	92.0	96.4	89.2	98.2	70.6
Americas						
Caribbean						
Antigua and Barbuda	102	155.0	171.4	185.7	157.1	116.7
Bahamas	148	94.7	75.0	111.5	133.3	77.8
Barbados	252	104.9	70.9	121.2	137.5	154.5
Cuba	256	130.6	168.4	115.9	94.7	120.0
Dominica	200	108.3	125.9	121.4	74.1	114.3
Dominican Republic	288	130.4	151.5	132.6	154.8	26.7
Grenada	245	97.6	116.2	97.1	84.8	84.2
Jamaica	10,044	103.2	106.5	105.6	100.9	100.2
Montserrat	470	122.7	111.8	120.8	109.2	155.3
St Lucia	479	93.1	90.9	81.3	107.7	103.0
St Vincent	298	124.1	126.8	109.6	134.6	150.0
Trinidad and Tobago	1,411	106.9	120.7	104.8	103.6	81.6
Central America						
El Salvador	103	63.5	90.5	42.9	54.5	100.0
Guatemala	126	103.2	93.1	137.5	84.6	100.0
Mexico	1,398	113.8	119.1	111.3	112.2	72.0

Country of mother's origin[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]
South America						
Argentina	1,209	105.6	112.6	101.5	97.9	100.0
Bolivia	551	94.0	81.9	96.2	116.0	92.0
Brazil	7,618	107.3	107.6	109.4	98.0	113.5
Chile	619	106.3	103.5	108.7	121.1	82.4
Colombia	2,856	107.7	109.6	105.6	103.6	112.6
Ecuador	1,284	100.0	108.5	106.6	81.7	103.8
Guyana	686	105.4	90.1	116.1	93.5	154.1
Peru	925	109.3	110.5	105.0	100.0	160.0
Uruguay	120	96.7	104.5	73.9	120.0	100.0
Venezuela	1,347	101.6	100.3	109.8	81.5	107.5
Northern America						
Bermuda	328	102.5	75.7	126.2	128.1	105.6
Canada	6,354	106.4	106.4	104.9	107.4	113.0
United States	17,793	104.0	105.5	103.5	101.6	104.9
Asia						
Asia (Except Middle East) (NOS)[2]	347	129.8	100.0	126.0	268.4*	100.0
Central Asia						
Kazakhstan	792	108.4	110.8	111.2	102.1	86.4
Kyrgyzstan	260	101.6	86.5	104.3	142.9	80.0
Tajikistan	109	159.5	207.7	241.7	64.3	66.7
Turkmenistan	225	112.3	177.8	61.2	120.0	116.7
Uzbekistan	624	121.3	115.3	134.6	101.9	140.0
Eastern Asia						
China	20,337	104.8	106.0	102.3	105.1	108.1
China (Taiwan)	844	99.5	89.9	116.5	114.3	45.5
Hong Kong (Special admin. Region of China)	4,849	108.5	107.5	112.0	98.8	119.3
Japan	4,134	111.9	113.5	114.4	100.4	100.0
Korea (South)	1,496	117.4	123.7	116.2	94.0	127.8
Mongolia	442	115.6	122.6	107.7	116.3	122.7
Southern Asia						
Afghanistan	14,132	104.6	99.2	105.4	107.2	90.0
Bangladesh	40,481	103.2	106.2	101.6	102.7	102.3
India	73,409	107.4	105.4	107.8	111.9	114.9
Iran	5,203	106.6	102.4	113.9	100.3	109.4
Nepal	5,228	109.2	108.3	105.5	132.7	100.0

Country of mother's origin[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]
Pakistan	95,060	103.8	106.2	103.9	102.6	96.4
Sri Lanka	16,707	102.5	100.3	103.2	105.0	100.4
South-Eastern Asia						
Brunei	321	119.9	96.1	141.5	136.0	250.0
Burma	652	119.5	110.3	138.1	111.7	150.0
Cambodia	138	133.9	152.9	123.1	130.8	133.3
East Timor	344	94.4	98.0	82.1	90.9	118.5
Indonesia	1,245	107.2	102.1	96.5	140.8	116.0
Malaysia	4,785	100.8	96.2	105.6	101.8	104.2
Philippines	12,834	106.8	110.4	103.3	106.2	109.1
Singapore	1,250	100.6	97.5	100.9	98.9	134.5
Thailand	5,228	105.0	101.1	107.8	113.3	91.6
Vietnam	4,483	109.2	105.2	105.0	117.6	123.1
Western Asia						
Armenia	264	89.9	79.1	100.0	85.0	200.0
Azerbaijan	479	108.3	98.1	112.5	130.3	111.1
Bahrain	474	100.0	92.5	108.4	100.0	110.0
Cyprus	2,044	105.4	105.9	103.8	113.2	95.8
Georgia	567	106.2	100.8	113.8	114.6	92.9
Iraq	12,395	105.8	109.5	103.6	104.3	111.7
Israel	2,323	108.0	103.3	93.8	118.9	166.7
Jordan	758	97.4	100.0	102.4	88.3	150.0
Kuwait	2,001	108.7	118.8	103.2	107.9	95.1
Lebanon	1,852	106.5	106.0	100.3	114.4	100.0
Oman	314	107.9	114.0	127.8	89.1	300.0
Palestine	295	116.9	137.1	133.3	98.4	100.0
Qatar	296	98.7	103.8	112.2	85.7	66.7
Saudi Arabia	3,997	106.5	110.6	102.9	108.0	79.0
Syria	1,885	107.6	106.1	111.8	103.7	137.5
Turkey	12,154	110.6	113.0	108.1	110.9	109.7
United Arab Emirates	1,786	103.9	104.4	105.7	103.7	87.2
Yemen	2,474	113.8	110.2	141.2	106.0	84.0
Europe						
Eastern Europe						
Belarus	967	108.4	99.5	110.8	147.9	96.6
Bulgaria	8,973	108.7	108.6	109.3	110.5	105.1
Czech Republic	9,220	105.4	102.7	105.6	109.7	106.3
Hungary	9,139	105.4	102.0	108.2	110.4	108.8
Kosovo	3,128	106.7	103.7	108.8	107.9	104.5

Country of mother's origin[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]
Poland	117,975	105.9	107.7	105.3	102.9	104.5
Moldova	1,569	109.8	97.2	114.7	132.5	145.7
Romania	28,438	104.0	104.8	101.2	105.9	107.8
Russia	6,265	105.6	106.8	102.4	111.4	101.7
Slovakia	13,625	108.3	110.9	108.8	105.2	103.9
Ukraine	3,940	105.1	103.4	105.8	106.7	110.4
Union of Soviet Socialist States	299	95.4	97.7	80.4	121.4	200.0
Northern Europe						
Channel Islands	1,311	106.5	100.4	105.0	106.0	133.3
Denmark	1,777	108.8	116.9	99.7	113.8	101.2
England	2,440,683	105.4	105.3	105.2	105.4	105.6
Estonia	1,560	104.2	114.5	93.8	101.2	100.9
Finland	1,444	100.8	120.4	89.6	76.7	105.8
Iceland	194	92.1	103.1	94.1	68.2	100.0
Ireland	16,102	105.2	105.7	106.7	103.1	103.2
Isle of Man	685	94.1	110.9	90.2	80.0	74.5
Latvia	14,096	105.8	107.1	102.3	105.7	110.4
Lithuania	23,425	105.2	101.7	108.0	107.4	107.6
Northern Ireland	13,319	106.3	110.9	105.2	101.7	100.8
Norway	1,212	95.8	102.8	93.2	83.8	95.5
Scotland	245,204	105.3	105.3	105.4	104.5	105.8
Sweden	3,446	107.1	109.1	101.9	123.2	99.5
Wales	146,161	105.3	108.1	105.6	102.3	103.2
Southern Europe						
Albania	6,410	111.1	111.7	107.3	120.4	107.6
Bosnia and Herzegovina	802	106.2	106.0	114.2	90.6	102.9
Croatia	735	111.8	103.0	131.1	118.8	78.6
Gibraltar	741	109.9	112.2	110.9	113.5	95.6
Greece	2,981	109.2	114.5	107.0	102.1	85.0
Italy	7,820	104.5	102.4	106.6	111.4	100.3
Macedonia	593	102.4	136.9	90.2	88.4	41.7
Malta	628	97.5	104.3	107.7	82.2	81.6
Portugal	9,695	105.5	102.6	109.6	108.1	100.5
Serbia	735	100.8	96.0	123.8	74.6	104.8
Slovenia	268	98.5	81.8	84.8	110.5	475*
Spain	8,106	103.6	101.5	107.6	101.2	104.3
Yugoslavia	146	135.5	169.6	95.5	140.0	142.9
Western Europe						
Austria	879	103.0	106.0	111.9	92.3	78.9

Country of mother's origin[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]
Belgium	2,226	109.6	100.0	128.2	97.3	143.1
France	13,170	104.2	103.2	106.1	102.3	106.1
Germany	26,258	105.2	104.8	106.2	103.6	105.9
Luxembourg	152	117.1	125.8	116.0	80.0	150.0
Netherlands	3,904	99.9	98.1	111.1	96.5	79.3
Sw itzerland	1,475	100.7	103.0	95.1	95.7	150.0
Oceania						
Australia and New Zealand						
Australia	10,651	106.1	104.9	107.1	109.3	103.2
New Zealand	5,209	107.6	102.6	113.0	121.2	95.4
Melanesia						
Fiji	898	103.2	120.4	100.0	94.1	171.4
Papua New Guinea	149	81.7	64.3	80.0	100.0	100.0
Not Stated	139	78.2	71.4	52.6	61.5	131.6

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

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

The asterisk (*) indicates that the result is statistically significant after applying the Benjamini-Hochberg procedure. See paragraph 3.8 for explanations.

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, 2011-2015[1]

England and Wales — *Totals and Ratios*

Ethnicity of the child	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]
Total	3,537,963	105.3	105.5	105.3	105.1	105.3
White British	2,263,007	105.4	105.6	105.3	105.2	105.5
White Other	335,025	105.9	106.6	105.6	105.4	104.9
Indian	112,499	105.5	104.6	104.4	110.7	99.0
Pakistani	143,177	104.2	105.5	104.9	103.2	99.8
Bangladeshi	49,630	102.7	103.5	103.6	101.8	100.5
Black African	119,647	104.0	104.7	102.7	105.1	102.3
Black Caribbean	32,465	104.0	101.0	106.0	105.0	103.8
Other	362,859	105.5	105.1	106.1	105.5	105.4
Not Stated	119,654	105.6	105.3	105.4	105.1	107.4

[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 placed in this 'ratio unknown' category.

Source: Office for National Statistics

Appendix A: Abortions by Gestation and Ethnicity

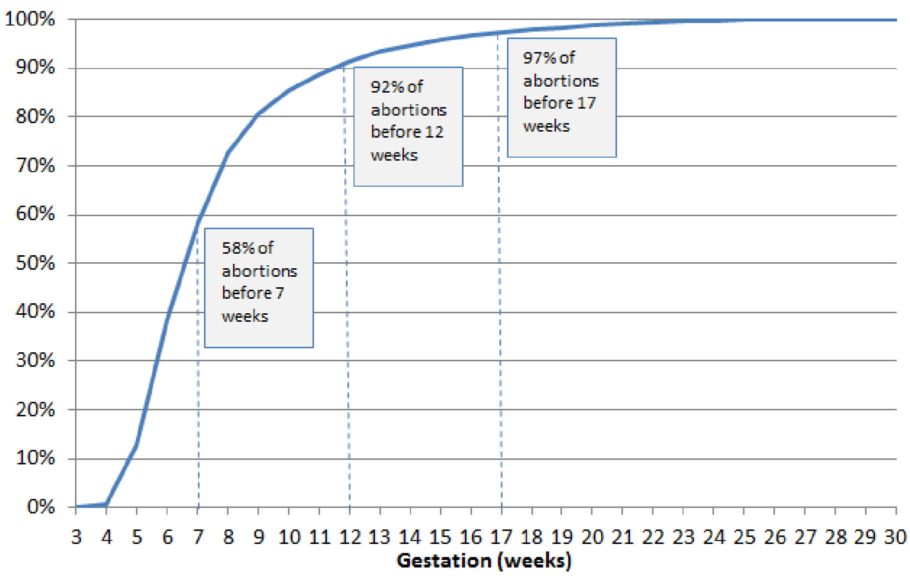
This section adds some additional context on abortions by gestation and ethnicity from the annual abortion statistics publication:
https://www.gov.uk/government/statistics/report-on-abortion-statistics-in-england-and-wales-for-2016

This covers residents of England and Wales in 2016.

All Abortions, by gestation

The total number of abortions for residents of England and Wales in 2016 was 185,596. This was a very minor decline from 2015 of 0.1%, but an increase of 0.6% from 2014. The majority of abortions took place in the early stages of pregnancy:

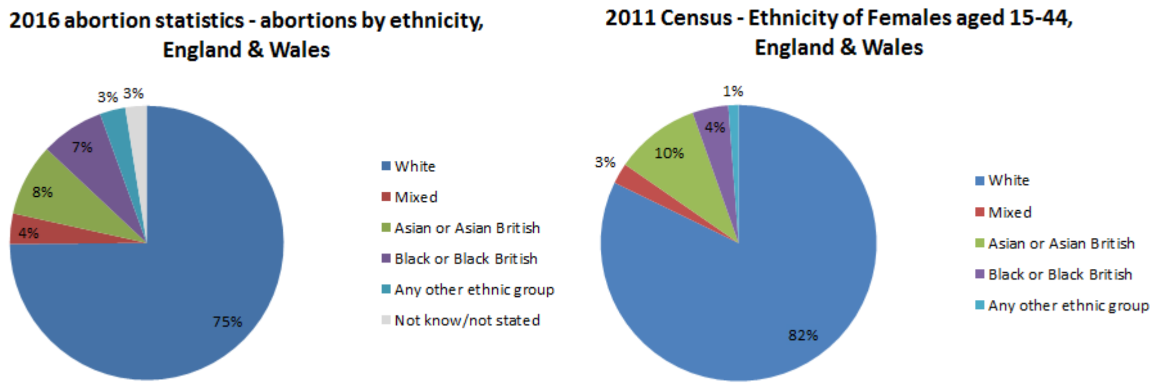
Chart 1: Proportion of abortions by gestation week, England & Wales, 2016



All Abortions, by ethnic group

Of women whose ethnicity was recorded in 2016, 75% were reported as White, 8% as Asian or Asian British and 7% as Black or Black British. This differs from the ethnicity population estimates based on the 2011 census of females aged 15-44 years where 82% are reported as White, 10% as Asian or Asian British and 4% as Black or Black British.

Chart 2 a) abortion statistics split by ethnic group, England & Wales, 2016; and b) ethnicity of females aged 15-44 in England and Wales, 2011 census data



All Abortions, by gestation and ethnic group

There are variations between the gestation period of an abortion when comparing different ethnicities. The proportion of abortions before 17 weeks range from 96 to 98 per cent depending on the ethnic group of the woman. For abortions carried out before 12 weeks the range between different ethnic groups is from 88 to 91 per cent, with a wider range for abortions carried out before 7 weeks from 34 to 46 per cent depending on the ethnic group of the woman.

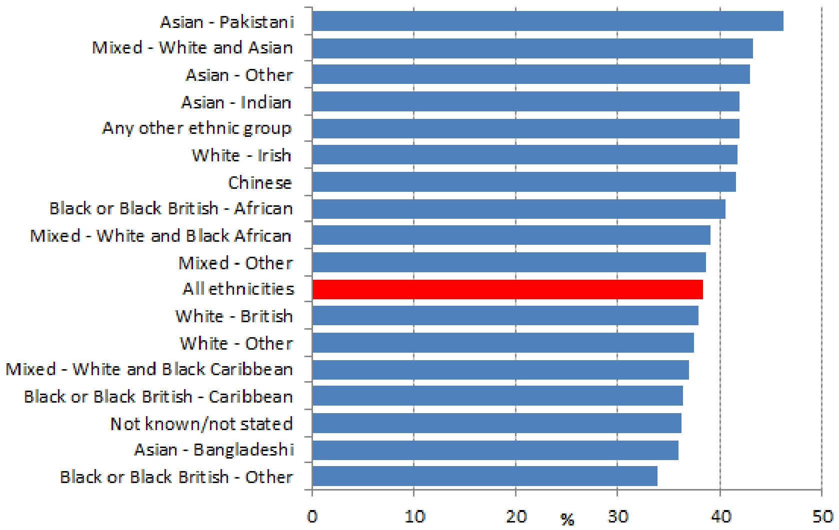
Table 1: Abortions by gestation and ethnic group, residents of England and Wales, 2016

	Gestation weeks										
			Number						***Percentage***		
	Total	**<7**	**7-11**	**12-16**	**17-21**	**22+**	***<7***	***7-11***	***12-16***	***17-21***	***22+***
All ethnicities	185,596	71,264	93,734	14,397	4,693	1,508	*38*	*51*	*8*	*3*	*1*
White - British	120,284	45,551	61,433	9,395	2,975	930	*38*	*51*	*8*	*2*	*1*
White - Irish	1,163	486	540	90	30	17	*42*	*46*	*8*	*3*	*1*
White - Other	17,511	6,553	8,827	1,501	468	162	*37*	*50*	*9*	*3*	*1*
Mixed - White and Black Caribbean	2,919	1,079	1,488	248	74	30	*37*	*51*	*8*	*3*	*1*
Mixed - White and Asian	954	412	454	61	22	5	*43*	*48*	*6*	*2*	*1*
Mixed - White and Black African	941	368	478	67	24	4	*39*	*51*	*7*	*3*	*0*
Mixed - Other	1,861	720	911	151	59	20	*39*	*49*	*8*	*3*	*1*
Asian - Indian	5,989	2,512	2,851	372	192	62	*42*	*48*	*6*	*3*	*1*
Asian - Pakistani	3,867	1,789	1,676	255	113	34	*46*	*43*	*7*	*3*	*1*
Asian - Bangladeshi	1,625	583	871	115	43	13	*36*	*54*	*7*	*3*	*1*
Asian - Other	4,323	1,853	2,028	300	97	45	*43*	*47*	*7*	*2*	*1*
Black or Black British - African	8,842	3,592	4,288	635	249	78	*41*	*48*	*7*	*3*	*1*
Black or Black British - Caribbean	4,201	1,529	2,152	375	118	27	*36*	*51*	*9*	*3*	*1*
Black or Black British - Other	833	282	452	75	19	5	*34*	*54*	*9*	*2*	*1*
Chinese	1,554	647	756	97	35	19	*42*	*49*	*6*	*2*	*1*
Any other ethnic group	2,512	1,051	1,199	188	52	22	*42*	*48*	*7*	*2*	*1*
Not known/not stated	6,217	2,257	3,330	472	123	35	*36*	*54*	*8*	*2*	*1*

For abortions under 7 weeks, ‘Asian or Asian British – Pakistani’ women have the highest proportion (46 per cent), with ‘Mixed – White and Asian’ and ‘Asian – Other’ also having a high proportion of women having abortions under 7 weeks (both 43 per cent).

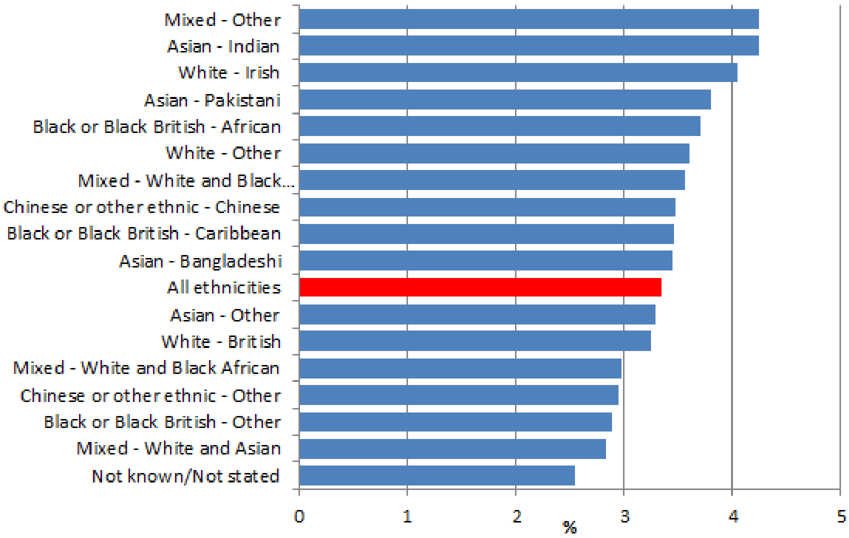
Ethnic groups with the lowest proportion having an abortion under 7 weeks gestation were: ‘Black or Black British – Other’ (34 per cent) ‘Asian or Asian British – Bangladeshi’ (36 per cent).

Chart 3: abortions by gestation and ethnic group: proportion under 7 weeks gestation



Abortions over 17 weeks of gestation account for 3.3 per cent of all abortions. There is variation across ethnicities for this gestation with women from ‘Mixed – Other’, ‘Asian – Indian’ and ‘White – Irish’ ethnicities having over 4 per cent of abortions over 17 weeks.

Chart 4: abortions by gestation and ethnic group: proportion over 17 weeks gestation



Repeat abortions and ethnic group

Of all women who had an abortion in 2016, 38 per cent had already had one or more previous abortions. Again, amongst women who have had a previous abortion, there was variation across ethnic groups.

33% of Chinese and Asian or Asian British women having abortions in 2016 had previously had an abortion, compared with 48% of Black or Black British women and 46% of women of Mixed ethnic groups.

Table 2: Percentage of women who had one, two and three or more previous abortions, by ethnic group, England and Wales, 2016

	Number of previous abortions				
	Percentage				
	0	**1**	**2**	**3 or more**	**Total**
All ethnicities	*62*	*28*	*8*	*3*	*100*
White	*62*	*28*	*8*	*3*	*100*
Mixed	*54*	*31*	*11*	*4*	*100*
Asian or Asian British	*67*	*25*	*7*	*2*	*100*
Black or Black British	*52*	*32*	*11*	*5*	*100*
Chinese	*67*	*24*	*7*	*3*	*100*
Any other ethnic group	*64*	*28*	*6*	*2*	*100*
Not know/not stated	*67*	*24*	*7*	*2*	*100*

Appendix B: Analytical techniques

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 country of origin of the mother and the ethnicity of the child, this leads to a ‘multiple testing problem’. This is because the probability of getting a significant result purely by chance, 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 a significant result, when multiple tests are being run. To assist in the detection of results which are still significant when many tests are run simultaneously, 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 for all tests which have a rank of i where $i = k, \ldots, m$ that they are significant results.

Storey technique

The Benjamini-Hochberg procedure makes adjustments to the critical values for the group of test being used, in such a way as to control the false discovery rate (that is, to limit the proportion of outcomes where the test says that a result is significant, but no effect is actually present). Storey (2002)[19] and Storey & Tibshirani (2003)[20] suggested an alternative procedure, where the positive false discovery rate is estimated for a fixed region where the null hypothesis would be rejected (i.e. the result is statistically significant) .This area is called the q-value and can be compared for different rejection regions as evidence for what proportion of false discoveries is actually seen across the series of tests.

[19] Storey, J. D. (2002). A direct approach to false discovery rates. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, *64*(3), 479-498

[20] Storey, J. D., & Tibshirani, R. (2003). Statistical significance for genomewide studies. *Proceedings of the National Academy of Sciences*, *100*(16), 9440-9445.

Appendix C: Power Considerations

This information on power calculations has been included for illustration purposes only. Power describes the likelihood of a testing procedure finding a significant result when the underlying sex-ratio is truly in excess of 107.

In testing whether a result is statistically significant, it is common practice to construct the test so that the likelihood of getting a value that is significant, when the true sex ratio does not exceed 107, is less than 5%. This figure of 5% is known as the alpha (α) value. It is also called the 'size' of the test, or it's 'significance level'. The power of the test is the likelihood of achieving a significant result when the true ratio is in excess of 107. In simple circumstances the question is how many births do there need to be in order to be able to construct a 5 % level significance test that has a specified power, say 80%, against a specific alternative such as the true ratio being 107.5

The circumstances here are however not simple, and we are testing many hypotheses (e.g. one for each country and each birth order) simultaneously. It is not possible to evaluate the power of the Benjamini-Hochberg procedure in a straightforward manner.

However, for illustrative purposes the table below shows how large a particular country's observed ratio of boys to girls would have to be, before the testing procedure would report a ratio significantly above 107.

For example, to identify that one of the ethnic groups with just 100 births is significant, the observed sex ratio for that group would have to be at least 203. Similarly if one of the countries of mother's origin had 100,000 births it would not be identified as significant unless its observed ratio was 110 or more.

Table 4: Required observed sex ratio for the testing procedure to show a result significant at the 5 % level for the shown number of births.

	Ratio of Boys to Girls x 100		
Number of births	**Single Test**	**Ethnic Group (45 tests)***	**Country of origin (865 tests)****
100	149	203	244
500	124	141	152
1,000	119	130	137
5,000	112	117	119
10,000	111	114	116
50,000	109	110	111
100,000	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 173 country of origin groups, by five lots of parity tests (All, 1st born, 2nd born, 3rd born or more, unknown), total 865 tests.

For comparison with the actual data the table below shows how many countries of origin had a number of births in the shown range.

Table 5: Number of Countries of Origin of mother that were in the shown range of birth numbers

Number of births	Number of Countries of origin of mother
0-99	0
100-499	49
500-999	27
1,000-4,999	52
5,000-9,999	16
10,000-49,999	23
50,000-99,999	2
100,000-499,999	3
500,000 or more	1

Appendix D: 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 Benjamini-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 Benjamini-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 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 the birth order is of primary policy interest, the methodology review recommended reporting birth ratios and analyses for the unknown birth order from 2016.

Appendix E: Further Information

Enquiries

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

Birth Ratio Statistics
Department of Health
Richmond House
79 Whitehall
London
SW1A 2NS

e-mail:

- birthratios@dh.gsi.gov.uk

Links

This bulletin for birth ratio analysis for 2011-2015, 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, 2016

- https://www.gov.uk/government/statistics/report-on-abortion-statistics-in-england-and-wales-for-2016