Occurrence of fertility problems presenting to primary care: population-level estimates of clinical burden and socioeconomic inequalities across the UK

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STUDY QUESTION: What are the age-specific incident rates of clinically recorded fertility problems in women aged 15–49 years and how do they vary by socioeconomic group and geographic area.

SUMMARY ANSWER: The incident rate of recorded fertility problems was highest in women age 30–34 years: about 1% of women per annum. Overall rates did not vary by socioeconomic group; however, age-specific rates varied substantially by socioeconomic deprivation quintile; among younger women, deprivation was associated with higher infertility rates.

WHAT IS KNOWN ALREADY AND WHAT THIS PAPER ADDS: The rates of infertility in the UK range from 2 to 26%. Infertility definitions and denominators vary widely, and most current evidence is based on questionnaire studies that are subject to recall, reporting and selection bias. The current paper presents population-based estimates of clinically recorded fertility problems in women of reproductive age and the variation by age and socioeconomic deprivation quintile across different regions of the UK, using a nationally representative cohort of women that is larger than any previous study. Although infertility overall does not vary by socioeconomic status, consultation for fertility problems is closely related to socioeconomic patterns of women’s age at first conception, demonstrating that many couples have pre-existing, rather than specifically age-related, infertility.

STUDY DESIGN, SIZE, DURATION: This cohort study used data from The Health Improvement Network, a computerized primary care database of anonymized patient records from general practices across the UK, with prospective health records on over 1.7 million women between 1990 and 2010.

PARTICIPANTS/MATERIALS, SETTING AND METHODS: Our cohort included 1 776 746 women of reproductive age (age 15–49 years) who contributed one or more years of active general practice registration. We estimated rates of new clinically recorded fertility problems in these women using medical records and medications exclusively used to treat infertility. We assessed variation in age-specific incidence by socioeconomic deprivation quintile and geographic area using Poisson regression.

MAIN RESULTS AND THE ROLE OF CHANCE: The rate of incident recorded fertility problems was highest in women in the 30–34 year age group (10.9 per 1000 person-years), which equates to approximately 1% of women per annum in this age group. Lowest rates were in women in the 15–19 and 45–49 year age groups (0.7 and 0.4 per 1000 person-years, respectively). Overall rates did not vary by socioeconomic group, measured using quintiles of the Townsend index. Age-specific rates, however, varied substantially with socioeconomic deprivation quintile (P-value for interaction < 0.0001) such that up to age 25, women with more deprivation had higher fertility problems [rate ratio (RR) comparing most to least deprived 5.6, 95% confidence interval (CI) 4.4–7.2 at 15–20 years of age]. This reversed from age 25 to 39, when women with more deprivation had fewer recorded fertility problems (RR 0.6 95% CI 0.5–0.6 at age 30–34). After age 40, there was no socioeconomic gradient in absolute rates.
Fertility problems presenting to primary care

LIMITATIONS, REASONS FOR CAUTION: This is by far the largest population-based study to estimate clinically recorded fertility problems in women and the first in the UK to assess variation across such a broad age group from 15 to 49 years. Our data, however, did not capture women who experience difficulty in conceiving, but do not consult their general practitioner (GP) regarding fertility problems.

WIDER IMPLICATIONS OF THE FINDINGS: Compared with existing estimates, our measures of the extent and distribution of recorded fertility problems in primary care are more useful for GPs, primary care trusts and policy makers for the planning and delivery of fertility services. We have shown a high burden of infertility with little geographic variation; however, the significant burden in young, more deprived women needs recognition in light of age restrictions for treatment availability for infertility in the UK. Not only does treatment access need to be universal and more equitably allocated across socioeconomic groups, but also more resources are required to reduce fertility problems by targeting modifiable risk factors.

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Key words: infertility / primary care / general practice / socioeconomic inequalities / population-based study

Introduction

Infertility is a global public health issue such that accessibility to infertility treatments and assisted reproduction is a key millennium challenge for the World Health Organization (Vayena et al., 2002; Boivin et al., 2007). Not only does it have social and demographic implications, but also the burden includes consequent mental health disorders such as depression and anxiety (Fassino et al., 2002; Ramezanzadeh et al., 2004). To address the burden of infertility for accurate planning of fertility services, it is crucial to characterize the problem. However, estimates are lacking worldwide.

In the UK, the National Institute of Health and Clinical Excellence estimates that one in seven couples will experience difficulties in conceiving (National Collaborating Centre for Women’s and Children’s Health, 2004); however, infertility estimates from the UK range from 2 to 26%, whereas the international range is wider (Hull et al., 1985; Page, 1989; Greenhall and Vessey, 1990; Templeton et al., 1990, 1991; Gunnell and Ewings, 1994; Wilkes and Jones, 1995; Buckett and Bentick, 1997; Oakley et al., 2008; Bhattacharya et al., 2009; Wilkes et al., 2009). Differences in prevalence estimates are due to vastly inconsistent definitions of infertility and denominators used to define the population at risk (Schmidt and Münster, 1995; Habbema et al., 2004); however, selection bias, response bias and recall bias likely also make a large contribution as most studies use self-administered postal questionnaires with resultant low response rates and small sample sizes.

Furthermore, it is unclear as to how existing infertility estimates in the UK translate into the proportion of couples who may need medical intervention provided by the National Health Service. Almost, all are single estimates that do not distinguish by women’s age or socio-demographic factors that may be relevant to plan service provision. Data from the Human Fertilisation and Embryology Authority are the only source of information on infertility treatment at a population level, yet they include only women and couples undergoing specialized infertility treatments from both public and private sectors and, thus, exclude women who initially report fertility problems to their general practitioner (GP), but do not subsequently need or choose to undergo specialized treatment. Despite some evidence of a socioeconomic gradient in infertility in the UK (Gunnell and Ewings, 1994; Morris et al., 2010), few studies include very young women, and none have assessed whether socioeconomic disparities in infertility exist across all age groups.

We used prospective health records from over 1.5 million women to estimate population-based incident rates of clinically recorded fertility problems in women of reproductive age and to assess variation by age, socioeconomic deprivation quintile and geographic area in the UK. In addition, we assessed the variation in clinically recorded fertility problems before and after the implementation of the National Institute of Health and Clinical Excellence guidelines on infertility management (pre- versus post-guideline change). Such data are expected to provide useful estimates of the burden of infertility for equitable organization of national fertility services.

Materials and Methods

Data source and study population

Data were obtained from The Health Improvement Network, a computerized primary care database of anonymized patient records from general practices across the UK. At the time of data collection for this study, the database contained 495 practices with a total of 9.5 million women (World Health Organization, 2006). Our cohort included all women of reproductive age (age 15–49 years) who contributed one or more years of active registration time between January 1990 and September 2010 to a general practice. We selected women aged 15–49 years in accordance with the World Health Organization denominator for prevalence of infertility in women (World Health Organization, 2006). We used an open cohort design in which women could enter and exit the study at different ages and time periods. Each woman’s entry date in the study was taken to be the latest date out of the day she turned 15, 1 January 1990 or when she started active registration. A woman’s exit date was the earliest date out of the date when she turned 50, the date she left general practice, 21 September 2010, or her incident date of a fertility problem (as defined). In the UK, secondary care referrals for couples’ fertility evaluation are issued through women’s GPs, making...
them the ideal population for assessing rates of initial presentation of fertility problems. Furthermore, using a female population provides an appropriate denominator for external comparisons and service planning.

Definition of incident records of fertility problems

Fertility problems were defined using Read codes for fertility investigations (e.g. 3189.00 Infertility investigation female), interventions (e.g. 7M10h.00 IVF), non-specific diagnoses (e.g. 1AZ2.11, Infertility problem), specific diagnoses (e.g. K580000, Primary anovulatory infertility), specialist referrals (e.g. 8HTB.00—Referral to fertility clinic) or drug prescriptions used exclusively to treat infertility (principally clomiphene citrate) (Joint Formulary Committee, 2011). To avoid underestimation, we included Read codes for male factor fertility problems recorded in the woman’s record (e.g. K26.00 Male infertility). We identified the first clinically recorded fertility problem in a woman’s general practice record between the study entry and exit dates as the incident date.

Statistical analysis

We estimated incident rates of clinically recorded fertility problems as the number of first recorded fertility problems per 1000 person-years. Given that female fertility naturally declines with age (National Collaborating Centre for Women’s and Children’s Health, 2004; Balen and Rutherford, 2007), we presented age-specific rates using lexis expansion to stratify by 5-year age groups, allowing women to contribute person-time to more than one group as they aged throughout the study period. Rates were then stratified by geographic area of residence, measured using National Health Services Strategic Health Authorities, and socioeconomic groups, measured as quintiles of Townsend deprivation index. Townsend deprivation index measures area level deprivation based on four indicators: unemployment, house ownership, car ownership and overcrowding and was derived using the 2001 Census data, converted into five quintiles to maintain anonymity, and then assigned to patients’ home postcodes to give a deprivation quintile for each person (CSD Medical Research UK, 2011). We used an additional lexis expansion to split the study follow-up for assessing the variation in incident rates of clinically recorded fertility problems before and after the implementation of the National Institute of Health and Clinical Excellence guidelines on fertility management. We reported age-specific rates for each period (i.e. before and after) as the introduction of national guidelines on fertility management recommended better accessibility to infertility treatments (National Collaborating Centre for Women’s and Children’s Health, 2004). Data are presented as incident rates and incident rate ratios. Using Poisson regression, incidence rate ratios (IRR) were calculated to compare calendar periods and socioeconomic deprivation quintiles for each 5-year age group. We used the 25–29 years age group as the reference category to estimate IRR as the average age at birth in England and Wales in the past 10 years has been within this age group (29.5 in 2000 and 29.4 in 2010). Likelihood ratio tests were performed to test interactions between age and both socioeconomic group and pre–post guidance change. Rate ratios for each Strategic Health Authority compared with the overall UK population were calculated, accounting for age and socioeconomic variation.

Finally, because the World Health Organization guidelines for generation of reproductive health indicators recommend calculating the rates in the 15–44 years age group in addition to the 15–49 years denominator, we calculated the overall rates by Strategic Health Authority in an age-restricted population of women aged 15–44 (World Health Organization, 2006). All statistical analyses were carried out using Stata version 10.

Sensitivity analyses

In women aged 15–49 years, we conducted a sensitivity analysis excluding women with evidence of fertility problems before the study entry to determine if associations between age-specific rates and socioeconomic group, pre–post guidance or Strategic Health Authority changed. For this purpose, women were excluded, if they had a prior history of fertility problems recorded (e.g. 1597.11—H/O: female infertility) or if they had records of fertility problems within the first month following registration with their GP as these may have been recordings of prior problems.

Ethical approval

Ethical approval for this study was obtained from The Health Improvement Network Scientific Research Committee (EPIC Data Company) (reference number 11–027).

Results

In this study, 1,934,846 women met the inclusion criteria for our study. Of these, 158,100 (8%) women were excluded because of missing information on the Townsend socioeconomic deprivation score. The age distribution of this 8% was the same as the population overall, so these women were excluded from further analysis, leaving a study population of 1,776,746 women with a median follow-up time of 4.8 years (interquartile range 2.5–9.2) per woman between age 15 and 49 years. Of these, 58,866 (3.3%) were identified as having at least one record for a fertility problem during follow-up. Of these incident cases, 80% were first identified by a medical code in their record, 16% had both a medical code and a prescription for an infertility treatment drug, and 4% had a prescription only (of which 88% were for clomiphene citrate). Only 0.06% of women had a code solely for infertility in their male partner.

Age-specific incidence rates

Table 1 shows the rates of fertility problems by age. Women were most likely to initially present with a fertility problem between 30 and 34 years of age (incidence rate 10.9 per 1000 person-years, 95% confidence interval (CI) 10.8–11.2). This equates to approximately 1% of women per annum in this age group. The rate declined after age 35 years with the lowest rates of initial presentation of a fertility problem in women aged 45–49 years [0.4 per 1000 person-years (95% CI 0.3–0.4)]. The rate in the youngest group, age 15–19 years, was 0.7 per 1000 person-years (95% CI 0.7–0.8).

Incidence rates by socioeconomic group

The overall incidence rates of recorded fertility problems across quintiles of Townsend deprivation index were almost identical (e.g. 5.5 per 1000 person-years in the least deprived quintile and 5.1 per 1000 person-years in the most deprived quintile) (Table 2). However, there was considerable socioeconomic variation in the age-specific rates (test for interaction P < 0.001) as shown in Table 2 and Fig. 1. Up to 25 years of age, recorded fertility problems were increased for women in the higher socioeconomic deprivation quintiles when compared with the other women. Women of 20–24 years of age from the most deprived quintile were 80% more likely to have recorded fertility problems when compared with those from the least deprived quintile [(IRR = 1.8 95% CI 1.6–1.9)]. From ages 25 to 39, this reversed such that fertility problems were decreased for...
women in higher socioeconomic deprivation quintiles when compared with the other women. The gradient was strongest for women of age 30–34 who were 40% less likely to have incident recorded fertility problems, if they were from the most deprived quintile when compared with the least deprived quintile (IRR = 0.6, 95% CI 0.5–0.6).

After age 40, recorded fertility problems decreased substantially overall, and absolute rates did not differ substantially across socioeconomic groups.

**Incidence rates by Strategic Health Authority**

The overall rates of clinically recorded fertility problems were very similar across most regions other than London that had an incidence rate of 6.9 per 1000 person-years, 95% CI 6.8–7.1 (Table 3). After adjusting for age and socioeconomic deprivation quintile, while fitting an interaction term between them, IRRs for each Strategic Health Authority compared with the overall UK study population showed minimal regional variation in reporting fertility problems. However, incidence rates were 30% higher in London (IRR 1.3, 95% CI 1.2–1.3) when compared with the overall UK study population.

The overall rates by Strategic Health Authorities remained fairly unchanged when the baseline population was restricted to women between the ages of 15 and 44 (see Supplementary data, Table I).

**Incidence rates before and after the introduction of national fertility guidelines**

There was only a modest increase in overall rates of recorded fertility problems after the implementation of national guidelines on infertility in 2005 (4.8 per 1000 person-years, 95% CI 4.8–4.9 before and 5.9 per 1000 person-years, 95% CI 5.9–6.0 after). Rates increased across all age groups. However, the relative increase was greater in older age groups ($P < 0.0001$ for interaction between age and calendar time). For example, the rate in women age 35 years and over was 50% higher (IRR 1.52, 95% CI 1.48–1.57) after the implementation of

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Incident record of fertility problem</th>
<th>Number of women ($n = 17 767 746^a$)</th>
<th>Person-years (total = 11 338 754)</th>
<th>Rate$^b$</th>
<th>95% CI</th>
<th>IRR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–19</td>
<td>939</td>
<td>392 047</td>
<td>1 312 039</td>
<td>0.7</td>
<td>0.7–0.8</td>
<td>0.08</td>
<td>0.07–0.09</td>
</tr>
<tr>
<td>20–24</td>
<td>6315</td>
<td>543 448</td>
<td>1 374 735</td>
<td>4.6</td>
<td>4.5–4.7</td>
<td>0.5</td>
<td>0.4–0.5</td>
</tr>
<tr>
<td>25–29</td>
<td>14 967</td>
<td>606 097</td>
<td>1 582 157</td>
<td>9.4</td>
<td>9.3–9.6</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>30–34</td>
<td>18 935</td>
<td>599 494</td>
<td>1 721 478</td>
<td>10.9</td>
<td>10.8–11.2</td>
<td>1.2</td>
<td>1.1–1.2</td>
</tr>
<tr>
<td>35–39</td>
<td>12 740</td>
<td>575 308</td>
<td>1 813 887</td>
<td>7.0</td>
<td>6.9–7.1</td>
<td>0.7</td>
<td>0.7–0.8</td>
</tr>
<tr>
<td>40–44</td>
<td>4327</td>
<td>551 104</td>
<td>1 811 910</td>
<td>2.4</td>
<td>2.3–2.5</td>
<td>0.3</td>
<td>0.2–0.3</td>
</tr>
<tr>
<td>45–49</td>
<td>643</td>
<td>491 943</td>
<td>1 720 548</td>
<td>0.4</td>
<td>0.3–0.4</td>
<td>0.04</td>
<td>0.03–0.04</td>
</tr>
</tbody>
</table>

$^a$Sum of all ages is not equal to the overall n as women contributed time in more than one age category.

$^b$Incident fertility problems per 1000 person-years.

<table>
<thead>
<tr>
<th>Quintiles of Townsend index</th>
<th>Quintile 1 least deprived $n = 427 723$</th>
<th>Quintile 2 $n = 366 914$</th>
<th>Quintile 3 $n = 373 419$</th>
<th>Quintile 4 $n = 350 507$</th>
<th>Quintile 5 most deprived $n = 258 183$</th>
<th>IRR (95% CI) for Quintile 5 versus Quintile 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall rate (95% CI)$^b$</td>
<td>5.5 (5.4–5.6)</td>
<td>5.1 (5.0–5.2)</td>
<td>5.3 (5.1–5.4)</td>
<td>5.1 (5.0–5.2)</td>
<td>5.1 (4.9–5.2)</td>
<td>0.9 (0.8–0.9)</td>
</tr>
<tr>
<td>Rate by age (95% CI)$^b$</td>
<td>0.3 (0.2–0.4)</td>
<td>0.4 (0.3–0.5)</td>
<td>0.7 (0.6–0.8)</td>
<td>1.1 (0.9–1.2)</td>
<td>1.6 (1.4–1.8)</td>
<td>5.6 (4.4–7.2)</td>
</tr>
<tr>
<td>15–19</td>
<td>3.3 (3.1–3.5)</td>
<td>3.8 (3.6–4.1)</td>
<td>4.6 (4.4–4.9)</td>
<td>5.4 (5.2–5.7)</td>
<td>5.8 (5.5–6.1)</td>
<td>1.8 (1.6–1.9)</td>
</tr>
<tr>
<td>20–24</td>
<td>10.7 (10.4–11.0)</td>
<td>9.7 (9.4–10.1)</td>
<td>9.2 (8.9–9.5)</td>
<td>8.9 (8.6–9.2)</td>
<td>8.6 (8.2–8.9)</td>
<td>0.8 (0.7–0.8)</td>
</tr>
<tr>
<td>25–29</td>
<td>13.5 (13.2–13.9)</td>
<td>11.7 (11.3–12.0)</td>
<td>10.6 (10.3–10.9)</td>
<td>9.3 (8.9–9.6)</td>
<td>8.1 (7.7–8.4)</td>
<td>0.6 (0.5–0.6)</td>
</tr>
<tr>
<td>30–34</td>
<td>7.8 (7.6–8.0)</td>
<td>7.1 (6.9–7.4)</td>
<td>7.2 (6.9–7.5)</td>
<td>6.2 (5.9–6.5)</td>
<td>5.8 (5.5–6.1)</td>
<td>0.7 (0.6–0.8)</td>
</tr>
<tr>
<td>35–39</td>
<td>2.4 (2.3–2.5)</td>
<td>2.2 (2.1–2.4)</td>
<td>2.6 (2.4–2.7)</td>
<td>2.3 (2.1–2.5)</td>
<td>2.6 (2.4–2.8)</td>
<td>1.1 (0.9–1.2)</td>
</tr>
<tr>
<td>40–44</td>
<td>0.3 (0.2–0.3)</td>
<td>0.3 (0.2–0.4)</td>
<td>0.4 (0.3–0.5)</td>
<td>0.4 (0.3–0.5)</td>
<td>0.5 (0.4–0.7)</td>
<td>1.9 (1.4–2.4)</td>
</tr>
</tbody>
</table>

$^a$Number of women in each quintile of Townsend index.

$^b$Incident fertility problems per 1000 person-years.
Figure 1  Incident rates of clinically recorded fertility problems per 1000 person-years by quintile of Townsend deprivation index overall and in different age bands (upper and lower bars are 95% CIs for rates).

Table III  Overall incident rates and rate ratios of clinically recorded fertility problems by Strategic Health Authorities.

<table>
<thead>
<tr>
<th>Strategic Health Authority</th>
<th>Incident record of fertility problem</th>
<th>Number of women</th>
<th>Rate$^a$</th>
<th>95% CI</th>
<th>Adjusted IRR$^b$ (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK (overall study population)</td>
<td>58 866</td>
<td>1 776 746</td>
<td>5.2</td>
<td>5.2–5.3</td>
<td>Reference</td>
</tr>
<tr>
<td>East Midlands</td>
<td>2611</td>
<td>73 571</td>
<td>4.9</td>
<td>4.7–5.0</td>
<td>0.9 (0.9–1.0)</td>
</tr>
<tr>
<td>East of England</td>
<td>4288</td>
<td>132 309</td>
<td>5.3</td>
<td>5.1–5.4</td>
<td>1.0 (1.0–1.0)</td>
</tr>
<tr>
<td>London</td>
<td>7789</td>
<td>210 582</td>
<td>6.9</td>
<td>6.8–7.1</td>
<td>1.3 (1.2–1.3)</td>
</tr>
<tr>
<td>North East</td>
<td>1865</td>
<td>53 203</td>
<td>5.1</td>
<td>4.8–5.3</td>
<td>1.0 (1.0–1.1)</td>
</tr>
<tr>
<td>North West</td>
<td>6021</td>
<td>167 252</td>
<td>4.9</td>
<td>4.8–5.0</td>
<td>0.9 (0.9–1.0)</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>1855</td>
<td>49 889</td>
<td>5.2</td>
<td>4.9–5.4</td>
<td>1.0 (1.0–1.1)</td>
</tr>
<tr>
<td>Scotland</td>
<td>4591</td>
<td>173 649</td>
<td>4.2</td>
<td>4.1–4.3</td>
<td>0.8 (0.8–0.9)</td>
</tr>
<tr>
<td>South Central</td>
<td>7573</td>
<td>222 364</td>
<td>5.6</td>
<td>5.5–5.7</td>
<td>1.0 (1.0–1.1)</td>
</tr>
<tr>
<td>South East Coast</td>
<td>5768</td>
<td>174 346</td>
<td>5.5</td>
<td>5.3–5.6</td>
<td>1.0 (1.0–1.1)</td>
</tr>
<tr>
<td>South West</td>
<td>6065</td>
<td>181 868</td>
<td>5.3</td>
<td>5.2–5.4</td>
<td>1.0 (1.0–1.1)</td>
</tr>
<tr>
<td>Wales</td>
<td>2668</td>
<td>103 825</td>
<td>4.4</td>
<td>4.2–4.6</td>
<td>0.9 (0.8–0.9)</td>
</tr>
<tr>
<td>West Midlands</td>
<td>5768</td>
<td>166 285</td>
<td>5.3</td>
<td>5.2–5.4</td>
<td>1.0 (1.0–1.0)</td>
</tr>
<tr>
<td>Yorkshire/Humber</td>
<td>2004</td>
<td>67 603</td>
<td>4.2</td>
<td>4.0–4.4</td>
<td>0.8 (0.8–0.9)</td>
</tr>
</tbody>
</table>

$^a$Incident fertility problems per 1000 person-years.

$^b$Adjusted for socioeconomic quintiles and age group with an interaction term fitted between socioeconomic status and age.
national guidelines on infertility management compared with the pre-guideline period. The equivalent IRR in women younger than age 35 years was 1.13, 95% CI 1.11–1.15).

Sensitivity analysis

Furthermore, to assess the robustness of our findings, we applied our restrictive definition to define incident cases in our original population (15–49 years) and the total number of cases decreased to 49,875. Rates of clinically recorded fertility problems in each age group decreased only slightly (Table 4), yet all associations with age, socioeconomic group, Strategic Health Authorities and time of implementation of infertility guidelines remained unaltered (see Supplementary data, Tables II and III).

Discussion

Using data from 1.7 million women across the UK, we found the highest rates of clinically recorded fertility problems, approximately 1% of women per annum in women age 30–34 years. The rate in very young women, age 15–19 years, was 0.7 per 1000 women per year while the lowest rate of 0.4 per 1000 women per annum was in women aged 45–49 years. We found little variation in rates by geographic area and importantly no variation by socioeconomic status in the overall rate that included women of all ages. Recording of fertility problems, however, is closely related to socioeconomic patterns of women’s age at first conception, indicating that many couples have pre-existing rather than specifically age-related infertility. At younger ages, women from more deprived socioeconomic groups had higher rates of recorded fertility problems compared with the other women, whereas after age 25 women from less deprived groups had higher rates compared with the other women. These age-specific incidence rates provide useful measures of the high burden of infertility at a population level and reinforce the continued need for universal fertility services.

We have provided robust evidence to show that fertility problems overall do not vary by socioeconomic status at a population level. Previous UK evidence for a socioeconomic gradient in infertility is limited to two postal surveys where response rates were limited. The first, conducted in Somerset on a sample of 2377 women between 36 and 50 years, showed no substantial differences in reported infertility but women from higher socioeconomic groups were more likely than women from lower socioeconomic groups to seek medical help and to be referred by their GP to hospital (Gunnell and Ewings, 1994). Using a larger sample of 6584 women who were age 40–55 years in 2001 from the UK electoral register, Morris et al. (2010) showed that women classified as social class I/II were 30% more likely to report previous fertility problems than women from social class IV/V, however associations with help seeking were not demonstrated (Morris et al., 2010). Although Morris et al. (2010) did adjust for women’s age at first trying for a pregnancy, our data show that socioeconomic gradients differ by age, so statistical adjustment is inappropriate. Studies from Sweden, Finland and the United States have reported slightly more infertility among women with lower educational attainment but more seeking of medical help for women from higher socioeconomic groups, however, these countries have different financial organization of fertility services to the UK (Wulff et al., 1997; Bidler and Schmidt, 2006; Terava, 2008; Eisenberg et al., 2010).

Most of these studies only reported overall differences in socioeconomic status and none separately assessed gradients in very young women between age 15 and 25 years. Whilst the delay of conception to differing extents (Fairley and Leyland, 2006) prevents determination of the true occurrence of age-specific infertility from observational data, the association of fertility problems in more deprived young women indicates that many women, and potentially men as well, have pre-existing problems that are unmasked later. Although fertility is biologically affected by age, our data demonstrate that age-specific estimates in older more affluent women may be exaggerated by delaying conception. This interaction between age and socioeconomic status has also been demonstrated for birth rates in the UK (Ruddock et al., 1998) as well as internationally (Kogevinas et al., 1997).

The incidence rates in women aged 40–49 were very low as most women will have either reported fertility problems by this age or would not have tried to conceive a pregnancy at this time in their life. Our rates also show some increase in fertility problems after the introduction of the national fertility treatment guidelines (National Collaborating Centre for Women’s and Children’s Health, 2004), which may reflect increased awareness and availability of fertility

### Table IV Age-specific incident rates and rate ratios of clinically recorded fertility problems per 1000 person-years, excluding women with evidence of prior history of fertility problems before study entry.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Incident record of fertility problem</th>
<th>Number of women (n = 1 736 920)</th>
<th>Person-years (total = 11 023 486)</th>
<th>Rate</th>
<th>95% CI</th>
<th>IRR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–19</td>
<td>839</td>
<td>91 799</td>
<td>1 211 633</td>
<td>0.7</td>
<td>0.6–0.7</td>
<td>0.08</td>
<td>0.07–0.09</td>
</tr>
<tr>
<td>20–24</td>
<td>5659</td>
<td>541 623</td>
<td>1 372 338</td>
<td>4.1</td>
<td>4.0–4.2</td>
<td>0.5</td>
<td>0.4–0.5</td>
</tr>
<tr>
<td>25–29</td>
<td>13 031</td>
<td>599 759</td>
<td>1 571 928</td>
<td>8.3</td>
<td>8.1–8.4</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>30–34</td>
<td>15 884</td>
<td>586 128</td>
<td>1 692 982</td>
<td>9.4</td>
<td>9.2–9.5</td>
<td>1.1</td>
<td>1.1–1.2</td>
</tr>
<tr>
<td>35–39</td>
<td>10 443</td>
<td>556 693</td>
<td>1 765 166</td>
<td>5.9</td>
<td>5.8–6.0</td>
<td>0.7</td>
<td>0.6–0.7</td>
</tr>
<tr>
<td>40–44</td>
<td>3504</td>
<td>531 057</td>
<td>1 748 373</td>
<td>2.0</td>
<td>1.9–2.1</td>
<td>0.4</td>
<td>0.2–0.3</td>
</tr>
<tr>
<td>45–49</td>
<td>515</td>
<td>474 587</td>
<td>1 661 066</td>
<td>0.3</td>
<td>0.3–0.4</td>
<td>0.04</td>
<td>0.03–0.04</td>
</tr>
</tbody>
</table>

*Sum of all ages is not equal to the overall n as women contributed time in more than one age category.

Incident fertility problems per 1000 person-years.
services (Jenkins et al., 2005; Human Fertilisation and Embryology Authority, 2011) or an increasing expectation of the benefits of medical advice; however, absolute increases were modest.

**Strengths and limitations**

This is by far the largest population-based study to estimate incident rates of recorded fertility problems in women and the first in the UK to assess variation across such a broad age group. With prospective data on 1.7 million women over a period of 20 years, providing over 11 million person-years of follow-up, we had statistical power to assess variation in rates by age and socio-demographic factors. Our use of primary care data to ascertain the burden of fertility problems showed, unsurprisingly, a much higher clinical presentation of fertility problems when compared with those captured by the Human Fertilisation and Embryology Authority treatment statistics (Human Fertilisation and Embryology Authority, 2011). As specialist fertility investigations and treatments initially require GP referral in the UK (National Collaborating Centre for Women’s and Children’s Health, 2004; Balen and Rutherford, 2007), even if couples opt for private treatment, electronic primary care data provide a more complete picture of the extent and distribution of fertility problems at a population level. Although some couples presenting with fertility problems in primary care may not need or choose not to undergo advanced fertility treatment, primary care data allowed us to also include the women in whom existing medical conditions confer a low likelihood of successful fertility treatment. Our data did not capture women who experience difficulty in conceiving, but do not consult their GP regarding fertility problems. Available estimates of the proportion of women with fertility problems who sought medical help in the UK range from 50 to 85%, although most were based on data from well over a decade ago, and fertility problems were defined differently across these studies (Gunnell and Ewings, 1994; Buckett and Bentick, 1997; Bhattacharya et al., 2009; Morris et al., 2010). Our rates of initial presentation of fertility problems in primary care are limited to women as opposed to couples as the infertility treatments and referrals for specialist care in the UK are issued through women’s primary care records, and linkage of couples’ data in primary care is difficult due to anonymization of records. Inevitably, therefore, we could not use couples as a baseline group. We included male factor infertility codes to identify our incident cases; however, only 0.06% of our infertility cases were identified solely through male infertility codes; an overestimation of the age-specific rate of initial presentation of fertility problems in our female population is, therefore, unlikely. Finally, using primary care data, we could not always distinguish between the types and origins of fertility problems as most of the recording for fertility problems in primary care data did not include specific diagnoses (e.g. tubal versus ovulatory infertility).

**Comparing estimates of fertility problems with previous literature**

The aim of most infertility studies has been to obtain estimates at a population level; however, the sensitive detail required about couples’ reproductive behaviours and their perceptions of fertility has meant that these are restricted to questionnaire studies that are subject to recall, reporting and selection bias, where participation is incomplete. Researchers also use various denominators and definitions of infertility, which has resulted in a large range of estimates for infertility in the UK (2–26%), even within similar definitions such as primary or lifetime infertility (Hull et al., 1985; Page, 1989; Greenhall and Vessey, 1990; Templeton et al., 1990, 1991; Gunnell and Ewings, 1994; Wilkes and Jones, 1995; Buckett and Bentick, 1997; Oakley et al., 2008; Bhattacharya et al., 2009; Wilkes et al., 2009). Comparison of our population-level, age-specific rates of clinically recorded fertility problems with questionnaire studies is thus problematic; however, our estimates follow patterns of the Human Fertilisation and Embryology Authority statistics and show that our rates are approximately double those of women undergoing specialized fertility treatment in the UK. Infertility treatment data from 2006 showed that the average age of women starting treatment was 35 years, whereas the total age range of treated women was 17–49 years, which is very similar to the age pattern in our study (Kurinczuk and Hockley, 2010). Kurinczuk and Hockley’s (2010) estimate of treatment rates (per 1000 women aged 15–44 years) were an overall rate of 3.5, a peak rate of 6.0 in London and otherwise little variation across most of the UK. These were closely mirrored by our findings; however, our overall incident rate of clinically recorded fertility problems after 2005 in women aged 15–49 was inevitably higher (5.9 per 1000 women) than the rate reported by Human Fertilisation and Embryology Authority as over half of the women who report fertility problems may not undergo specialized treatments (Gunnell and Ewings, 1994; Buckett and Bentick, 1997). Our results are also consistent with a smaller primary care study with a more similar study design, where 681 couples were identified from 58 general practices (Wilkes et al., 2009). The authors estimated an infertility rate of 6 per 1000 women; however, they did not assess variation by age or other socio-demographic factors (Wilkes et al., 2009).

Our study is the first to provide a robust, population-based estimate of initially recorded fertility problems in women as young as 15–19 in the UK. Compared with older women whose rates will include age-related fertility declines, rates in young women are more likely to include a larger group with modifiable risk factors or medical problems. These include polycystic ovarian syndrome that is mostly to include a larger group with modifiable risk factors or medical problems. This is by far the largest population-based study to estimate incident rates of recorded fertility problems in women as young as 15–19 in the UK. Compared with older women whose rates will include age-related fertility declines, rates in young women are more likely to include a larger group with modifiable risk factors or medical problems. These include polycystic ovarian syndrome that is mostly...
primary care are more useful for GPs, primary care trusts, and policy makers for the planning and delivering of fertility services. We have shown a high burden of infertility with little geographic variation; however, the significant burden in young more deprived women needs recognition in light of age restrictions of treatment availability for infertility in the UK. Given the health detriments of teenage pregnancies, women should not be encouraged to conceive at such early ages. However, early detection of fertility problems in these younger more socially deprived women could give them better chances of conception at later ages. Therefore, not only does treatment access need to be universal and more equitably allocated across socioeconomic groups, but also more resources are required to reduce fertility problems by targeting modifiable risk factors in younger, more socio-economically deprived women to increase their likelihood of conceiving during their later reproductive years.

**Supplementary data**

Supplementary data are available at http://humrep.oxfordjournals.org/

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**Authors’ roles**

L.J.T. conceived the idea for the study and analyses that was conducted using a dataset created by L.F. and L.J.T. of women in their potential childbearing years from The Health Improvement Network database. N.N.D. carried out the data management and analysis and wrote the first draft of the manuscript. J.W. provided interpretation at different stages of the project and L.J.T. and J.W. helped to draft the manuscript. All authors read and approved full drafts and the final manuscript.

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**Conflict of interest**

There are no conflicts of interests to declare.

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