Title:

Quantifying miscarriage sex bias in England and Wales, 1993-2017

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Keywords: Miscarriage; sex ratio; sex bias; abortion; conception; pregnancy; stillbirth

Abstract:

Background:

The human sex ratio at birth is skewed towards males, with on average 1,053 boys born for every 1,000 girls in England and Wales between 1993 and 2017. Stillbirth also shows a male bias, averaging 1,112 boys lost per 1,000 girls over the same period. If the sex ratio at conception is equal, and more boys are lost to stillbirth, how is the sex ratio at birth biased towards boys? Logically, we must be losing a large number of girls early in pregnancy.

Methods:

Here I use data on live births, stillbirths and abortions in England and Wales between the years 1993-2017, and estimates of miscarriage rates from the literature (where 10%, 20%, 25% or 33% of conceptions result in miscarriage), to determine numbers of conceptions. The primary sex ratio at conception is taken to be 50:50. Subtracting known numbers of boys and girls in live births and stillbirths, and predicting sex ratios of aborted foetuses, allows calculation of the sex ratio of miscarried products of conception.

Findings:

For every year in this 25 year dataset, more girls are miscarried than boys. If early abortions (≤12 weeks) are female biased (55:45) and later abortions (≥13 weeks) male biased (45:55), then, depending on the number of conceptions that end in miscarriage, 941-986 males are miscarried per 1,000 females. If the abortus sex ratio is balanced, the miscarriage sex bias is exacerbated, with between 691-921 males lost per 1,000 females.

Interpretation:

Girls are more susceptible to miscarriage than boys, and there is a greater loss of girls throughout pregnancy. This study quantifies the extent of this miscarriage sex bias, and provides a starting point for understanding why this bias exists, and when it is established during pregnancy.

Background:

Males and females differ from the very point of conception, with females having two X chromosomes, and males one X and one Y. Only males can express genes on the Y chromosome, and, prior to the completion of X chromosome inactivation, females can produce up to twice the amount of gene product for any gene encoded by the X chromosome. These differences are evident not only in the metabolism of early male and female embryos[1–4], but also in differential survival throughout gestation. The human sex ratio at birth is consistently biased towards boys, and remarkably stable (Figure 1), with on average 1,053 boys born for every 1,000 girls in England and Wales between 1927 and 2017. Indeed, the slight bias towards boys at birth is so stable that deviations are indicative of sex-specific abortions[5]. This bias at birth is consistent, even though boys are more susceptible to stillbirth[6], with on average 1,127 boys lost per 1,000 girls between 1927 and 2017, and only three years between 1927 and 2017 where more girls were stillborn (1974, 1975 and 2016 (Figure 1)). More generally, the human sex ratio fluctuates from conception to birth, with a greater loss of males in the first few weeks, followed by a greater loss of females in the first trimester, and a general male bias from around week 20 onwards[7], although these fluctuations are generally minor, and the overall sex ratio never deviates by more than a few percent. Historically, the male bias at birth was taken to result from the production of a greater proportion of males at conception (the primary sex ratio), although more recent data from *in vitro* fertilisation supports a balanced PSR in humans (see Orzack et al.[7] for discussion), as does the simple mechanics of equal segregation of X and Y chromosomes during spermatogenesis. If the sex ratio at fertilisation is equal, then there must be an overall greater loss of girls during gestation.

Whilst 10% of clinically-recognised pregnancies end in miscarriage, the true number is estimated to be much higher as many pregnancies are lost before they are identified, and up to one third of all pregnancies may end in miscarriage[8–12]. Determining the sex of miscarried products of conception has typically been complicated by the necessity to collect foetal tissue and identify sex chromosomes, where contamination by maternal tissues could lead to an overestimation of the number of miscarried girls[13]. What is needed therefore is an alternative method of determining the sex ratio of miscarried products of conception.

In England and Wales, all births and stillbirths must be registered, and there is extensive historical data available on numbers of live births and stillbirths, including sex ratios (it should be noted however that in October 1992, the Stillbirth (Definition) Act 1992 changed the gestation cut-off for stillbirths from 28 or more weeks of gestation to 24 or more weeks, and so data from 1993 onwards is not comparable to previous

years). In addition to extensive live birth and stillbirth data, the requirement that all practitioners in England and Wales who perform an abortion must notify the Chief Medical Officer means that abortion statistics (including number of abortions by gestation week) are available going back to the late 1960's. The stability of the overall sex ratio at birth (Figure 1) suggests that, in England and Wales at least, there is no sex-selective abortion, and the general increase in the number of legal abortions, and the lack of maternal deaths due to complications of illegal abortions[14] also suggests that there are few if any unrecorded abortions in England and Wales. If the human sex ratio is female-biased until around week 12, and male-biased subsequently[7], then we can calculate the proportion of males and females that are legally aborted each year and so determine the total number of pregnancies (here defined as a conception resulting in a live birth, stillbirth, or abortion). Using predicted values for the number of conceptions that resulted in miscarriage, it is then possible to calculate the total number of conceptions, and, from that, the miscarriage sex ratio.

Here, I use a 25 year dataset from 1993 to 2017, comprising 16,656,203 live births, 86,714 stillbirths, and 4,512,654 legal abortions to calculate the miscarriage sex ratio for 23,616,601 to 31,723,793 predicted conceptions and so demonstrate the extent of the hypothesised miscarriage sex bias.

Methods:

Data for numbers of maternities, live births and stillbirths, including numbers of males and females, were collected from the Office for National Statistics (https://www.ons.gov.uk/) 'Review of the Registrar General on births and patterns of family building in England and Wales', Series FM1 (numbers 22-37, covering 1993-2008), the 'Characteristics of Birth 2, England and Wales' dataset (2009-2013), the 'Birth characteristics dataset' (2014-2016), and the 'Summary of key birth statistics, 1838 to 2017'. Data on numbers of legal abortions from 2011-2017 were obtained from the Department of Health and Social Care (DHSC) 'Abortion statistics, England and Wales' collection (https://www.gov.uk/government/collections/abortion-statistics-for-england-and-wales), and for 1993-2010 from the UK Government Web Archive (http://www.nationalarchives.gov.uk/webarchive/). Numbers of stillbirths by age of mother for 2012 were obtained from the from the 'Child Mortality Statistics 2012' dataset (https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/childmortalitystatisticschildhoodinfantandperinatalchildhoodinfantandperinatalmortalityinenglandandwales), and

England and Wales population data were obtained from the 'MYE2: Population Estimates by single year of age and sex for local authorities in the UK, mid-2012' (https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland).

Gestation week data is variable across the abortion dataset, and so statistics were pooled into abortions occurring either ≤12 weeks or ≥13 weeks. Investigations of abortus sex have consistently shown a bias towards females, ranging from around 0.55 to 0.71-0.77[15–17]. A comprehensive study of the human sex ratio from conception to birth[7] supports the lower values, and I have therefore chosen a conservative estimate of a sex ratio of 55:45 female:male ≤12 weeks and 45:55 female:male ≥13 weeks. Using these values, I calculated the number of male and female abortuses each year.

Adding together the total number of live births, stillbirths and legal abortions provided the number of pregnancies, and accepting that these represent 90%, 80%, 75% or 67% of actual conceptions (i.e. the probability that a conception resulted in miscarriage was 10%, 20%, 25% or 33%) determined the relevant number of conceptions. If the primary sex ratio is equal, then equal numbers of males and females are conceived, and subtraction of the known numbers of live and stillborn males and females, and the predicted male and female abortuses left the number of products of conception lost to miscarriage.

Statistical significance of deviation of calculated numbers of miscarried males and females from expected numbers (males and females are equally susceptible to miscarriage) was assessed using Pearson's χ^2 test. All calculations were rounded to the nearest whole number to reflect the impossibility of conceiving a fraction of a person, and so in some cases annual totals are not the sum of their constituent parts. It also goes without saying that the ratios presented here address only a narrow range of biological sex, not gender, and are predicated on the simplistic assumption that XX = female and XY = male.

Role of the funding source: No relevant funding to declare.

Results:

In England and Wales between 1993 and 2017 there were 16,489,289 maternities (a pregnancy resulting in the birth of one or more children including stillbirths, of which around 1.5% resulted in multiple births); 16,656,203 live births (8,114,739 female and 8,541,464 male, with on average 1,053 males born per 1,000 females); 86,714 stillbirths (41,059 female and 45,655 male, with on average 1,112 males stillborn per 1,000

females); 4,512,024 legal abortions, and between 23,616,601 to 31,723,793 conceptions (Supplemental table S1). Of the 4,512,024 abortions, 4,044,380 occurred ≤12 weeks of gestation and 467,644 occurred ≥13 weeks, with 2,435,740 girls aborted to 2,076,284 boys, for an average of 853 boys aborted per 1,000 girls (Figure 2, Table 1). There were 2,361,660 – 10,468,852 miscarriages in the years 1993-2017, averaging between 94,466 per year (941 males per 1,000 females) if 10% of all conceptions result in miscarriage to 418,754 per year (986 males per 1,000 females) for a miscarriage risk of 33% (Table 2). From this 25 year dataset for England and Wales, more girls were aborted than boys, more boys were born live and stillborn, and significantly more girls were miscarried ($P < 0.00001$, Pearson's χ^2 test, Figure 3).

Discussion:

Miscarriage affects around 10% of clinically-recognised pregnancies, and a far higher number of unrecognised ones. If we are to reduce or remove the prevalence of this emotionally-damaging pregnancy outcome, we must understand the factors that influence pregnancy retention or loss. The bias towards males in the human sex ratio at birth has long hinted at a greater loss of females during pregnancy, but the problems inherent in obtaining and interpreting tissue samples from miscarried products of conception has made estimation of the role played by fetal sex in pregnancy outcome almost impossible. Using population-level data on births and abortions, I show that the male bias in the human sex ratio at birth is the result of a greater loss of females to miscarriage during pregnancy. More females than males are also aborted, largely as a result of a greater number of abortions occurring ≤12 weeks of gestation when the sex ratio is skewed towards females. There is no evidence that the greater proportion of aborted females is the result of sex-specific abortion. If the female abortion bias is removed (i.e. the abortus sex ratio is equal, irrespective of when the abortion occurred) then the female bias in miscarriage is exacerbated, with between 691-921 males lost per 1,000 females (Supplemental tables S2, and S3, Supplemental Figure S1).

Interestingly, only a relatively minor change in primary sex ratio to produce between 49.85% and 49.89% females rather than 50% is sufficient to remove the miscarriage sex bias, even with the greater number of females aborted (Supplemental table S4). If the abortus sex ratio is equal, the primary sex ratio must produce between 49.09% to 49.32% females to remove the miscarriage sex bias (Supplemental table S5). Given unbiased segregation of sex chromosomes during sperm formation, a primary sex ratio of 50:50 can be assumed, and the miscarriage sex bias is real.

My analysis represents the first attempt to theoretically determine both the sex ratio of abortuses, and the sex ratio of miscarried products of conception. Obviously, there is a disconnect between year of birth, stillbirth or abortion and year of conception, and certain assumptions had to be made, such as the number of aborted males and females (55:45 in favour of females ≤12 weeks and 45:55 in favour of males ≥13 weeks), and these reflected the typical ranges in the literature as far as was possible[15–17]. Similarly, the number of conceptions that result in miscarriage is unknown, but the values used here (10%, 20%, 25%, 33%) are in accordance with accepted ranges[8–11]. However, far higher values have been proposed. In 1975, Roberts and Lowe attempted to predict the annual number of conceptions in England and Wales in 1971[18], and suggested that up to 78% of conceptions were lost. Their analysis was based only on married women, hypothesised a mean frequency of coitus twice a week (one in four of which was unprotected), and did not include data for pregnancies ending in abortion. Using data from the National Surveys of Sexual Attitudes and Lifestyles (Natsal) it is possible to refine these calculations, and Natsal-3[19] suggests that women aged 16-44 in the survey period (6th September 2010 – 31st August 2012) had on average 4.9 occasions of sexual intercourse (defined as vaginal, oral or anal intercourse) in the preceding 4 weeks, of which 69% included vaginal sex (defined as a man's penis in a woman's vagina). The frequency of sexual intercourse for this age group is likely nearer 1.2 occasions per week, with 0.85 instances of vaginal sex per week. The annual frequency (i.e. for 52 weeks) of vaginal sex for women aged 16-44 in the survey period was therefore 44.2, not the 104 previously used by Roberts and Lowe[18]. The proportion of unprotected acts of coitus during the survey period is also now lower than the 25% estimate of Roberts and Lowe, and is likely nearer 5-7% for women aged 16-44[20], increasing to around 10% if less effective methods of contraception are included, or to 1/6 if some consideration is given to those trying to conceive or who were already pregnant. The number of unprotected instances of vaginal sex per woman per year is therefore around 7, and, of these, 1/14 will occur within 48 hours of ovulation. Given a fertilisation rate of around 60% in *in vitro* fertilisation[21], where sperm quality is likely higher than that of a "normal" ejaculate, an *in vivo* fertilisation rate of one in three seems reasonable. The Office for National Statistics mid-year population estimate for mid-2012 predicted that there were 8,884,341 women between the ages of 16-39 in England and Wales, and using these values I have estimated the number of "missing" conceptions (i.e. those not accounted for in the relevant live birth, stillbirth and abortion statistics, which can be considered to represent miscarried products of conception) (Table 3). For women aged 16-39 in 2012, the overall miscarriage rate was 43%, and for women aged 20-39

(responsible for 91% of all live births, 88% of stillbirths and 78% of abortions), the average rate of loss was 38%. Given the inherent uncertainty in these calculations, the miscarriage ranges used in my analysis (10%, 20%, 25%, 33%) therefore seem in accordance with this theoretical prediction, and the identification of an inherent female bias seems robust.

Finally, it should be noted that I cannot (and do not) make any distinction between sporadic and recurrent miscarriages. This may prove to be significant in future, as a study of fetal sex in recurrent miscarriages[13] found a much higher females-biased sex ratio than found here (64:36, based on 313 products of conception), although this study may have had issues with maternal contamination, and is based on a much smaller sample size. Luckily, we are now in a position where investigation of miscarriage sex bias may not be so heavily influenced by maternal contamination, as cell-free fetal DNA[22] offers an alternative method of determining fetal sex based on presence or absence of a Y chromosome (or a specific region of the Y chromosome)[23,24], even as early as 5-7 weeks of gestation. With an appropriate program of blood sampling and tracking of pregnancy outcomes, it will be possible to assess miscarriage sex ratio, and definitively show to what extent fetal sex influences adverse pregnancy outcomes.

Declaration of interests:

No interests to declare

Acknowledgements:

I would like to thank Tom Brekke, Daniel Brison and David Steinsaltz for comments and advice on the manuscript, and Gudrun Rieck for general discussion.

References:

1 Machado AF, Zimmerman EF, Hovland DN, Weiss R, Collins MD. Diabetic embryopathy in C57BL/6J mice. Altered fetal sex ratio and impact of the splotch allele. *Diabetes* 2001; **50**: 1193–9.

2 Gutiérrez-Adán A, Granados J, Pintado B, De La Fuente J. Influence of glucose on the sex ratio of bovine IVM/IVF embryos cultured in vitro. *Reprod Fertil Dev* 2001; **13**: 361–5.

3 Kimura K, Spate LD, Green MP, Roberts RM. Effects of oxidative stress and inhibitors of the pentose phosphate pathway on sexually dimorphic production of IFN-? by bovine blastocysts. *Mol Reprod*

Dev 2004; **68**: 88–95.

4 Cameron EZ, Lemons PR, Bateman PW, Bennett NC. Experimental alteration of litter sex ratios in a mammal. *Proc R Soc B Biol Sci* 2008; **275**: 323–7.

5 Urquia ML, Moineddin R, Jha P, *et al.* Sex ratios at birth after induced abortion. *CMAJ* 2016; **188**: E181-90.

6 Mondal D, Galloway TS, Bailey TC, Mathews F. Elevated risk of stillbirth in males: Systematic review and meta-analysis of more than 30 million births. *BMC Med* 2014; **12**: 220.

7 Orzack SH, Stubblefield JW, Akmaev VR, *et al.* The human sex ratio from conception to birth. *Proc Natl Acad Sci U S A* 2015; **112**: E2102-11.

8 Wilcox AJ, Weinberg CR, O'Connor JF, *et al.* Incidence of Early Loss of Pregnancy. *N Engl J Med* 1988; **319**: 189–94.

9 Maconochie N, Doyle P, Prior S, Simmons R. Risk factors for first trimester miscarriage-results from a UK-population-based case-control study. *BJOG An Int J Obstet Gynaecol* 2007; **114**: 170–86.

10 Ammon Avalos L, Galindo C, Li D-K. A systematic review to calculate background miscarriage rates using life table analysis. *Birth Defects Res Part A Clin Mol Teratol* 2012; **94**: 417–23.

11 Wilcox AJ, Baird DD, Weinberg CR. Time of Implantation of the Conceptus and Loss of Pregnancy. *N Engl J Med* 1999; **340**: 1796–9.

12 Wang X, Chen C, Wang L, Chen D, Guang W, French J. Conception, early pregnancy loss, and time to clinical pregnancy: a population-based prospective study. *Fertil Steril* 2003; **79**: 577–84.

13 Del Fabro A, Driul L, Anis O, *et al.* Fetal gender ratio in recurrent miscarriages. *Int J Womens Health* 2011; **3**: 213–7.

14 Cantwell R, Clutton-Brock T, Cooper G, *et al.* Saving Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006-2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. *Bjog* 2011; **118 Suppl**: 1–203.

15 Eiben B, Bartels I, Bähr-Porsch S, *et al.* Cytogenetic analysis of 750 spontaneous abortions with the direct-preparation method of chorionic villi and its implications for studying genetic causes of pregnancy wastage. *Am J Hum Genet* 1990; **47**: 656–63.

16 Guerneri S, Bettio D, Simoni G, Brambati B, Lanzani A, Fraccaro M. Prevalence and distribution of chromosome abnormalities in a sample of first trimester internal abortions. *Hum Reprod* 1987; **2**:

735–9.

17 Bartels I, Hansmann I, Eiben B. Excess of females in chromosomally normal spontaneous abortuses. *Am J Med Genet* 1990; **35**: 297–8.

18 Roberts C, Lowe C. Where have all the conceptions gone? *Lancet* 1975; **305**: 498–9.

19 Mercer CH, Tanton C, Prah P, *et al.* Changes in sexual attitudes and lifestyles in Britain through the life course and over time: Findings from the National Surveys of Sexual Attitudes and Lifestyles (Natsal). *Lancet* 2013; **382**: 1781–94.

20 Wellings K, Jones KG, Mercer CH, *et al.* The prevalence of unplanned pregnancy and associated factors in Britain: Findings from the third National Survey of Sexual Attitudes and Lifestyles (Natsal-3). *Lancet* 2013; **382**: 1807–16.

21 Braude P, Rowell P. Assisted conception. II—In vitro fertilisation and intracytoplasmic sperm injection. *BMJ* 2003; **327**: 852.

22 Lo YMD, Corbetta N, Chamberlain PF, *et al.* Presence of fetal DNA in maternal plasma and serum. *Lancet* 1997; **350**: 485–7.

23 Rijnders RJP, Van Der Luijt RB, Peters EDJ, *et al.* Earliest gestational age for fetal sexing in cell-free maternal plasma. *Prenat Diagn* 2003; **23**: 1042–4.

24 Illanes S, Denbow M, Kailasam C, Finning K, Soothill PW. Early detection of cell-free fetal DNA in maternal plasma. *Early Hum Dev* 2007; **83**: 563–6.

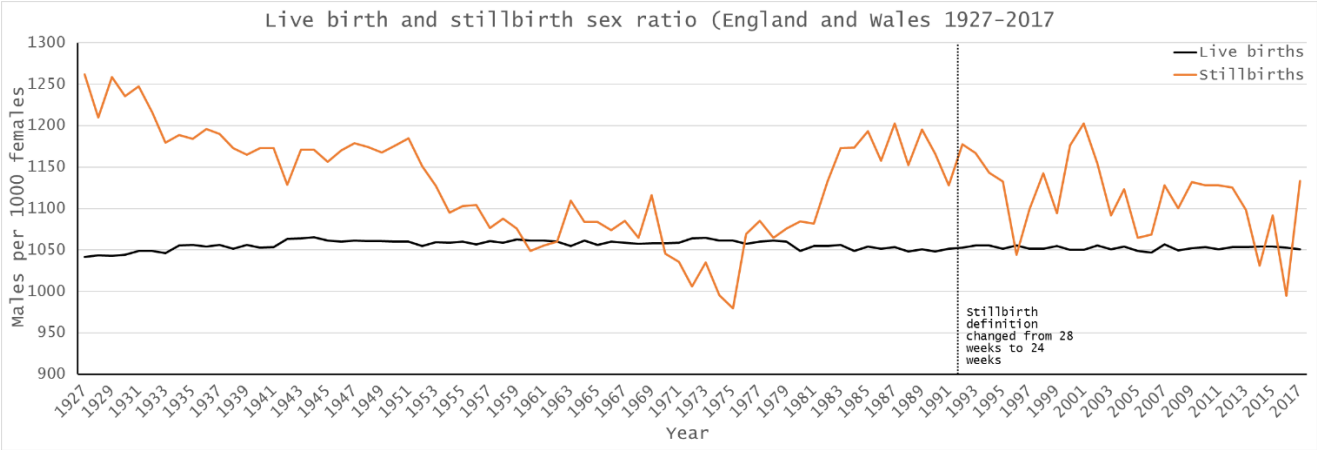


Figure 1. Live birth and stillbirth sex ratio in England and Wales, 1927-2017. On average 1,055 males were born per 1,000 females, and there are no years where more females are born than boys. The definition of stillbirth changed from 28 weeks of gestation to 24 weeks of gestation in 1992, and on average 1,133 boys were stillborn per 1,000 girls between 1927 and 1992, and 1,112 per 1,000 between 1993 and 2017. In the entire dataset, there are only three years where more girls were stillborn than boys (1974, 1975, 2016).

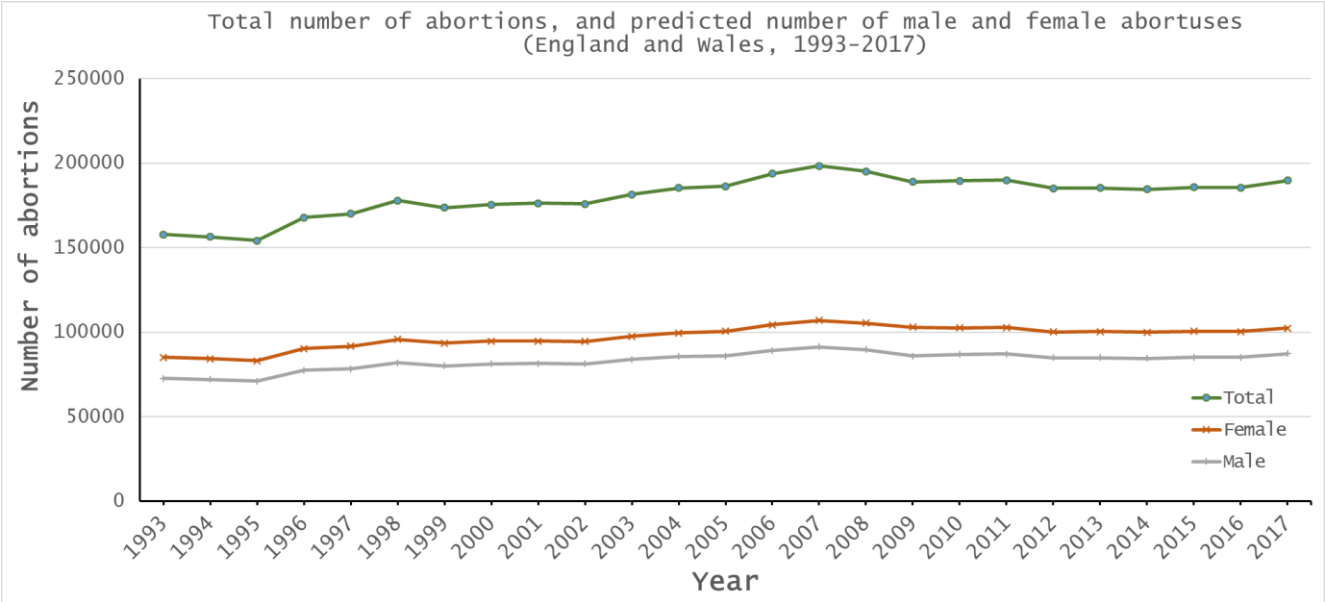


Figure 2. Sex ratio of legal abortions in England and Wales, 1993-2017, determined on the assumption that early (≤12 weeks) abortions are biased towards females (55:45) and later abortions (≥13 weeks) are biased towards males (45:55).

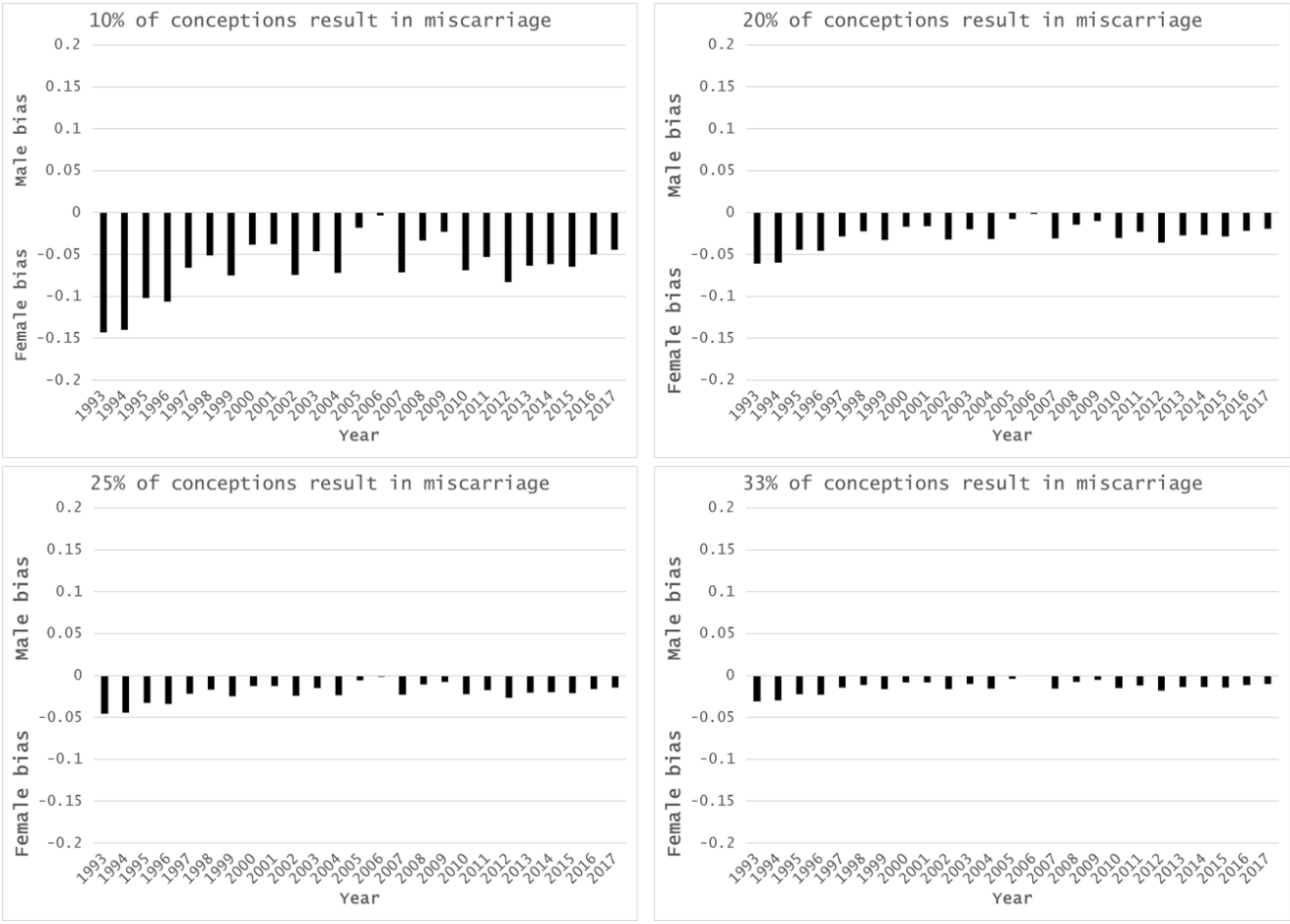


Figure 3. Relative miscarriage sex bias in England and Wales, 1993-2017, calculated as *1-(females miscarried/males miscarried)*, calculated if 10%, 20%, 25% or 33% of all conceptions result in miscarriage. A value of 0 would indicate no bias, a positive value would show male bias, and a negative values a female bias. Average values are -0.071 for the 10% dataset, -0.035 for 20%, -0.028 for 25% and -0.021 for 33%). Although the value for 2006 in the 33% dataset is very low (-0.001), miscarriages are biased towards females in every year of this 25 year dataset.

Table 1. Live births, stillbirths and abortions in England and Wales, 1993-2017. Numbers of male and females for live births and stillbirths reflect classifications as recorded on the relevant birth registers. Abortus sex is calculated from the total number of abortions on the assumption that the sex ratio ≤12 weeks of gestation is 55:45 in favour of females, and 45:55 in favour of males from ≥13 weeks of gestation. Total or average values are provided in the bottom rows.

Year	Live births				Stillbirths				Abortions				Pregnancies (live births + stillbirth + abortions)
	Total	Female	Male	Male live births per 1,000 female live births	Total	Female	Male	Male stillbirths per 1000 female stillbirths	Total	Female	Male	Male abortuses per 1000 female abortuses	
1993	673467	327632	345835	1056	3855	1779	2076	1167	157846	85072	72775	855	835168
1994	664726	323405	341321	1055	3813	1779	2034	1143	156539	84363	72176	856	825078
1995	648138	315950	332188	1051	3600	1688	1912	1133	154315	83211	71104	854	806053
1996	649485	315995	333490	1055	3539	1731	1808	1044	167916	90444	77472	857	820940
1997	642093	313021	329072	1051	3439	1638	1801	1100	170145	91732	78413	855	815677
1998	635901	309998	325903	1051	3417	1595	1822	1142	177871	95875	81996	855	817189
1999	621872	302617	319255	1055	3305	1578	1727	1094	173701	93634	80067	855	798878
2000	604441	294816	309625	1050	3203	1472	1731	1176	175542	94485	81057	858	783186
2001	594634	289999	304635	1050	3159	1434	1725	1203	176364	94851	81513	859	774157
2002	596122	290059	306063	1055	3372	1565	1807	1155	175932	94542	81390	861	775426
2003	621469	303041	318428	1051	3585	1711	1874	1091	181582	97557	84025	861	806636
2004	639721	311381	328340	1054	3686	1736	1950	1123	185415	99690	85725	860	828822
2005	645835	315235	330600	1049	3483	1687	1796	1065	186416	100535	85881	854	835734
2006	669601	327172	342429	1047	3602	1741	1861	1069	193737	104469	89268	854	866940
2007	690013	335525	354488	1057	3598	1691	1907	1128	198499	107139	91360	853	892110
2008	708711	345748	362963	1050	3617	1722	1895	1100	195296	105514	89782	851	907624
2009	706248	344113	362135	1052	3688	1730	1958	1132	189100	103114	85986	834	899036
2010	723165	352199	370966	1053	3714	1745	1969	1128	189574	102582	86992	848	916453
2011	723913	352939	370974	1051	3811	1791	2020	1128	189931	102787	87144	848	917655
2012	729674	355328	374346	1054	3558	1674	1884	1125	185122	100150	84972	848	918354
2013	698512	340129	358383	1054	3284	1565	1719	1098	185331	100360	84971	847	887127
2014	695233	338461	356772	1054	3254	1602	1652	1031	184571	99998	84573	846	883058
2015	697852	339716	358136	1054	3147	1498	1649	1092	185824	100649	85175	846	886823
2016	696271	339225	357046	1053	3112	1560	1552	995	185596	100501	85095	847	884979
2017	679106	331035	348071	1051	2873	1347	1526	1133	189859	102488	87371	853	871838
Total:	16656203	8114739	8541464	-	86714	41059	45655	-	4512024	2435740	2076284	-	21254941
Average:	666248	324590	341659	1053	3469	1642	1826	1112	180481	97430	83051	853	850198

Table 2. Predicted miscarriages in England and Wales, 1993-2017. Values are determined based on the number of calculated number of conceptions, as determined by the number of live births, stillbirths and abortions, accounting for the relevant miscarriage risk factor (where 10%, 20%, 25% or 33% of all conceptions result in miscarriage). Total or average values are provided in the bottom rows.

Year	10% miscarriage				20% miscarriage				25% miscarriage				33% miscarriage			
	Total	Females	Males	Males per 1000 females	Total	Females	Males	Males per 1000 females	Total	Females	Males	Males per 1000 females	Total	Females	Males	Males per 1000 females
1993	92796	49500	43297	875	208792	107498	101295	942	278389	142296	136093	956	411351	208777	202574	970
1994	91675	48829	42846	877	206270	106126	100143	944	275026	140505	134521	957	406382	206183	200199	971
1995	89561	46958	42604	907	201513	102934	98579	958	268684	136519	132165	968	397011	200683	196328	978
1996	91216	47908	43308	904	205235	104917	100318	956	273647	139123	134524	967	404344	204472	199872	978
1997	90631	46763	43868	938	203919	103407	100512	972	271892	137394	134499	979	401751	202323	199428	986
1998	90799	46526	44273	952	204297	103275	101022	978	272396	137325	135071	984	402496	202375	200121	989
1999	88764	45992	42772	930	199720	101470	98249	968	266293	134757	131536	976	393477	198349	195128	984
2000	87021	44331	42690	963	195797	98719	97078	983	261062	131351	129711	988	385748	193694	192054	992
2001	86017	43804	42214	964	193539	97564	95975	984	258052	129821	128231	988	381301	191445	189856	992
2002	86158	44626	41533	931	193857	98475	95382	969	258475	130784	127691	976	381926	192510	189417	984
2003	89626	45822	43804	956	201659	101839	99820	980	268879	135449	133430	985	397298	199658	197640	990
2004	92091	47650	44441	933	207206	105207	101998	970	276274	139741	136533	977	408226	205717	202509	984
2005	92859	46839	46020	983	208934	104876	104057	992	278578	139699	138879	994	411630	206225	205405	996
2006	96327	48251	48075	996	216735	108456	108279	998	288980	144578	144402	999	427000	213588	213412	999
2007	99123	51262	47861	934	223028	113214	109814	970	297370	150385	146985	977	439397	221399	217998	985
2008	100847	51252	49595	968	226906	114281	112625	986	302541	152099	150442	989	447039	224348	222691	993
2009	99893	50507	49385	978	224759	112941	111818	990	299679	150400	149278	993	442809	221965	220843	995
2010	101828	52615	49213	935	229113	116257	112856	971	305484	154443	151041	978	451387	227394	223993	985
2011	101962	52292	49670	950	229414	116018	113396	977	305885	154253	151632	983	451979	227301	224679	988
2012	102039	53045	48994	924	229589	116820	112769	965	306118	155084	151034	974	452324	228187	224137	982
2013	98570	50794	47776	941	221782	112400	109382	973	295709	149364	146345	980	436943	219981	216963	986
2014	98118	50526	47591	942	220765	111850	108915	974	294353	148644	145709	980	434939	218937	216002	987
2015	98536	50816	47719	939	221706	112401	109304	972	295608	149352	146255	979	436793	219945	216848	986
2016	98331	50369	47962	952	221245	111826	109419	978	294993	148700	146293	984	435885	219146	216739	989
2017	96871	49485	47386	958	217960	110029	107930	981	290613	146356	144257	986	429413	215756	213657	990
Total:	2361660	1216763	1144897	-	5313735	2692800	2620935	-	7084980	3578423	3506558	-	10468852	5270358	5198493	-
Average:	94466	55860	38607	941	212549	107712	104837	973	283399	143137	140262	980	418754	210814	207940	986

Table 3. Theoretical prediction of the number of miscarried products of conception in England and Wales in 2012. Sexual habits are based on Natsal-3[19] for women aged 16-44, and the remaining data are from ONS statistical datasets as described in the text. The predicted miscarriage rate is 43% overall, or 38% for women aged 20-39 (responsible for the majority of live births, stillbirths and abortions).

	Age					
	Under 20	**20-24**	**25-29**	**30-34**	**35-39**	**All**
Number of women	1362919	1893629	1925992	1898383	1803418	8884341
Annual acts of vaginal sex (assuming 44 per woman per year)	59968436	83319676	84743648	83528852	79350392	390911004
Annual acts of unprotected vaginal sex (assuming one in six is unprotected)	9994739	13886613	14123941	13921475	13225065	65151834
Unprotected acts occurring within 48-hour period around ovulation (i.e. 1/14)	713910	991901	1008853	994391	944648	4653702
Assume one in three of these results in fertilisation	237970	330634	336284	331464	314883	1551234
Number of live births to these women	33815	132456	202370	216242	114797	699680
Number of stillbirths to these women	217	669	936	912	601	3118
Number of abortions to these women	30539	54558	41882	30353	18523	145316
Estimated loss	173399	142951	91096	83957	180962	672364
Percentage loss	73%	43%	27%	25%	57%	43%

Supplemental data

Table S1. Predicted numbers of conceptions, and conceptus sex ratios, assuming a balanced primary sex ratio.

Table S2. Live birth, stillbirth and abortion numbers and sex ratios if the abortus sex ratio is balanced (i.e. an abortus has an equal probability of being male or female, irrespective of when in gestation the abortion occurred).

Table S3. Miscarriage numbers and sex ratios if the abortus sex ratio is balanced (i.e. an abortus has an equal probability of being male or female, irrespective of when in gestation the abortion occurred).

Table S4. Predicted primary sex ratios needed to remove miscarriage sex bias. Abortus sex is calculated from the total number of abortions on the assumption that the sex ratio ≤12 weeks of gestation is 55:45 in favour of females, and 45:55 in favour of males from ≥13 weeks of gestation.

Table S5. Predicted primary sex ratios needed to remove miscarriage sex bias. Abortus sex is calculated on the assumption that the abortus sex ratio is balanced (i.e. an abortus has an equal probability of being male or female, irrespective of when in gestation the abortion occurred).

Figure S1. Relative miscarriage sex bias if the abortus sex ratio is balanced (i.e. an abortus has an equal probability of being male or female, irrespective of when in gestation the abortion occurred).

Supplemental table S1. Predicted number of conceptions in England and Wales 1993-2017, determined as the sum of live births, stillbirths and abortions, and assuming that 10%, 20%, 25% or 33% of all conceptions result in miscarriage. The number of males and females conceived is equal (i.e. the primary sex ratio is 50:50). The year column refers to the year of registration of live births, stillbirths and abortions, and does not correlate to date of conception.

Year	Pregnancies (live births + stillbirths + abortions)	Number of conceptions if 10%, 20%, 25% or 33% result in miscarriage											
		10%			20%			25%			33%		
		Total conceptions	Females conceived	Males conceived	Total conceptions	Females conceived	Males conceived	Total conceptions	Females conceived	Males conceived	Total conceptions	Females conceived	Males conceived
1993	835168	927964	463982	463982	1043960	521980	521980	1113557	556779	556779	1246519	623260	623260
1994	825078	916753	458377	458377	1031348	515674	515674	1100104	550052	550052	1231460	615730	615730
1995	806053	895614	447807	447807	1007566	503783	503783	1074737	537369	537369	1203064	601532	601532
1996	820940	912156	456078	456078	1026175	513088	513088	1094587	547293	547293	1225284	612642	612642
1997	815677	906308	453154	453154	1019596	509798	509798	1087569	543785	543785	1217428	608714	608714
1998	817189	907988	453994	453994	1021486	510743	510743	1089585	544793	544793	1219685	609843	609843
1999	798878	887642	443821	443821	998598	499299	499299	1065171	532585	532585	1192355	596178	596178
2000	783186	870207	435103	435103	978983	489491	489491	1044248	522124	522124	1168934	584467	584467
2001	774157	860174	430087	430087	967696	483848	483848	1032209	516105	516105	1155458	577729	577729
2002	775426	861584	430792	430792	969283	484641	484641	1033901	516951	516951	1157352	578676	578676
2003	806636	896262	448131	448131	1008295	504148	504148	1075515	537757	537757	1203934	601967	601967
2004	828822	920913	460457	460457	1036028	518014	518014	1105096	552548	552548	1237048	618524	618524
2005	835734	928593	464297	464297	1044668	522334	522334	1114312	557156	557156	1247364	623682	623682
2006	866940	963267	481633	481633	1083675	541838	541838	1155920	577960	577960	1293940	646970	646970
2007	892110	991233	495617	495617	1115138	557569	557569	1189480	594740	594740	1331507	665754	665754
2008	907624	1008471	504236	504236	1134530	567265	567265	1210165	605083	605083	1354663	677331	677331
2009	899036	998929	499464	499464	1123795	561898	561898	1198715	599357	599357	1341845	670922	670922
2010	916453	1018281	509141	509141	1145566	572783	572783	1221937	610969	610969	1367840	683920	683920
2011	917655	1019617	509808	509808	1147069	573534	573534	1223540	611770	611770	1369634	684817	684817
2012	918354	1020393	510197	510197	1147943	573971	573971	1224472	612236	612236	1370678	685339	685339
2013	887127	985697	492848	492848	1108909	554454	554454	1182836	591418	591418	1324070	662035	662035
2014	883058	981176	490588	490588	1103823	551911	551911	1177411	588705	588705	1317997	658999	658999
2015	886823	985359	492679	492679	1108529	554264	554264	1182431	591215	591215	1323616	661808	661808
2016	884979	983310	491655	491655	1106224	553112	553112	1179972	589986	589986	1320864	660432	660432
2017	871838	968709	484354	484354	1089798	544899	544899	1162451	581225	581225	1301251	650625	650625
Totals:	21254941	23616601	11808301	11808301	26568676	13284338	13284338	28339921	14169961	14169961	31723793	15861896	15861896

Supplemental table S2. Live births, stillbirths and abortions in England and Wales, 1993-2017. Numbers of male and females for live births and stillbirths reflect classifications as recorded on the relevant birth registers. Abortus sex is calculated from the total number of abortions on the assumption that the abortus sex ratio is equal (i.e. an abortus has an equal probability of being male or female, irrespective of when the abortion occurred).

Year	Live births				Stillbirths				Abortions			
	Total	Female	Male	Male live births per 1,000 female live births	Total	Female	Male	Male stillbirths per 1000 female stillbirths	Total	Female	Male	Male abortuses per 1000 female abortuses
1993	673467	327632	345835	1056	3855	1779	2076	1167	157846	78923	78923	1000
1994	664726	323405	341321	1055	3813	1779	2034	1143	156539	78270	78270	1000
1995	648138	315950	332188	1051	3600	1688	1912	1133	154315	77158	77158	1000
1996	649485	315995	333490	1055	3539	1731	1808	1044	167916	83958	83958	1000
1997	642093	313021	329072	1051	3439	1638	1801	1100	170145	85073	85073	1000
1998	635901	309998	325903	1051	3417	1595	1822	1142	177871	88936	88936	1000
1999	621872	302617	319255	1055	3305	1578	1727	1094	173701	86851	86851	1000
2000	604441	294816	309625	1050	3203	1472	1731	1176	175542	87771	87771	1000
2001	594634	289999	304635	1050	3159	1434	1725	1203	176364	88182	88182	1000
2002	596122	290059	306063	1055	3372	1565	1807	1155	175932	87966	87966	1000
2003	621469	303041	318428	1051	3585	1711	1874	1091	181582	90791	90791	1000
2004	639721	311381	328340	1054	3686	1736	1950	1123	185415	92708	92708	1000
2005	645835	315235	330600	1049	3483	1687	1796	1065	186416	93208	93208	1000
2006	669601	327172	342429	1047	3602	1741	1861	1069	193737	96869	96869	1000
2007	690013	335525	354488	1057	3598	1691	1907	1128	198499	99250	99250	1000
2008	708711	345748	362963	1050	3617	1722	1895	1100	195296	97648	97648	1000
2009	706248	344113	362135	1052	3688	1730	1958	1132	189100	94550	94550	1000
2010	723165	352199	370966	1053	3714	1745	1969	1128	189574	94787	94787	1000
2011	723913	352939	370974	1051	3811	1791	2020	1128	189931	94966	94966	1000
2012	729674	355328	374346	1054	3558	1674	1884	1125	185122	92561	92561	1000
2013	698512	340129	358383	1054	3284	1565	1719	1098	185331	92666	92666	1000
2014	695233	338461	356772	1054	3254	1602	1652	1031	184571	92286	92286	1000
2015	697852	339716	358136	1054	3147	1498	1649	1092	185824	92912	92912	1000
2016	696271	339225	357046	1053	3112	1560	1552	995	185596	92798	92798	1000
2017	679106	331035	348071	1051	2873	1347	1526	1133	189859	94930	94930	1000
Totals:	16656203	8114739	8541464	Av = 1053	86714	41059	45655	Av = 1112	4512024	2256012	2256012	Av = 1000

Supplemental table S3. Predicted miscarriages in England and Wales, 1993-2017, where abortus sex ratios are equal (i.e. an abortus has an equal probability of being male or female, irrespective of when the abortion occurred). Values are determined based on the number of calculated number of conceptions, as determined by the number of live births, stillbirths and abortions, accounting for the relevant miscarriage risk factor (where 10%, 20%, 25% or 33% of all conceptions end in miscarriage).

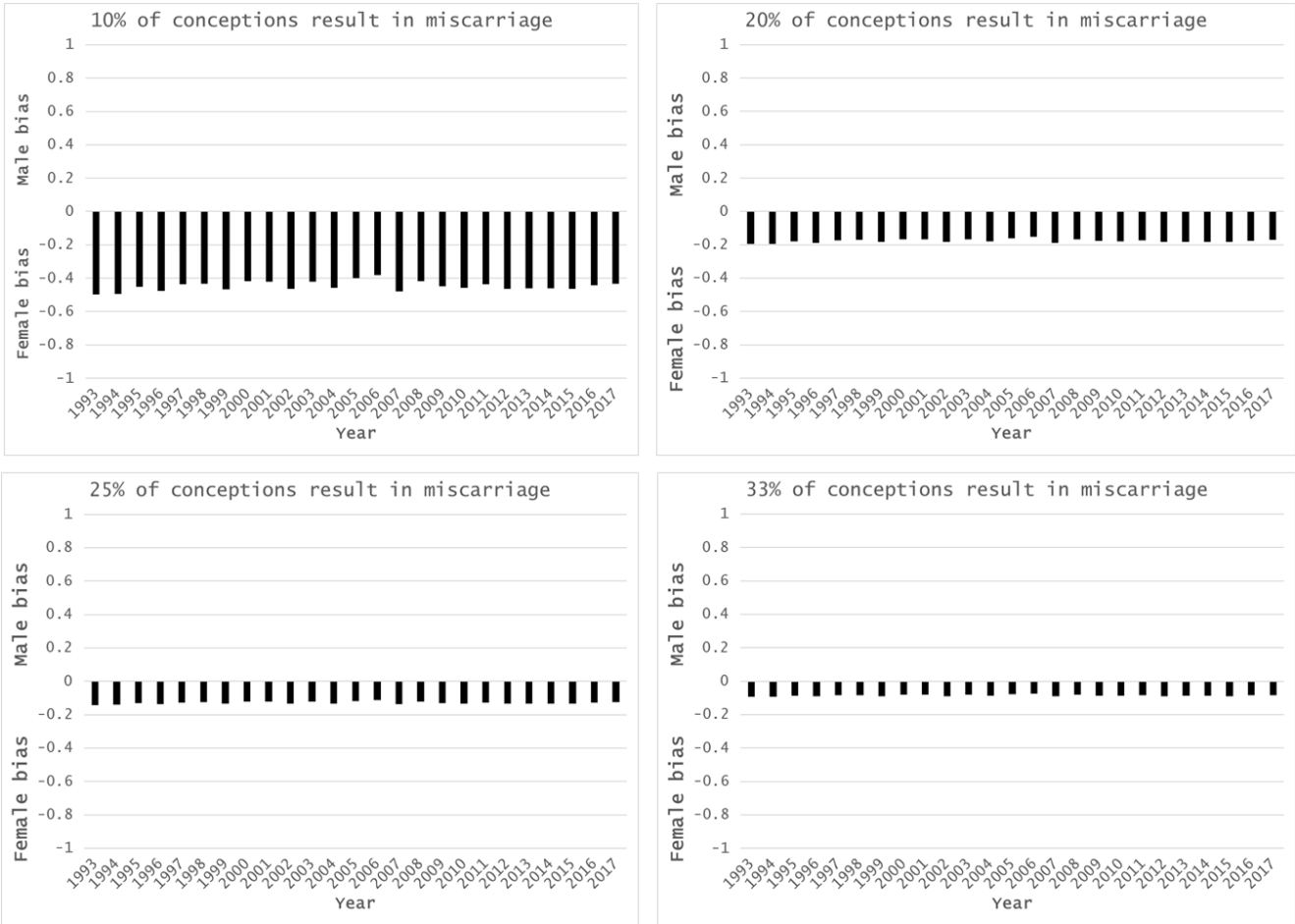
Year	10% miscarriage				20% miscarriage				25% miscarriage				33% miscarriage			
	Total	Females	Males	Males per 1000 females	Total	Females	Males	Males per 1000 females	Total	Females	Males	Males per 1000 females	Total	Females	Males	Males per 1000 females
1993	92796	55648	37148	668	208792	113646	95146	837	278389	148445	129945	875	411351	214926	196426	914
1994	91675	54923	36752	669	206270	112220	94049	838	275026	146599	128428	876	406382	212276	194105	914
1995	89561	53012	36550	689	201513	108988	92526	849	268684	142573	126111	885	397011	206737	190275	920
1996	91216	54394	36822	677	205235	111404	93832	842	273647	145609	128037	879	404344	210958	193386	917
1997	90631	53422	37208	696	203919	110067	93853	853	271892	144053	127839	887	401751	208983	192769	922
1998	90799	53465	37333	698	204297	110215	94083	854	272396	144264	128132	888	402496	209314	193182	923
1999	88764	52776	35989	682	199720	108253	91466	845	266293	141540	124753	881	393477	205132	188345	918
2000	87021	51044	35976	705	195797	105432	90364	857	261062	138065	122997	891	385748	200408	185340	925
2001	86017	50472	35545	704	193539	104233	89306	857	258052	136490	121563	891	381301	198114	183187	925
2002	86158	51202	34956	683	193857	105051	88805	845	258475	137361	121115	882	381926	199086	182840	918
2003	89626	52588	37038	704	201659	108605	93055	857	268879	142214	126664	891	397298	206424	190874	925
2004	92091	54632	37459	686	207206	112189	95016	847	276274	146724	129551	883	408226	212699	195526	919
2005	92859	54167	38693	714	208934	112204	96730	862	278578	147026	131552	895	411630	213552	198078	928
2006	96327	55852	40475	725	216735	116056	100679	868	288980	152179	136802	899	427000	221189	205812	930
2007	99123	59151	39972	676	223028	121103	101924	842	297370	158275	139096	879	439397	229288	210109	916
2008	100847	59118	41730	706	226906	122147	104759	858	302541	159965	142577	891	447039	232213	214825	925
2009	99893	59071	40821	691	224759	121505	103255	850	299679	158964	140714	885	442809	230529	212279	921
2010	101828	60410	41419	686	229113	124052	105061	847	305484	162238	143247	883	451387	235189	216198	919
2011	101962	60113	41849	696	229414	123839	105575	853	305885	162075	143811	887	451979	235122	216858	922
2012	102039	60634	41406	683	229589	124408	105180	845	306118	162673	143445	882	452324	235776	216548	918
2013	98570	58489	40081	685	221782	120095	101687	847	295709	157059	138651	883	436943	227676	209268	919
2014	98118	58239	39878	685	220765	119563	101202	846	294353	156357	137996	883	434939	226650	208289	919
2015	98536	58553	39982	683	221706	120138	101567	845	295608	157089	138518	882	436793	227682	209111	918
2016	98331	58072	40259	693	221245	119529	101716	851	294993	156403	138590	886	435885	226849	209036	921
2017	96871	57043	39828	698	217960	117587	100372	854	290613	153914	136699	888	429413	223314	206099	923
Average	94466	55860	38607	691	212549	114901	97648	850	283399	150326	133073	885	418754	218003	200751	921

Supplemental table S4. The predicted primary (conception) sex ratio (PSR) required to remove the female bias in miscarriage in England and Wales 1993-2017, determined as the sum of live births, stillbirths and abortions, and assuming that 10%, 20%, 25% or 33% of all conceptions result in miscarriage. Abortus sex is calculated from the total number of abortions on the assumption that the sex ratio ≤12 weeks of gestation is 55:45 in favour of females, and 45:55 in favour of males from ≥13 weeks of gestation. If 49.85% and 49.89% of conceptions are female, the proportion of males and females subsequently lost to miscarriage is equal.

Year	Pregnancies (live births + stillbirth + abortions)	Conceptions if 10%, 20%, 25% or 33% result in miscarriage															
		10%				20%				25%				33%			
		Total	Female	Male	PSR (% female)	Total	Female	Male	PSR (% female)	Total	Female	Male	PSR (% female)	Total	Female	Male	PSR (% female)
1993	835168	927964	460881	467084	49.67	1043960	518879	525082	49.70	1113557	553677	559880	49.72	1246519	620158	626361	49.75
1994	825078	916753	455385	461368	49.67	1031348	512682	518665	49.71	1100104	547060	553044	49.73	1231460	612738	618722	49.76
1995	806053	895614	445630	449984	49.76	1007566	501606	505960	49.78	1074737	535192	539546	49.80	1203064	599355	603709	49.82
1996	820940	912156	453778	458378	49.75	1026175	510788	515387	49.78	1094587	544994	549593	49.79	1225284	610342	614942	49.81
1997	815677	906308	451706	454601	49.84	1019596	508351	511246	49.86	1087569	542337	545232	49.87	1217428	607267	610162	49.88
1998	817189	907988	452867	455121	49.88	1021486	509616	511870	49.89	1089585	543666	545920	49.90	1219685	608716	610969	49.91
1999	798878	887642	442211	445431	49.82	998598	497688	500909	49.84	1065171	530975	534196	49.85	1192355	594567	597788	49.86
2000	783186	870207	434283	435924	49.91	978983	488671	490312	49.92	1044248	521304	522944	49.92	1168934	583647	585287	49.93
2001	774157	860174	429292	430882	49.91	967696	483053	484643	49.92	1032209	515310	516899	49.92	1155458	576934	578524	49.93
2002	775426	861584	429246	432339	49.82	969283	483095	486188	49.84	1033901	515404	518497	49.85	1157352	577130	580223	49.87
2003	806636	896262	447122	449140	49.89	1008295	503138	505157	49.90	1075515	536748	538767	49.91	1203934	600958	602976	49.92
2004	828822	920913	458852	462061	49.83	1036028	516409	519618	49.85	1105096	550944	554152	49.85	1237048	616920	620128	49.87
2005	835734	928593	463887	464706	49.96	1044668	521924	522743	49.96	1114312	556746	557566	49.96	1247364	623272	624092	49.97
2006	866940	963267	481545	481721	49.99	1083675	541749	541926	49.99	1155920	577872	578048	49.99	1293940	646882	647058	49.99
2007	892110	991233	493916	497317	49.83	1115138	555869	559269	49.85	1189480	593040	596440	49.86	1331507	664053	667454	49.87
2008	907624	1008471	503407	505064	49.92	1134530	566437	568093	49.93	1210165	604254	605911	49.93	1354663	676503	678160	49.94
2009	899036	998929	498903	500025	49.94	1123795	561336	562459	49.95	1198715	598796	599918	49.95	1341845	670361	671483	49.96
2010	916453	1018281	507440	510841	49.83	1145566	571082	574484	49.85	1221937	609268	612669	49.86	1367840	682219	685621	49.88
2011	917655	1019617	508497	511119	49.87	1147069	572223	574845	49.89	1223540	610459	613081	49.89	1369634	683506	686128	49.90
2012	918354	1020393	508171	512222	49.80	1147943	571946	575997	49.82	1224472	610211	614261	49.83	1370678	683314	687364	49.85
2013	887127	985697	491339	494357	49.85	1108909	552945	555963	49.86	1182836	589909	592927	49.87	1324070	660526	663544	49.89
2014	883058	981176	489120	492055	49.85	1103823	550444	553379	49.87	1177411	587238	590173	49.88	1317997	657531	660466	49.89
2015	886823	985359	491131	494228	49.84	1108529	552716	555813	49.86	1182431	589667	592764	49.87	1323616	660260	663357	49.88
2016	884979	983310	490451	492859	49.88	1106224	551908	554316	49.89	1179972	588782	591190	49.90	1320864	659228	661636	49.91
2017	871838	968709	483305	485404	49.89	1089798	543849	545948	49.90	1162451	580176	582275	49.91	1301251	649576	651675	49.92
Totals:	21254941	23616601	11772368	11844233	Av = 49.85	26568676	13248405	13320271	Av = 49.86	28339921	14134028	14205893	Av = 49.87	31723793	15825964	15897829	Av = 49.89

Supplemental table S5. The predicted primary (conception) sex ratio required to remove the female bias in miscarriage in England and Wales 1993-2017, determined as the sum of live births, stillbirths and abortions, and assuming that 10%, 20%, 25% or 33% of all conceptions result in miscarriage. Abortus sex is calculated from the total number of abortions on the assumption that the abortus sex ratio is equal equal (i.e. an abortus has an equal probability of being male or female, irrespective of when the abortion occurred). If 49.09% and 49.32% of conceptions are female, the proportion of males and females subsequently lost to miscarriage is equal.

Year	Pregnancies (live births + stillbirth + abortions)	Conceptions if 10%, 20%, 25% or 33% result in miscarriage															
		10%				20%				25%				33%			
		Total	Female	Male	PSR (% female)	Total	Female	Male	PSR (% female)	Total	Female	Male	PSR (% female)	Total	Female	Male	PSR (% female)
1993	835168	927964	454732	473232	49.00	1043960	512730	531230	49.11	1113557	547529	566029	49.17	1246519	614010	632510	49.26
1994	825078	916753	449291	467462	49.01	1031348	506588	524759	49.12	1100104	540967	559138	49.17	1231460	606644	624815	49.26
1995	806053	895614	439576	456038	49.08	1007566	495552	512014	49.18	1074737	529138	545600	49.23	1203064	593301	609763	49.32
1996	820940	912156	447292	464864	49.04	1026175	504302	521874	49.14	1094587	538507	556079	49.20	1225284	603856	621428	49.28
1997	815677	906308	445047	461261	49.11	1019596	501691	517905	49.20	1087569	535678	551892	49.25	1217428	600607	616821	49.33
1998	817189	907988	445928	462060	49.11	1021486	502677	518809	49.21	1089585	536727	552859	49.26	1219685	601777	617909	49.34
1999	798878	887642	435428	452215	49.05	998598	490905	507692	49.16	1065171	524192	540979	49.21	1192355	587784	604571	49.30
2000	783186	870207	427569	442637	49.13	978983	481957	497025	49.23	1044248	514590	529658	49.28	1168934	576933	592001	49.36
2001	774157	860174	422624	437551	49.13	967696	476385	491312	49.23	1032209	508641	523568	49.28	1155458	570266	585193	49.35
2002	775426	861584	422669	438915	49.06	969283	476518	492764	49.16	1033901	508828	525074	49.21	1157352	570553	586799	49.30
2003	806636	896262	440356	455906	49.13	1008295	496373	511923	49.23	1075515	529982	545532	49.28	1203934	594192	609742	49.35
2004	828822	920913	451870	469043	49.07	1036028	509427	526600	49.17	1105096	543962	561135	49.22	1237048	609937	627110	49.31
2005	835734	928593	456560	472034	49.17	1044668	514597	530071	49.26	1114312	549419	564893	49.31	1247364	615945	631419	49.38
2006	866940	963267	473945	489322	49.20	1083675	534149	549526	49.29	1155920	570272	585649	49.33	1293940	639282	654659	49.41
2007	892110	991233	486027	505206	49.03	1115138	547979	567158	49.14	1189480	585151	604330	49.19	1331507	656164	675343	49.28
2008	907624	1008471	495542	512930	49.14	1134530	558571	575959	49.23	1210165	596389	613777	49.28	1354663	668637	686025	49.36
2009	899036	998929	490339	508589	49.09	1123795	552773	571023	49.19	1198715	590232	608482	49.24	1341845	661797	680047	49.32
2010	916453	1018281	499645	518636	49.07	1145566	563288	582279	49.17	1221937	601473	620464	49.22	1367840	674425	693416	49.31
2011	917655	1019617	500676	518940	49.10	1147069	564402	582666	49.20	1223540	602638	620902	49.25	1369634	675685	693949	49.33
2012	918354	1020393	500583	519811	49.06	1147943	564357	583585	49.16	1224472	602622	621850	49.21	1370678	675725	694953	49.30
2013	887127	985697	483644	502052	49.07	1108909	545250	563658	49.17	1182836	582214	600622	49.22	1324070	652831	671239	49.30
2014	883058	981176	481407	499768	49.06	1103823	542731	561092	49.17	1177411	579525	597886	49.22	1317997	649818	668179	49.30
2015	886823	985359	483394	501965	49.06	1108529	544979	563550	49.16	1182431	581930	600501	49.21	1323616	652523	671094	49.30
2016	884979	983310	482749	500562	49.09	1106224	544205	562018	49.19	1179972	581080	598893	49.25	1320864	651526	669339	49.33
2017	871838	968709	475747	492962	49.11	1089798	536291	553506	49.21	1162451	572618	589833	49.26	1301251	642018	659233	49.34
Totals:	21254941	23616601	11592640	12023961	Av = 49.09	26568676	13068678	13499999	Av = 49.19	28339921	13954300	14385621	Av = 49.24	31723793	15646236	16077557	Av = 49.32



Supplemental figure S1. Relative miscarriage sex bias in England and Wales, 1993-2017, calculated as *1-(females miscarried/males miscarried)*, calculated if 10%, 20%, 25% or 33% of all conceptions result in miscarriage and where abortus sex ratios are equal (i.e. an abortus has an equal probability of being male or female, irrespective of when the abortion occurred). A value of 0 would indicate no bias, a positive value would show male bias, and a negative values a female bias. In every year of this 25 year dataset, miscarriages are biased towards females, and to a greater extent than if abortions are female-biased ≤12 weeks and male-biased ≥13 weeks (Figure 4).