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Effect of Ethnicity on Live Birth Rates after IVF/ICSI Treatment: Analysis of a National Database

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Running Title:

Ethnicity and Success of ART

ABSTRACT

Objective:

To evaluate the effect of ethnicity of women on the outcome of In-Vitro Fertilisation (IVF) or Intra-Cytoplasmic Sperm Injection (ICSI) treatment.

Design:

Observational cohort study

Setting:

UK National Database

Population:

Data from 2000 to 2010 involving 38,709 women undergoing their first IVF/ICSI cycle were analysed.

Methods:

Anonymous data were obtained from the Human Fertilization and Embryology Authority (HFEA), the statutory regulator of IVF and ICSI treatment in the UK. Data analysis was performed by regression analysis with adjustment for age, cause and type of infertility and treatment type (IVF or ICSI) to express results as odds ratio and 95% confidence intervals.

Main outcome measures:

Live birth rate per cycle of IVF or ICSI treatment

Results:

While white Irish (OR: 0.73; 95% CI: 0.60 - 0.90), Indian (0.85; 0.75 - 0.97), Bangladeshi (0.53: 0.33 – 0.85), Pakistani (0.68; 0.58 - 0.80), Black African (0.60; 0.51 – 0.72), and other non-Caucasian Asian (0.86; 0.73 – 0.99) had a significantly lower odds of live birth rates per fresh IVF/ICSI cycle than White British women, ethnic groups of White European (1.04; 0.96 – 1.13), Chinese (1.12; 0.77 – 1.64), Black Caribbean (0.76; 0.51 – 1.13), Middle Eastern (0.73; 0.51 – 1.04), Mediterranean European (1.18; 0.83 – 1.70) and Mixed race population (0.94; 0.73 – 1.19) had live birth rates that did not differ significantly. The cumulative live birth rates also showed similar pattern across different ethnic groups.

Conclusion:

Ethnicity is a major determinant of IVF/ICSI treatment outcome as indicated by significantly lower live birth rates in some of the ethnic minority groups compared to white British women.

Keyword(s): Ethnicity, infertility, assisted conception, IVF, ICSI, Live birth, Embryo.

INTRODUCTION

Infertility is a major public health problem that affects 10-15 % of the population and an exponentially growing number of people are seeking infertility treatment. Over the last decade, the advancement and acceptance of infertility treatment has been significant. Despite rapid advancement in infertility treatment, ethnicity as a primary prognostic factor has attracted limited attention unlike other areas in medicine due to paucity of robust evidence. Today, in the United Kingdom, for example, the treatment protocols for IVF/ ICSI treatment chosen for patients are based on factors such as age, BMI and ultrasound and endocrine markers of ovarian reserve (1), but not on the ethnic background of the patient. Further, most treatment protocols devised are based on research studies conducted in Caucasian population of Europe and North America with extrapolating the resulting data and applying the practices to population worldwide representing various ethnicities and races.

There are a few published studies highlighting ethnicity as a determining factor of importance in IVF/ICSI treatment outcome (2-9). However, most studies are based on small sample size and subjects described are of selected ethnicities and races and not representative of a general population sample, while larger published studies are based on the population of the USA. Another major issue of most published data is the pooling of different ethnicities under single wider categories such as Asians, which can include women from China, Japan, Korea, India, Bangladesh or Pakistan, who are significantly different racially and ethnically between each other. Further, most studies, especially that of smaller sample sizes, were from a single fertility unit (2), and a number of ethnic groups were under-represented to generate a valid conclusion.

We, therefore, accessed a large anonymized patient register held by the Human and Fertilisation and Embryology Authority (HFEA) of the UK with an overall objective to evaluate the effect of ethnicity of women on the clinical outcome of In-Vitro Fertilisation (IVF) or Intra-Cytoplasmic Sperm Injection (ICSI) treatment in a large population. The HFEA regulates fertility clinics in the UK, and as part of its role, it requires that all clinics submit the baseline data for each treatment cycle, which also include the ethnicity of women.

MATERIALS AND METHODS

This cohort study is carried out in the UK by reviewing the anonymised data obtained from the Human Fertilisation and Embryology Authority (HFEA) registry covering the period 2000-2010. Only women undergoing their first cycle of IVF/ICSI treatment were included and this was done to ensure that the data were truly unbiased (Figure 1). Approval for the study was granted by the National Health Service Research Ethics Committee and the Nottingham University NHS Trust Research and Development Department. The process of extracting data was in keeping with the rules governing data protection.

The variables extracted include women's age, ethnicity, cause and type of infertility, duration of infertility, IVF or ICSI, number of embryos transferred, and day of embryo transfer. Outcomes included number of oocytes retrieved, number of oocytes fertilised by IVF or ICSI, number of embryos created, fertilisation rate (number of oocytes fertilised per number of oocytes inseminated), clinical pregnancy rate (number of pregnancies with positive heart beat on ultrasound per number of women started IVF treatment), implantation rate (number of clinical pregnancies per number of embryos transferred), while live birth rate (proportion of cycles started that resulted in a live birth) was the main outcome measure in this study. Ethnicity was self-reported then categorised using nationally agreed guidelines

Data analysis was carried out using STATA 8.1. Univariate analysis using the available variables was done first to assess the differences in baseline characteristics between White British women and those from other ethnic groups. Based on the distribution, bivariate analysis of continuous data was done with the Student's t-test or Mann-Whitney U-test. The relationship between two categorical variables was analysed by performing unadjusted odds ratio (OR) with confidence interval (CI), Chi-square and Fisher exact tests. When the confidence interval around the odds ratio did not include 1.00, the difference was considered to be statistically significant in all statistical tests. Logistic regression models were used to assess the effects of ethnicity on the study outcomes controlling for confounding variables. The White British ethnic group was taken as reference group in the model given that it is the largest ethnic group in the data set. To estimate the independent contribution of ethnic minority group to treatment outcomes (relative to the White British reference group), multivariate logistic regression analyses were performed. Potential confounding factors found to be statistically significant in univariate analyses and variables regarded as clinically significant were included in the models. For continuous data, a multivariate linear regression model was used controlling for the same confounders in the logistic models.

RESULTS

Demographic information and prevalence of causes of infertility in patients of different ethnic background

Patients undergoing their first cycle of treatment were analysed in this study (Figure 1). A cohort of 38,709 distributed as White British – 28,408 (73.39%), White Irish – 635 (1.64%), White European – 3201 (8.27%), South-Asian Indian – 1226 (3.17%), South-Asian Bangladeshi – 105 (0.27%), South-Asian Pakistani – 878 (2.27%), Chinese – 135 (0.35%), Black British – 168 (0.43%), Black African – 879 (2.27%), Black Caribbean -1495 (3.86%), Mediterranean European – 144 (0.37%), Middle-Eastern – 171 (0.44%), Mixed Race – 366 (0.95%) and Other Asian – 898 (2.32%).

The mean age of patients ranged from 29.7 years to 35.8 years (Table 1). Patients of South-Asian Indian, South-Asian Pakistani, Black Caribbean and Middle-Eastern background were significantly younger than the White British women, while White Irish, White European and Black British women were significantly older than the reference ethnic group ($p<0.05$). The causes of infertility vary between ethnic groups as shown in Table 1 and figure 2.

Effects of ethnicity of patients on ovarian response and Clinical pregnancy rates

After adjusting for the all variables including age patient at time of treatment, cause of female or male infertility, and type of treatment (ICSI vs IVF) South Asian Bangladeshi, South Asian Pakistani, Black African, Middle Eastern, and Other Asians have a significantly lower number of eggs collected than White British patients (Table 2). Patients of a mixed race also demonstrated a significantly lower number of eggs collected per treatment cycle. On the other hand, White Europeans had significantly higher number of eggs collected ($P<0.0001$). There was no significant differences in the method of fertilisation (IVF or ICSI) used between patients of different ethnicities. The data on number of embryos transferred, cryopreserved and the day of embryo transfer have been shown in table 2. South Asian Indian, South Asian Bangladeshi, South Asian Pakistani, Black British, Black African, Black Caribbean and Middle Eastern were at higher risk of not reaching embryo transfer stage (cycle cancellation prior to embryo transfer after treatment started) (Table 2). The reported OHSS rates have been generally similar across all the ethnic groups except higher incidence reported at egg collection in Black British and Black Caribbean.

White Irish, South Asian Indian, South Asian Bangladeshi, South Asian Pakistani, Black African, and Other Asian groups had a significantly lower odds of clinical pregnancy than White British patients after adjusting

for age, cause of subfertility and type of treatment (Table 3). On the other hand, White Europeans had a significantly higher odds (OR: 1.09 (1.01-1.18) after adjusting for the aforementioned characteristics. Other Ethnicities had comparable outcome to that of White British patients.

Effects of ethnicity of patients on the primary outcome, live birth rate

After adjusting for the all variables including age patient at time of treatment, cause of female or male infertility, and type of treatment (ICSI vs IVF), White Irish, South Asian Indian, South Asian Bangladeshi, South Asian Pakistani, Black African, and Other Asian had a significantly lower odds of live birth than White British patients (Table 3 and Figure 3). Also, it is worth noting that, Middle Eastern had an odds ratio indicating a tendency (borderline significance p: 0.08) of lower odds of live birth outcomes (OR: 0.73 (0.51 – 1.04)). Other Ethnicities had comparable outcome to that of White British patients.

DISCUSSION

The data from this large UK national database (HFEA) has shown that ethnicity is a major independent factor determining the chances of IVF or ICSI treatment success. Live birth rates following IVF or ICSI treatment were significantly lower in some of the ethnic groups (White Irish, South Asian Indian, South Asian Bangladeshi, South Asian Pakistani, Black African, and Other Asian) compared with white British women, which suggests that ethnicity is a major determinant of live birth following IVF or ICSI treatment. While the reason for this association is difficult to explain, the potential factors could be the observed differences in cause of infertility, ovarian response, fertilisation rates and implantation rates, which are all independent predictors of IVF success.

While there are a number of similar studies reported (2-5, 7, 9-18), this study is unique in the sub-categorising of ethnicities to represent a more homogeneous subgroups of racial, cultural and lifestyle similarities: for example, Asian ethnicity clearly has very distinct ethnic subgroups such as Chinese, Indian, Pakistani and Bangladeshi among others. More over, this is the largest study to date to evaluate the effect of individual sub-ethnic groups as an independent factor on the success rates of IVF/ICSI treatment with the data derived from a reasonably large number of women from various individual ethnic groups treated in all the UK fertility units. As noted in most studies, varied underlying causes of infertility and age at which women undergoing IVF were evident in ethnic groups, however, the data suggests that after controlling for age and cause of subfertility, ethnicity of women remained a significant factor influencing the outcome of the treatment.

The quantitative ovarian reserve does not seem to be varying significantly across various ethnic groups, however, the observed differences of treatment outcome in the ethnic minority groups may be reflective of varied qualitative ovarian reserve or sperm factor as indicated by reduced fertilization rates in South Asian Indian, South Asian Bangladeshi, South Asian Pakistani, Black British, Black African, Black Caribbean, Middle Eastern and Other Asian population. While genetic background could be a potential determinant of egg and sperm quality, variation in environmental exposures relating to different life style, dietary factors, socio-economic and cultural factors could be influencing issues including the egg and sperm quality, accessibility of fertility treatment services and behaviour towards seeking medical care for fertility and consequently the reproductive outcomes. The observed implantation rates have also been varied among different ethnic groups with reduced implantation noted in white Irish and Black African population. The possible increased prevalence of PCOS in south Asian population may have adverse influence on oocyte quality and endometrial function resulting in low implantation rates. While increased prevalence of uterine and tubal factor infertility in Black African population could explain the reason for

reduced endometrial receptivity and implantation, the reason for low implantation rate in Irish population is unclear.

The observed variation in IVF treatment success among different ethnic groups raises a number of challenges for current clinical practices in terms of counselling patients about their realistic probabilities of successful outcome, individually tailored treatment protocols, and policies regarding referral and treatment criteria for patients of different ethnic background. Research is needed to understand the reasons behind the variation in treatment outcome between ethnic groups and the studies evaluating treatment strategies on modifying IVF outcome should incorporate ethnicity as a major determinant factor. Modifications in clinical strategies to bring about equivalent success rates among all ethnic groups can be achieved after the relationship between ethnicity and IVF outcome is better understood.

One of the key strengths of this population study is the sample size, it is the largest cohort study with UK wide representation for all ethnic and sub-ethnic minorities. As the sample size is significantly large, it was possible to statistically analyse the success rates of the IVF cycles among each of the sub-ethnic groups without merging the categories which was one of the drawbacks of the largest US based population studies that were previously published (5). However, the numbers in some of the sub-ethnic minorities (eg: Bangladeshi population) were low in our study. The use of the UK HFEA National database as a basis for this analysis is a major strength of the paper as its robust auditing and stringent regulations that standardizes treatment across all clinics with regards to variables such as the number of embryos transferred back to the patient and number of previous treatment cycles means that the data is reliable and consistent. Further, only first cycles are included which again gives a genuinely true comparison of IVF outcome between various ethnic groups as opposed to inclusion of multiple cycles from each women, which would have added bias to the results. The quality of the data included in the study may be limited

because of missing the ethnicity data in a significant proportion of cases reported to the HFEA (Figure 1). Factors like BMI, smoking and alcohol consumption were not collected by the HFEA and therefore could not be accounted for in this study. Further, a significant proportion of HFEA reported cycle do not have Socio-economic factors are also not accounted for, however, private and government funded patients are evenly represented in the register, and also, the number of patients analysed in the different ethnic sub-groups is large and represent the UK national distribution respectively.

CONCLUSION

Live birth rates following IVF treatment were significantly lower in some of the ethnic groups compared with white British women, which suggests that ethnicity is a major determinant of live birth following IVF or ICSI treatment. While the prevalence of various causes of infertility vary in different ethnic groups, the ethnicity of the patient is independently correlated with success rates of IVF treatment cycle after controlling for age and causes of infertility. Even though data on other variables such diet and socio-economic factors are not reported and they can potentially alter the outcome of clinical treatment, such variables are non-modifiable and therefore ethnicity should be considered while counselling women and couples about their realistic chances of IVF success. This study is just a first step and further research is needed to understand the reasons behind the variation in treatment outcome between ethnic groups and move towards tailoring tangible protocols specifically suited to each ethnic group to maximize their IVF/ ICSI success without compromising their safety.

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Table 1. Baseline Characteristics of the patients according to their Ethnic Group, and Unadjusted Effect of those Characteristics on Live Birth Outcome during the first treatment cycle, Expressed as OR +/- 95% CI														
	White British	White Irish	White European	South Asian Indian	South Asian Bangladeshi	South Asian Pakistani	Chinese	Black British	Black African	Black Caribbean	Mediterranean European	Middle Eastern	Mixed Race	Other Asian
Sample Size, N %	28408 (76.1)	635 1.7)	3201 (8.6)	1226 (3.3)	105 (0.3)	878 (2.4)	135 (0.4)	168 (0.5)	879 (2.4)	1495 (0.4)	144 (0.4)	171 (0.5)	366 (1.0)	898 (2.4)
Mean Age ± SD	34.4 ± 4.6	35.8 ± 4.1**	34.9 ± 4.3**	32.8 ± 4.3**	29.7 ± 4.3	31.2 ± 4.9*	34.9 ± 4.4	35.3 ± 5.6**	34.5 ± 4.7	34.1 ± 5.4**	33.2 ± 5.0	32.4 ± 5.8**	34.6 ± 4.8	33.6 ± 4.6
Cause of Infertility –														
Tubal (%)	4687 (16.5)	80 (12.6)**	439 (13.7)**	165 (13.5)*	16 (15.2)	130 (14.8)	33 (24.4)^	45 (26.8)^^	267 (30.4)^^	69 (46.3)^^	13 (9.0)*	27 (15.8)	76 (20.8)*	145 16.1
Uterine, %	234 (0.8)	5 (0.8)	41 (1.8)^^	19 (1.6)^^	1 (0.9)	7 (0.8)	2 (1.5)	14 (3.3)^^	73 (8.3)^^	7 (8.7)^^	3 (2.1)	4 (2.3)^^	3 (0.8)	12 (1.3)
Ovulatory, %	3359 (11.8)	59 (9.3)	315 (9.8)**	216 (17.6)^^	29 (17.6)^^	154 (17.5)^^	19 (14.1)	14 (8.9)	79 (9.0)*	14 (9.4)	17 (11.8)	26 (15.2)	41 (11.2)	154 (17.2)^^
Endometriosis, %	2302 (8.1)	46 (7.3)	252 (7.9)	94 (7.7)	4 (3.8)	57 (6.5)	9 (6.7)	9 (5.4)	36 (4.1)	8 (5.4)	10 (6.9)	5 (2.9)	42 (11.5)^	70 (7.8)
Unexplained, %	8605 (30.3)	188 (29.6)	1004 (31.4)	367 (29.9)	24 (22.9)	221 (25.2)**	44 (32.6)	34 (20.2)**	167 (19.0)**	16 (10.7)**	49 (34.1)	44 (25.7)	97 (26.5)	274 (30.5)
Male Factor, %	11453 (40.32)	266 (41.9)	1314 (41.1)	456 (37.2)*	36 (34.3)	380 (43.3)^	39 (28.9)**	65 (38.7)	365 (41.5)	57 (38.3)	58 (40.3)	69 (40.4)	136 (37.2)	309 (34.4)**

*Significantly lower **(***P<0.05, ** P<0.01); ^ Significantly higher (^P<0.05, ^^ P<0.01)

Table 2. Treatment and Outcome Characteristics of the patients according to their Ethnic Group														
	White British	White Irish	White European	South Asian Indian	South Asian Bangladeshi	South Asian Pakistani	Chinese	Black British	Black African	Black Caribbean	Mediterranean European	Middle Eastern	Mixed Race	Other Asian
Sample Size, N %	28408 (76.1)	635 1.7)	3201 (8.6)	1226 (3.3)	105 (0.3)	878 (2.4)	135 (0.4)	168 (0.5)	879 (2.4)	1495 (0.4)	144 (0.4)	171 (0.5)	366 (1.0)	898 (2.4)
IVF Cycles, N % (the rest were ICSI)	15,450 (54.6)	334 (52.8)	1644 (51.7)*	656 (53.8)	67 (64.4)^^	458 (52.5)	85 (62.9)	102 (60.7)	434 (49.5)*	75 (50.3)	77 (53.8)	80 (46.8)*	198 (54.4)	500 (56.0)
Mean No. Eggs collected ± SD	9.5 ± 6.5	8.6 ± 6.2**	10.1 ± 6.8^^	9.9 ± 6.9^	8.7 ± 7.1	9.9 ± 6.8	8.7 ± 5.9	8.9 ± 7.3	8.9 ± 7.4*	10.4 ± 7.9	9.5 ± 6.3	8.9 ± 6.7	8.9 ± 6.2	9.1 ± 6.3
Fertilisation rate Mean +/- SD	0.59 ± 0.26	0.59 ± 0.26	0.59 ± 0.25	0.55 ± 0.25 **	0.53 ± 0.27*	0.53 ± 0.27 **	0.60 ± 0.28	0.47 ± 0.29**	0.51 ± 0.27**	0.52 ± 0.27 *	0.54 ± 0.25	0.52 ± 0.29**	0.57 ± 0.26	0.55 ± 0.26 **
Mean No. Embryos created ± SD	5.5 ± 4.4	5.0* ± 4.1	5.9 ± 4.6^^	5.5 ± 4.5	4.7 ± 4.5	5.1 ± 4.3*	4.1 ± 3.8	4.2 ± 4.1**	4.6 ± 4.6**	5.4 ± 4.9	5.3 ± 4.3	4.4 ± 4.0**	4.9 ± 4.0**	4.9 ± 4.1**
Mean No. Embryo Stored ± SD	1.39 ±3.02	1.07 ± 2.66*	1.36 ±2.86	1.48 ± 3.00	1.25 ± 2.97	1.30 ± 3.04	0.75 ± 1.86**	0.67 ± 2.19**	0.91 ±2.31**	1.26 ± 3.04 **	0.78 ± 1.54	0.88 ± 2.43**	1.17 ± 2.50**	0.99 ± 2.27**
No. of Embryos Transferred														
0, N	4,262	95	449	216	24	175	22	49	220	35	28	40	51	157
%	(15.0)	(15.0)	(14.0)	(17.6)*	(22.9)*	(19.9)*	(16.3)	(29.2)*	(25.0)*	(23.5)*	(19.4)	(23.4)*	(13.9)	(17.5)
1, N	7,309	163	892	389	33	197	33	32	192	39	30	39	93	203
%	(25.7)	(25.7)	(27.9)	(31.7)	(31.4)	(22.4)	(24.4)	(19.0)	(21.8)	(22.8)	(20.8)	(22.8)	(25.4)	(22.6)
2, N	16,263	350	1,758	610	48	502	77	75	447	73	82	88	214	524
%	(57.3)	(55.1)	(54.9)	(49.8)	(45.7)	(57.2)	(57.1)	(44.6)	(50.9)	(48.9)	(56.9)	(51.5)	(58.5)	(58.4)
3, N	574	27	102	11	0	4	3	12	20	2	4	4	8	14
%	(2.0)	(4.3)	(3.2)	(0.9)	(0.0)	(0.5)	(2.2)	(7.1)	(2.3)	(1.3)	(2.8)	(2.3)	(2.2)	(1.6)
OHSS reported														
At Egg collection, N %	173 (0.6)	3 (0.5)	20 (0.6)	11 (0.9)	2 (1.9)	7 (0.8)	0 (0.0)	6 (3.6)^^	6 (0.7)	3 (2.0)^	2 (1.4)	2 (1.2)	0 (0.0)	9 (1.0)
At Embryo Transfer, N %	632 (2.2)	17 (2.7)	67 (2.1)	30 (2.5)	4 (3.8)	24 (2.7)	2 (1.5)	3 (1.8)	15 (1.7)	4 (2.7)	3 (2.1)	4 (2.3)	6 (1.6)	14 (1.6)
Implantation rate N %	22,056 (24.6)	507 (17.6)*	2,539 (25.0)	932 (25.2)	75 (20.8)	648 (23.6)	104 (27.9)	109 (24.8)	615 (17.7)*	108 (24.1)	102 (30.6)	121 (24.8)	291 (22.7)	675 (23.0)
Clinical Pregnancy N %	9830 (34.6)	177 (27.9)**	1142 (35.6)	396 (32.3)	33 (31.4)	264 (30.1)*	47 (34.8)	44 (26.2)*	196 (22.3)*	43 (28.9)	57 (39.6)	57 (33.3)	114 (31.1)	290 (32.3)
Live Birth (LB) N%	7507 (26.4)	122 (17.2)*	848 (26.5)	313 (25.5)	22 (20.1)	208 (23.7)	38 (28.1)	37 (22.0)	153 (17.4)*	32 (21.5)	45 (31.2)	40 (23.4)	90 (24.6)	221 (24.6)

*Significantly lower **(***P<0.05, ** P<0.01); ^ Significantly higher (^P<0.05, ^^ P<0.01)

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Table 3. Multivariate analysis for number of eggs collected (coefficient and 95% CI), clinical pregnancy rate and live birth rate (Odds Ratio and 95% CI). Adjusted for age, cause of infertility and treatment type (IVF or ICSI)

	White British	White Irish	White European	South Asian Indian	South Asian Bangladeshi	South Asian Pakistani	Chinese	Black British	Black African	Black Caribbean	Mediterranean European	Middle Eastern	Mixed Race	Other Asian
Sample Size, N %	28408 (76.1)	635 1.7)	3201 (8.6)	1226 (3.3)	105 (0.3)	878 (2.4)	135 (0.4)	168 (0.5)	879 (2.4)	1495 (0.4)	144 (0.4)	171 (0.5)	366 (1.0)	898 (2.4)
Number of eggs collected	1	- 0.25 (-0.75 to 0.25)	0.90 (0.67 to 1.12)^	-0.18 (-0.54 to 0.18)	-2.63 (-3.85 to -1.41)*	-0.81 (-1.23 to -0.38)*	-0.67 (-1.73 to 0.40)	-0.11 (-1.07 to 0.85)	-0.43 (-0.87 to -0.01)*	0.83 (-0.19 to 1.85)	-0.36 (-1.39 to 0.68)	-1.35 (-2.30 to -0.39)*	-0.51 (-1.16 to 0.14)	-0.79 (-1.21 to -0.38)*
Clinical pregnancy rate	1	0.81 (0.68 – 0.97)*	1.09 (1.01 – 1.18)^	0.80 (0.71 – 0.91)*	0.61 (0.40 – 0.92)*	0.63 (0.54 – 0.73)*	1.04 (0.73 – 1.49)	0.74 (0.52 – 1.06)	0.56 (0.47 – 0.66)*	0.77 (0.54 – 1.11)	1.16 (0.82 – 1.64)	0.81 (0.59 – 1.13)	0.88 (0.70 – 1.10)	0.84 (0.73 – 0.97)*
Live birth rate	1	0.73 (0.60 - 0.90)*	1.04 (0.96 – 1.13)	0.85 (0.75 - 0.97)*	0.53 (0.33 – 0.85)*	0.68 (0.58 - 0.80)*	1.12 (0.77 – 1.64)	0.86 (0.60 – 1.26)	0.60 (0.51 – 0.72)*	0.76 (0.51 – 1.13)	1.18 (0.83 – 1.70)	(OR: 0.73 (0.51 – 1.04)	0.94 (0.73 – 1.19)	0.86 (0.73 – 0.99)*

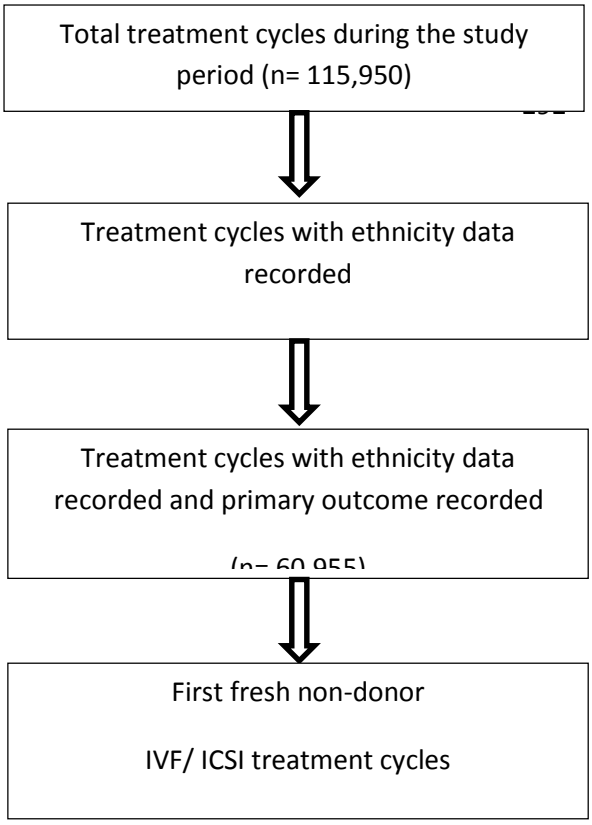
286

287 *Significantly lower **(***P<0.05); ^ Significantly higher (^P<0.05)

288

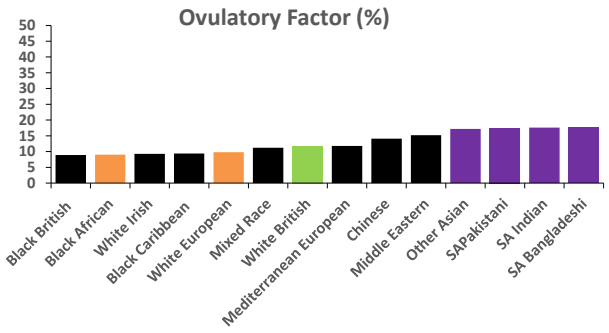
289 Figure 1. Flowchart demonstrating data filtering for inclusion and exclusion from the study.

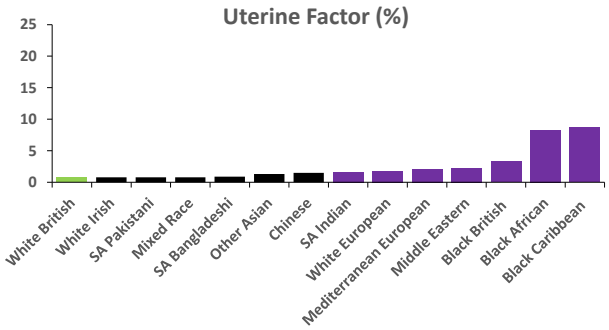
290

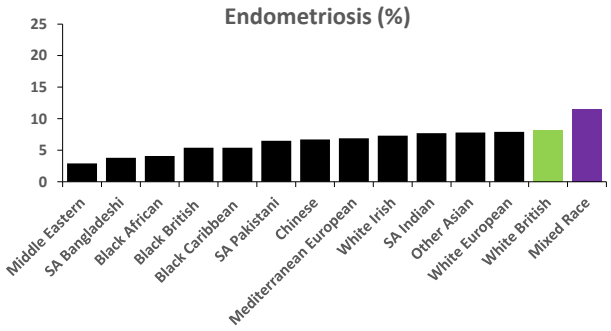


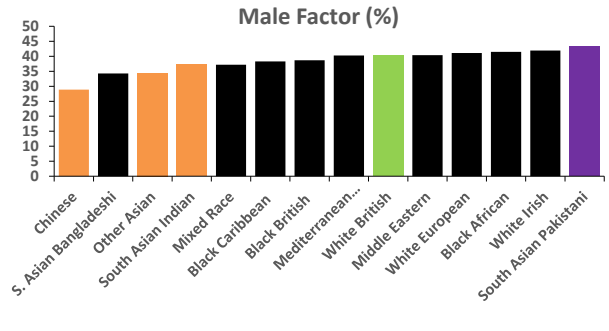
293

Figure 2: Causes of infertility among various ethnic groups; reference group (White British) in green, significantly higher or lower odds in purple or orange respectively, and no statistical difference to the reference group in black.









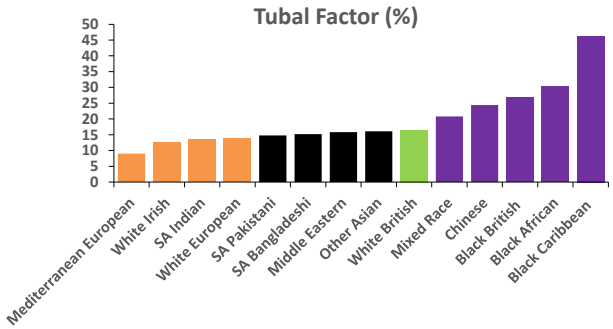


Figure 3: Live birth rate among various ethnic groups; reference group (White British) in green, significantly lower odds in purple or orange respectively, and no statistical difference to the reference group in black.