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ARTICLE

Reconceiving egg freezing: insights from an analysis of 5 years of data from a UK clinic

BIOGRAPHY

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KEY MESSAGE

Egg freezing is more heterogeneous than previously assumed. In addition to the accepted categories of social egg freezing (SEF) and medical egg freezing (MEF), we propose clinical egg freezing (CEF) and incidental egg freezing (IEF) as distinct categories, in order to better understand the underlying patterns of this fast-growing phenomenon.

ABSTRACT

Research question: What can we learn from 5 years of egg-freezing practice in the UK? What are the different categories of egg freezing, and what are the social and demographic characteristics of patients, and their decisions regarding subsequent storage or thawing?

Design: A retrospective analysis of clinical and laboratory data of all 514 cycles of 'own' egg freezing conducted at the London Women's Clinic in the 5-year period from the start of 2012 to the end of 2016.

Results: This analysis, the first of its kind, develops a clearer picture of egg-freezing trends in the UK and fills in the details behind the Human Fertilisation and Embryology Authority's national figures. Four different categories of egg freezing are identified and the appropriate category allocated to each of the 514 cycles undertaken by 352 patients. To the established categories of 'medical' and 'social' already discussed in the literature, we add the two new categories of 'clinical' and 'incidental' egg freezing. We show how each of these categories presents a distinct egg-freezing patient profile, and discuss the similarities and differences between them across variables such as age, relationship status, number of eggs frozen, number of egg-freezing cycles undertaken, and the current status of frozen eggs.

Conclusions: The data require a reconceptualization of the phenomenon of egg freezing, and argue for the importance of clearly and accurately differentiating between different categories of egg-freezing practice in clinical and national data collection in order to adequately inform future practice, regulation and the decision-making processes of patients considering these procedures.

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KEYWORDS

Egg freezing
Ethics
Fertility preservation
Oocyte cryopreservation
Regulation
Sociology of assisted reproduction

INTRODUCTION

Egg freezing, or oocyte vitrification, is one of the fastest growing techniques in assisted reproductive technology (ART), attracting attention not only from potential users but also more widely from social science scholars, ethicists and the popular media. While the USA is certainly leading this trend, with recent newspaper reports claiming that more than 20,000 American women have already elected to freeze their eggs (*Belluck, 2018*), egg freezing is also showing rapid growth in the UK, Israel, Australia, Scandinavia, and across many European countries, with some predicting its development into a big business on a global scale in the very near future (see *Browne, 2018*). Yet, as it is a relatively new technology, there is currently limited data available to understand the phenomenon and its characteristics, and little empirical evidence to support the range of views that have been expressed regarding the ethical aspects and social impact of such a technology (*Baldwin et al., 2014*).

The world's first birth following fertilization of a frozen egg was reported in 1986 (*Chen, 1986*); however, due to the difficulties with successfully thawing eggs, and the subsequent low rates of fertilization and pregnancy, the technology remained marginal for the following two decades. It was the advent of vitrification – a method of ultra-rapid cooling using liquid nitrogen that reduces potential damage to the internal structure of eggs, thereby enabling success rates for thawing and fertilization of frozen eggs to improve (*Argyle et al., 2016*) – that fuelled the growth of the practice. Following a series of randomized controlled trials (*Cobo et al., 2008, 2010; Parmegiani et al., 2011; Rienzi et al., 2010*), which suggested that IVF using vitrified-thawed eggs yielded comparable fertilization and pregnancy results to IVF cycles using fresh eggs, the American Society of Reproductive Medicine (ASRM) lifted the 'experimental' label from the practice of egg freezing via vitrification in 2012 (*ASRM, 2013*). This much-cited announcement by the ASRM, as well as the recommendations from the ESHRE Task Force on Ethics and Law (*Dondorp et al., 2012*), helped to both develop the confidence of potential patients in egg freezing using vitrification and also encouraged the spread of the practice to many clinics.

In the UK, the Human Fertilization and Embryology Authority (HFEA), the statutory body that regulates and inspects all clinics providing ART treatment, has allowed the use of frozen eggs in fertility treatments since 2000 (*Wise, 2000*). Although before 2007 clinics were almost exclusively practising the old 'slow freezing' method, most have now fully transitioned to the use of vitrification. Despite years of regulated practice however, it was only in 2016 that the HFEA began to publish national data on egg freezing (*HFEA, 2016*). Explaining the decision to include egg freezing for the first time in their report, Sally Cheshire, the Chair of the HFEA, stated in her foreword that, 'Freezing techniques are relatively new, and were very rare only 5 or 6 years ago. Interest from patients and the media has grown considerably in recent years, however, and we felt it was time to provide more clarity' (*HFEA, 2016*: 2).

The *HFEA's 2016* report provided a range of data on egg freezing in the UK, including the number and age of women freezing their eggs, the number of egg-freezing cycles undertaken, the number of thaw cycles undertaken, how long the eggs had been frozen for, and the outcomes and success rates of thawed cycles, as well as the number of clinics providing egg freezing in the UK. The HFEA's latest report, released in March 2018, updates this data by providing further figures for egg-freezing practice between 2014 and 2016 (*HFEA, 2018*). Although the two reports contain some important discrepancies due to the use of different definitions regarding what counts as an egg-freezing cycle (see *Gurtin, 2018*), the HFEA data remain the most comprehensive data on egg freezing in the UK, and are commonly referenced in public and media debates, whether in support of or in criticism of the practice (e.g. *Specter, 2017; Wooller, 2017*).

However, it is important to note that the HFEA data leaves some important questions about the practice and social context of egg freezing in the UK unanswered. For example, in the 2016 report, it is noted that only very limited information has been collected regarding women's reasons for seeking egg freezing. Instead, reasons are extrapolated from the available information, such as the fact that 54.1% of women aged 38 and older and 36.4% of women aged 37 and younger who froze their eggs recorded that they had 'no male partner'. However these details beg the question, for example, of why a considerable proportion of egg freezers are women who do have a male partner, suggesting a discrepancy between the data and the popular or media image of egg freezing as a technology almost exclusively undertaken by single women. Moreover, the HFEA's more recent *2018* report provides no details at all for the reason for egg freezing, making it very difficult indeed to gain any accurate picture of who is freezing their eggs and why they may be doing so. The 2016 report also points to some interesting questions regarding which patients are thawing their eggs, but stops short of providing answers. For example, the data show that, 'Of the thawed egg cycles performed, well over half used eggs which had been frozen for less than a year. These are unlikely to be those women freezing in order to preserve their fertility in the longer term, but may be those that had to put their treatment on hold for unexpected reasons, for instance, if donor or partner sperm was not available at the right time' (*HFEA, 2016*: 27).

Taking the gaps in the HFEA data as our starting point, we wanted to shed light on some of the questions surrounding the social context of egg freezing in the UK. In particular, we wanted to develop a more accurate and detailed understanding of the different categories of egg freezing practised in the UK, reflecting the different reasons why, or circumstances in which, women have frozen their eggs, and how these relate to other characteristics, such as their age or relationship status. We were also keen to find out whether our clinical experience could tell us something about why, according to national data, the majority of thawed eggs had been stored for less than a year, and the reasons behind such seemingly short storage periods. In this paper we report on the findings from a detailed analysis of 5 years of egg freezing at the London Women's Clinic Harley Street (LWC), from 2012 to the end of 2016, based on patient and laboratory records.

MATERIALS AND METHODS

Data for this paper were gathered using a retrospective evaluation of the LWC's existing documentation regarding

TABLE 1 NUMBER OF EGG-FREEZING CYCLES AND NUMBER OF PATIENTS FREEZING THEIR EGGS BY YEAR

Year	Number of cycles of egg freezing (*n* = 514)	Number of patients freezing eggs (*n* = 342[a])
2012	6	6
2013	52	43
2014	91	71
2015	179	135
2016	186	137

[a] The total number of patients does not tally with the number of patients for each year added together because some patients had egg-freezing cycles in more than one year (across 2 or 3 years).

past patients. Patient records and laboratory data were used to create a comprehensive database of all own egg-freezing cycles undertaken at the LWC.

All treatment cycles logged as 'own egg freezing' at the LWC were compiled in a spreadsheet and double-checked manually to ensure that all were instances of own egg freezing; any cycles of eggs frozen for donation were excluded. A total of 521 cycles of own egg freezing were recorded from 2008 onwards, however the current analysis was limited to a 5-year period, from 1 January 2012 to 31 December 2016, because 2012 was the first year in which there were more than five cycles of own egg freezing recorded. In all of the cycles, eggs were frozen using the vitrification method as the LWC laboratories did not use the 'slow freezing' method. This study sample thus represents 514 cycles of egg freezing undertaken by 342 women for their own later use, i.e. all 'own egg freezing cycles' undertaken at the LWC over the 5-year period, from 2012 to the end of 2016. (For the rest of this paper, for convenience 'egg freezing' refers exclusively to 'own egg freezing' and excludes any egg freezing as part of egg donation cycles or programmes.)

Researchers cross-checked each egg-freezing cycle logged against the relevant patient's records and lab sheets to create a spreadsheet that included the following details for all 514 cycles: year of cycle; month of cycle; date of egg collection; patient ID; patient age (at egg freeze); patient birth date; patient sexuality and/or relationship status (single, heterosexual couple, lesbian couple); egg-freezing cycle number (for patient); number of eggs collected; number of eggs frozen; reason for egg freezing; current status of eggs (in storage, thawed for conception attempt, discarded, moved); and (if applicable) details and outcome of egg thaw.

The above data were examined, analysed for patterns, and relevant categories generated regarding, for example, the reason for egg freezing. An in-depth numerical analysis of various aspects of the data was undertaken, including comparison of different variables (such as age, number of eggs frozen, and current status of frozen eggs) between women who had frozen their eggs for different reasons. Statistical analyses, using the chi-squared test and the one-way analysis of variance (ANOVA), were applied as appropriate, in particular to determine the statistical significance of the different characteristics between patients freezing their eggs for different reasons.

This retrospective analysis did not require ethical or institutional review board approval, as it assessed laboratory and

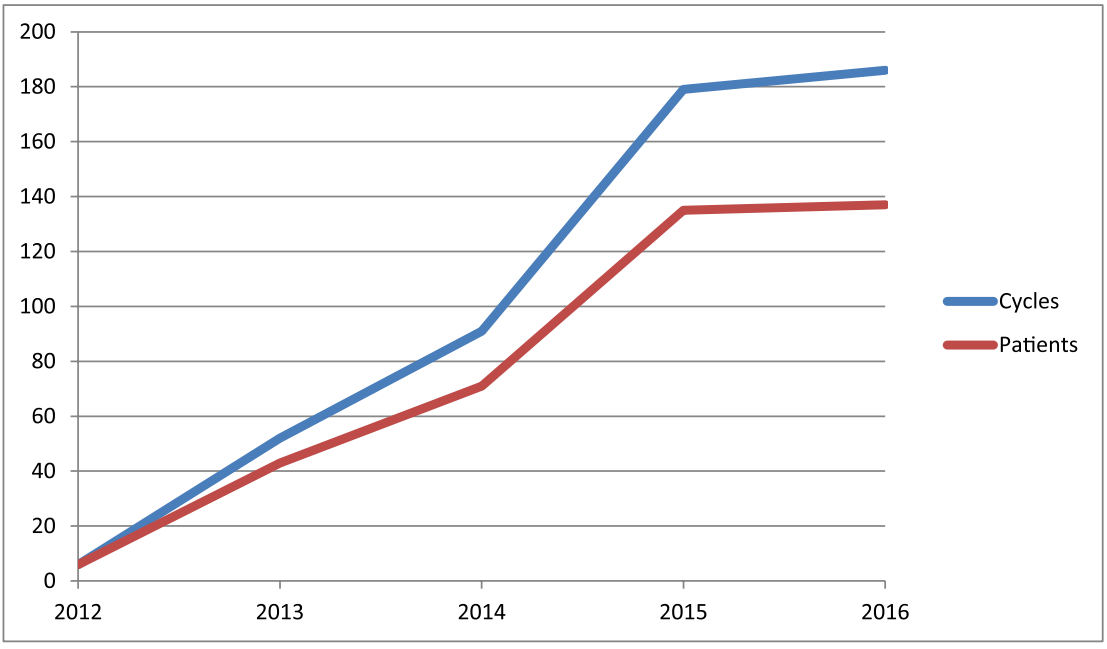

FIGURE 1 Number of egg-freezing cycles and number of women freezing eggs by year, 2012–2016.

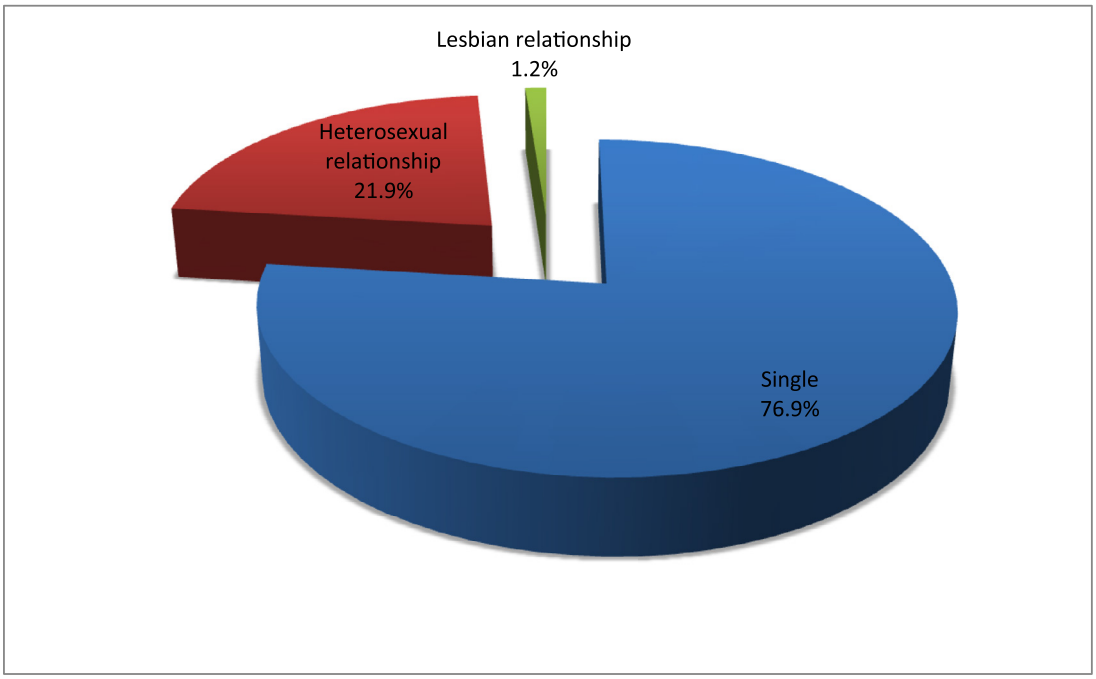

FIGURE 2 Egg-freezing patients by relationship status.

clinical records from previously validated and approved procedures, practised under licence from the HFEA.

RESULTS

As can be seen in TABLE 1, six women each underwent one cycle of egg freezing at the LWC in 2012. This increased to 52 cycles (undertaken by 43 women) in 2013; 91 cycles (by 71 women) in 2014; 179 cycles (by 135 women) in 2015; and 186 cycles by 137 women in 2016. This represents a dramatic increase in the number of egg-freezing cycles at the LWC over the 5 years, with numbers more than doubling (rising by 104.4%) in the latest 2 years alone (see also FIGURE 1). Although the sample comprised a total of 342 women who froze their eggs in the 5-year period, the total for each year added together gives a higher figure (392) because 46 women froze their eggs in multiple cycles across 2 or 3 different years.

Looking at the overall patient group, we can see that 76.9% of patients were single at the time of egg freezing, 21.9% were in a heterosexual relationship, and 1.2% were in a same-sex relationship. (see FIGURE 2).

When the sample was examined for patterns, differences were found in characteristics such as average age and relationship status among egg-freezing patients. These differences were associated with different categories of egg freezing. Thus, in order to better understand how these different categories affected other variables and demographic trends for egg-freezing patients, we sought to define and describe the categories of egg freezing. This showed that, within the LWC, there were four distinct categories for egg freezing: social egg freezing (SEF), medical egg freezing (MEF), clinical egg freezing (CEF) and incidental egg freezing (IEF). While the first two categories, SEF and MEF, are already established in the literature and public debates surrounding egg freezing, the third and fourth categories, CEF and IEF, are new categories proposed here based on a detailed analysis of the data. Each category is described in detail below.

Defining the categories

Social egg freezing (SEF) is the largest of the four categories and is the one most commonly associated with the phenomenon of egg freezing. It refers to women who have chosen to freeze their eggs for so-called 'social reasons'. These women are predominantly concerned with natural age-related fertility decline, and opt for egg freezing as a means of increasing their chance of motherhood in the future. (It is worth noting that three patients were included in this category who had frozen their eggs as part of a 'Freeze and Share' scheme, in which they donated half of their eggs to another woman and in return were able to freeze the remaining half of their eggs for free or at a greatly reduced cost.)

Medical egg freezing (MEF) refers to eggs frozen for medical reasons, including (in our sample) both eggs frozen prior to gender reassignment and prior to potentially fertility-damaging medical treatments, such as chemotherapy for cancer. The number of MEF cycles in our sample was very small, hence it was not possible to determine whether there might be any statistically significant intra-group differences. (For clinics or institutions performing large numbers of MEF cycles, it would be useful to conduct a further analysis to establish whether patients freezing eggs for different types of 'medical' reason present different egg-freezing profiles and trajectories.)

Clinical egg freezing (CEF) refers to cycles in which eggs were frozen for 'clinical' reasons, as an intentional part of the IVF treatment of certain patients. These patients were in the process of attempting conception through IVF, but had been advised to undergo egg freezing to 'batch' eggs, either because they were expected to produce a low number of eggs per cycle, or because they had a high likelihood of producing

TABLE 2 NUMBER OF EGG-FREEZING CYCLES AND NUMBER OF PATIENTS FREEZING THEIR EGGS BY YEAR AND BY CATEGORY

Year	Freezing cycle category				
	SEF	MEF	CEF	IEF	All
2012	6 (6)	0	0	0	6 (6)
2013	48 (39)	0	1 (1)	3 (3)	52 (43)
2014	73 (57)	1 (1)	12 (8)	5 (5)	91 (71)
2015	131 (102)	5 (5)	37 (22)	6 (6)	179 (135)
2016	131 (101)	5 (4)	42 (24)	8 (8)	186 (137)
Total[a]	389 (268)	11 (10)	92 (42)	22 (22)	514 (342)
Proportion of all cycles (%)	75.7	2.1	17.9	4.3	100.0

Values are: no. of cycles (no. of patients), unless otherwise stated.

[a] The total number of patients does not always tally with the number of patients for each year added together because some patients had egg-freezing cycles in more than one year (across 2 or 3 years).

eggs with chromosomal abnormalities. The plan for these patients was to 'batch' eggs from multiple consecutive cycles of ovarian stimulation together, fertilize them in one go, and usually to perform preimplantation genetic testing, so that a healthy embryo (if available) could be transferred. As such, these patients were not using egg freezing to postpone conception per se, but to increase their chance of a healthy pregnancy through IVF. Although CEF was the second largest category within our sample, it is not clear to what extent such treatment protocols are used across different clinics.

Incidental egg freezing (IEF) refers to the 'incidental' freezing of eggs during what was intended to be a routine IVF cycle, when, for some reason, there were no spermatozoa to enable fertilization on the day of egg collection. In our sample this included patients whose male partner wasn't able to reach the clinic that day, as well as patients whose partner's semen sample proved (unexpectedly) unusable on the day. In these cases, the eggs were frozen (as opposed to discarded) with the intention of fertilizing them as and when a viable sperm sample could be provided.

Number of egg-freezing cycles and patients, by year and category

TABLE 2 presents the number of egg-freezing cycles and the number of women freezing their eggs, according to category of egg freezing for each year. While the majority of egg-freezing cycles across the 5-year period refer to SEF (75.7%), CEF (17.9%) forms the second largest category; both IEF (4.3%) and MEF (2.1%) are much smaller categories. There were no patients who were included in more than one category of egg freezing. FIGURE 3 shows the relative size of each of the categories.

Number of egg-freezing cycles undertaken, average number of eggs frozen per cycle, and average age per cycle for each category

Of the 342 egg freezers in the sample, 234 women (68.4%) undertook only

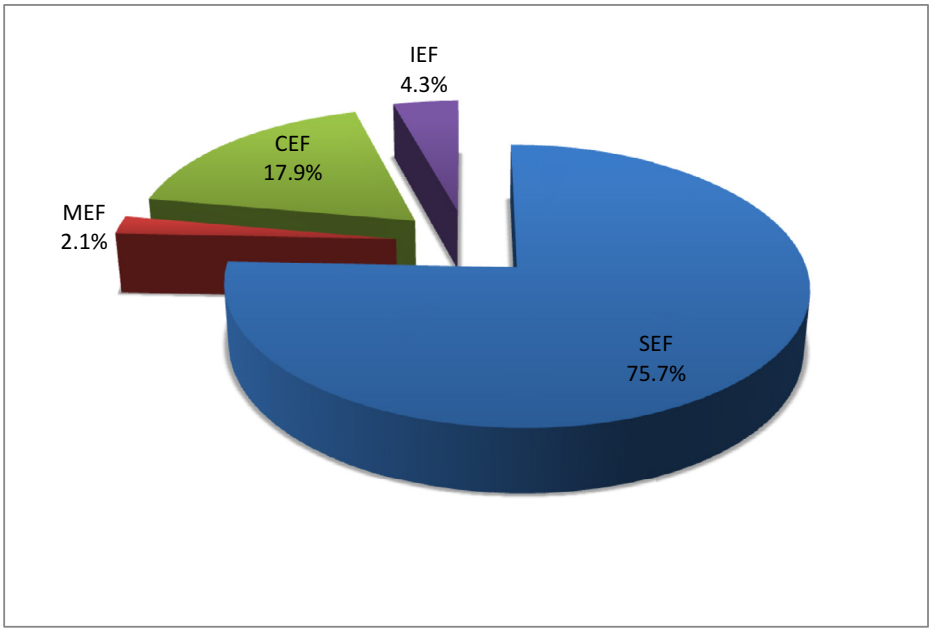

FIGURE 3 Egg-freezing cycles by category of freezing, 2012–2016.

TABLE 3 NUMBER OF PATIENTS IN EACH FREEZING CATEGORY UNDERTAKING ONE, TWO, OR THREE OR MORE FREEZING CYCLES

Number of cycles	Freezing cycle category				
	SEF (*n* = 268)	MEF (*n* = 10)	CEF (*n* = 42)	IEF (*n* = 22)	All (*n* = 342)
1	189 (70.5)	9 (90.0)	14 (33.3)	22 (100)	234 (68.4)
2	40 (14.9)	1 (10.0)	17 (40.5)	0 (0.0)	58 (17.0)
3 or more	39 (14.6)	0 (0.0)	11 (26.3)	0 (0.0)	50 (14.6)

Values are *n* (%).

one cycle of egg freezing, 58 (17.0%) undertook two cycles, and 50 (14.6%) undertook three or more cycles (which includes 44 women who undertook three; three who undertook four; two who undertook six; and one woman who completed eight consecutive cycles of egg freezing).

As shown in TABLE 3, all women in the IEF category undertook only one cycle of egg freezing, whereas approximately a third of patients in the SEF category and approximately two-thirds of the patients in the CEF category had undertaken more than one cycle. Comparing SEF and CEF, the two largest categories, we found that while 70.5% of social freezers underwent only one cycle, 14.9% underwent two, and 14.6% underwent three or more cycles of egg freezing; for CEF patients the respective percentages were 33.3%, 40.5% and 26.3%. These differences were statistically significant ($\chi^2 = 23.6$, $P < 0.0001$), reflecting that CEF patients were likely to undergo a higher number of egg-freezing cycles.

TABLE 4 provides information on the mean number of eggs frozen per cycle and the mean age of the patient per cycle across the four different categories of egg freezing. The differences between these categories were statistically significant as determined using a one-way ANOVA test (the *F*-ratio values are provided in TABLE 4, $P < 0.0001$). According to these results, MEF patients were the youngest, with a mean age of 27.3 years per cycle, and CEF patients were the oldest, with a mean age of 39.2. Although the mean age across all egg-freezing cycles is 37.5, this obscures the differences in mean age between the different categories, which may be an important consideration with regard to future outcomes for thawed eggs, including potential success rates for fertilization and live birth, because eggs frozen at different ages will be used.

TABLE 4 also shows that, as might be expected, the mean age per cycle in the different freezing categories was associated with the mean number of eggs frozen per cycle; with highest mean numbers of eggs frozen in the category with youngest mean age (i.e. MEF cycles with an mean age of 27.3 years and 11.4 eggs frozen per cycle), and lowest mean number of eggs frozen in the category with oldest mean age (i.e. CEF with a mean age of 39.2 years and 4.7 eggs frozen per cycle). It is also interesting to note that while the mode number of eggs frozen per cycle by SEF patients is 4, and the median is 5, the mean is 6.9, due to the wide distribution of this category, with a range from 0 to 28 eggs frozen in one cycle.

Age distribution of egg-freezing patients in each category

Looking across the 514 cycles, there is a wide range in the age of egg-freezing patients, from 22 to 46 years, with 37.5 years as the average age for all cycles. As TABLE 5 shows, over half of the egg-freezing cycles (52.4%) in the sample were undertaken by women aged 35–39; with 17.3% of cycles undertaken by women under 35, and 30.4% by women aged 40 and over. TABLE 5 provides a breakdown by age group and category of freezing, while FIGURE 4 shows a bar chart representing the differential distribution of egg-freezing cycles from different categories across the age groups. For example, while the highest number of SEF cycles are in the 35–37 years age group, the highest number of CEF cycles are undertaken by the 40–42 age group, and highest number of MEF cycles by the under 30 group.

Relationship status of egg freezers by category

TABLE 6 shows the relationship status of egg freezers in the different categories, with some striking differences between groups. For example, the two largest categories, SEF and CEF, show opposite characteristics: while 95.1% of SEF patients are single, this is only true for 2.4% of CEF patients. Conversely, while 97.6% of CEF patients are in (either heterosexual or same-sex) relationships, this is only true for 4.8% of SEF patients. These are highly statistically significant differences between the two categories of SEF and CEF with regards to the relationship

TABLE 4 MEAN NUMBER OF EGGS FROZEN PER CYCLE, AND MEAN AGE OF PATIENTS PER CYCLE IN EACH FREEZING CATEGORY

Parameter	Freezing cycle category					*F*	*P*-value[a]
	SEF	MEF	CEF	IEF	All cycles		
Number of eggs frozen per cycle	6.9 ± 4.5 (0–28)	11.4 ± 5.2 (6–20)	4.7 ± 3.7 (0–18)	8.8 ± 4.4 (0–15)	6.7 ± 4.5 (0–28)	12.4	<0.001
Age per cycle (years)	37.4 ± 3.4 (24–46)	27.3 ± 4.1 (22–37)	39.2 ± 3.7 (29–45)	35.5 ± 4.7 (27–44)	37.5 ± 3.9 (22–46)	40.9	<0.001
Total	389 cycles 268 patients	11 cycles 10 patients	92 cycles 42 patients	22 cycles 22 patients	514 cycles 342 patients		

Values are mean ± SD (range), unless otherwise stated.

[a] One-way analysis of variance (ANOVA).

TABLE 5 NUMBER OF EGG-FREEZING CYCLES BY AGE AND CATEGORY

Age (years)	Freezing cycle category				
	SEF (*n* = 389)	MEF (*n* = 11)	CEF (*n* = 92)	IEF (*n* = 22)	All (*n* = 514)
Under 30	9	9	2	3	23 (4.5%)
30–34	50	1	7	8	66 (12.8%)
35–37	129	1	20	4	154 (30.0%)
38–39	103	0	11	1	115 (22.4%)
40–42	74	0	38	5	117 (22.8%)
43–44	19	0	12	1	32 (6.2%)
Over 44	5	0	2	0	7 (1.4%)

status of patients ($\chi^2 = 217.23$, $P < 0.0001$). (Here, the analysis has been done by per patient record [rather than by per cycle] to avoid multiple counts of the same patient; where multiple cycles of egg freezing were undergone, patients' relationship status remained the same across all cycles.)

Thus, while the overall percentages of egg-freezing patients who are single, in a heterosexual relationship or in a lesbian relationship, as shown by FIGURE 2, correctly demonstrates the values for the sample as a whole, it fails to provide an accurate portrayal of any of the individual categories and obscures the distinct differences between them.

Current status of frozen eggs

As part of the analysis, the current status of the eggs that had been frozen in each of the 514 cycles was recorded as follows: still in storage (75.1%); had been thawed to attempt conception (22.2%); moved to another clinic (1.8%); or discarded (1.0%). These data are presented in FIGURE 5. As perhaps expected, the

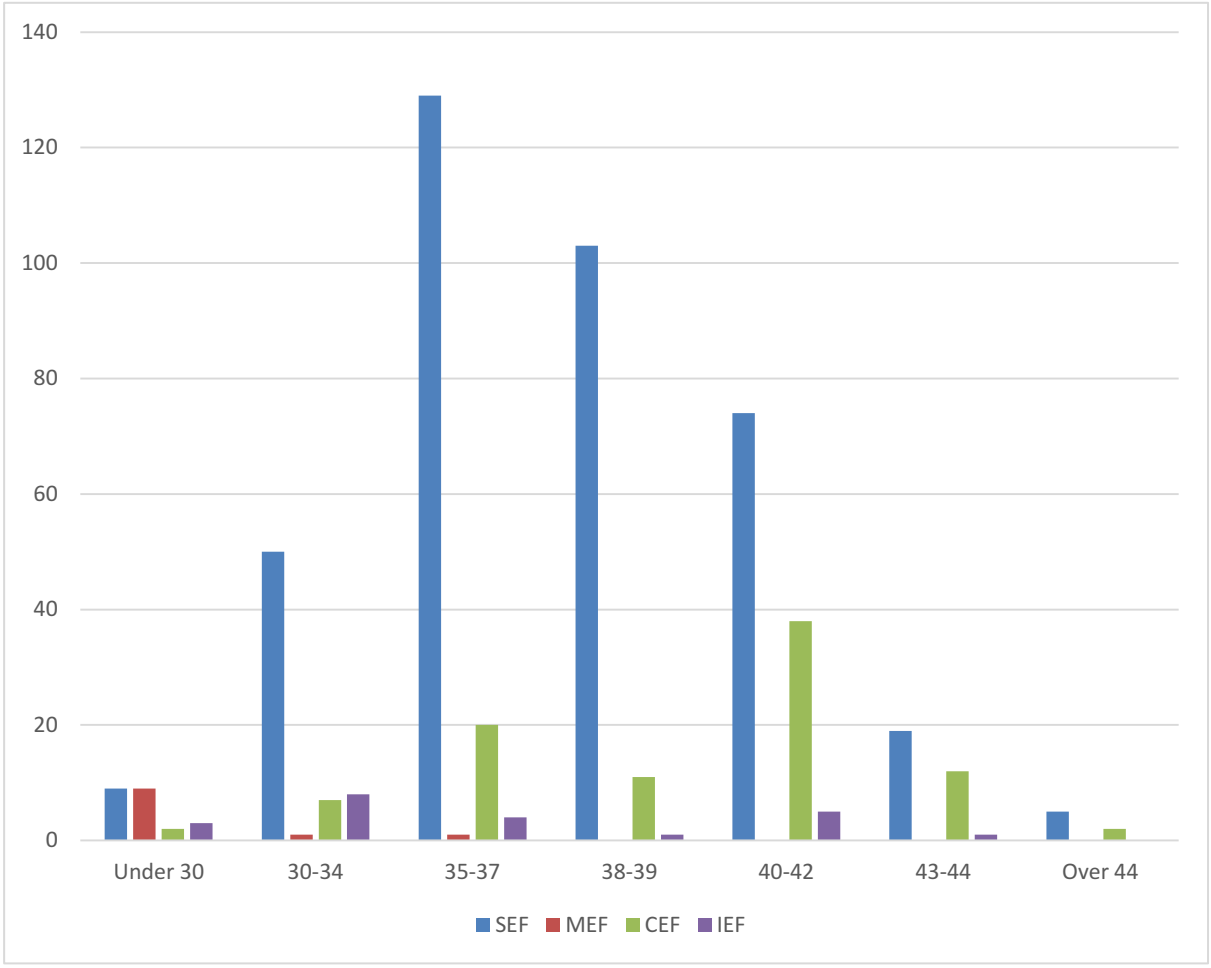

FIGURE 4 Egg-freezing cycles by age and category of freezing.

TABLE 6 RELATIONSHIP STATUS OF EGG-FREEZING PATIENTS BY FREEZING CATEGORY

Relationship status	SEF patients (*n* = 268)	MEF patients (*n* = 10)	CEF patients (*n* = 42)	IEF patients (*n* = 22)	All patients (*n* = 342)
Single	255 (95.1)	7 (70.0)	1 (2.4)	0 (0.0)	263 (76.9)
Heterosexual relationship	11 (4.1)	2 (20.0)	40 (95.2)	22 (100)	75 (21.9)
Lesbian relationship	2 (0.7)	1 (10.0)	1 (2.4)	0 (0.0)	4 (1.2)

Values are *n* (%).

majority of eggs frozen across the 5-year period from 2012 to 2016 were still in storage at the time of analysis (autumn 2017). However, looking comparatively at the origin of eggs that have been thawed versus the eggs that are still in storage, some striking differences emerge regarding the relationships between the current status of eggs and the category of egg freezing. As can be seen in FIGURE 5, while most of the eggs in storage (93.5%) come from SEF cycles, the great majority of thawed eggs (85.1%) come from CEF and IEF cycles. For example, SEF cycles accounted for 75.7% of the 514 freezing cycles over the 5 years, but only for 14.9% of the cycles in which eggs had been thawed. This is because eggs from 92.8% of the SEF cycles were still in storage, and only eggs from 4.4% of the SEF cycles had been thawed to attempt conception. Conversely, while CEF cycles accounted for only 17.9% of the 514 freezing cycles, this category accounted for a large proportion (72.8%) of those in which eggs had been thawed. This is because eggs from 90.2% of CEF cycles had already been thawed, and only 7.6% were still in storage. The difference between these categories regarding the current status of frozen eggs was highly statistically significant ($\chi^2 = 332.9$, $P < 0.0001$).

DISCUSSION

The current retrospective analysis responds to calls for more empirical enquiry into patients electing to freeze their eggs and monitoring of such practices (e.g. *Argyle et al., 2016; Baldwin et al., 2014*). The results show the phenomenon of egg freezing to be more heterogeneous than hitherto assumed and enable the development of a more accurate understanding of the various categories of egg-freezing practice, as well as sub-groups of egg-freezing patients. Contrary to assumptions to date, SEF, the category that has understandably captured most interest in recent years and dominated media discussions, is not the only category of egg freezing being practised. Indeed, while SEF accounts for the majority of egg-freezing cycles in this sample (and also, we believe, in the UK and across the globe more generally), it is essential to recognize the three other categories of egg freezing identified in this paper – CEF, IEF and MEF – if the full scope of egg-freezing practice and patterns is to be appreciated. These different categories, while not exhaustive, show that egg freezing is being used by different patient groups with differing needs and desires, and it is crucial to recognize these differences if we are not to arrive at misleading conclusions. Based on the results presented in this paper, four distinct 'typical profiles' of egg freezing patients from each of the four categories have been identified, which clearly illustrate not only demographic differences, but also different clinical

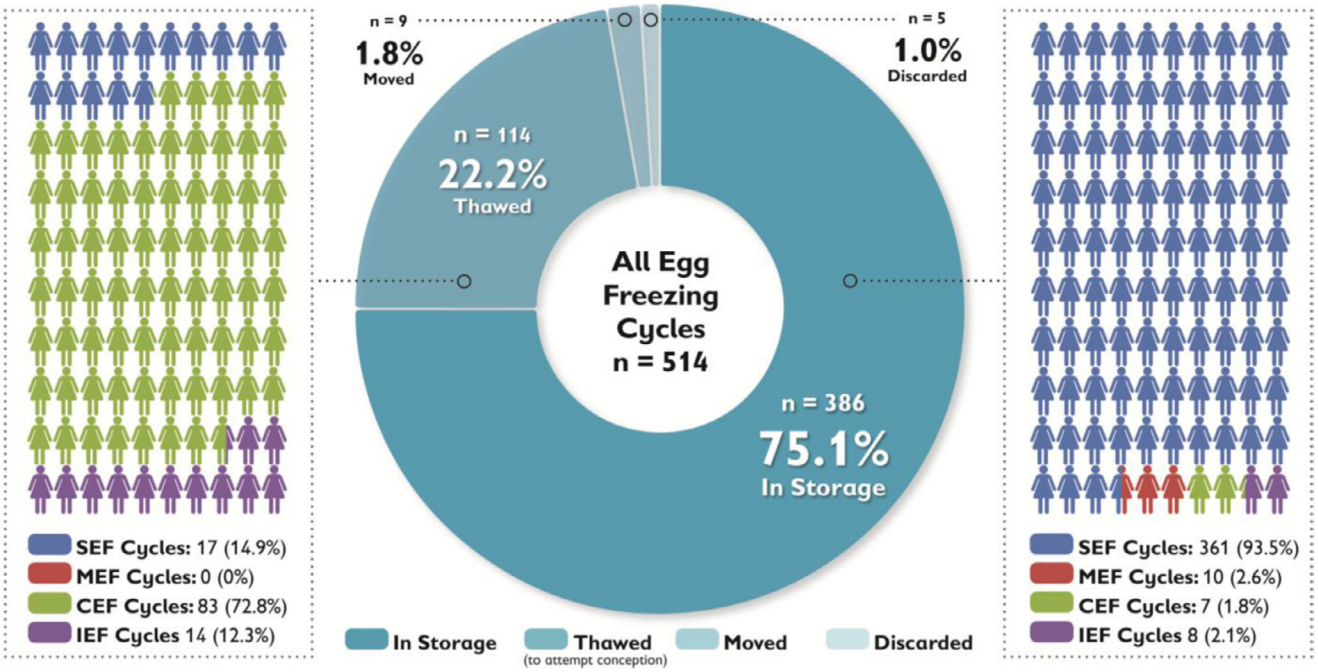

FIGURE 5 Current status of frozen eggs.

outcomes between patients from different groups.

Profile of an SEF patient: the typical patient who has frozen her eggs for 'social' reasons, as profiled from this data set, is 37.4 years old and single. She will most likely undertake only one cycle of egg freezing, although possibly two or three, freezing approximately 7 eggs in each cycle. She is very likely to still have her eggs in storage (even if she froze up to 5 years ago). This profile is similar to previously published demographic details of social egg freezers in the UK from a study of 23 women (*Baldwin et al., 2015*), although it is worth noting that the women in the present sample were a little older and more of them were single.

Profile of an MEF patient: there are two predominant groups of medical egg freezers – women freezing before cancer treatment, and transgender patients preserving their fertility prior to gender transition. These patients also tend to be single, but they are significantly younger than social egg freezers, with an average age of 27.3 at the time of freezing. Most medical egg freezers undertake one cycle of egg freezing, with approximately 11 eggs frozen in that cycle. This group has the highest number of eggs frozen per cycle, on account of their younger age. The eggs are likely to stay in storage for a long time.

Profile of a CEF patient: clinical egg freezing refers to all cycles where the freezing of eggs was clinically intended, usually to maximize the chance of a pregnancy in cases with a poor prognosis. As a group, these women are the oldest, with an average age of 39.2 years, and have 4.7 eggs (the lowest average) collected per cycle. These characteristics make sense with regard to the treatment protocol of this population, because the justification for clinically freezing eggs is to 'batch' the small number of eggs collected from multiple cycles in order to fertilize them all at once, often with subsequent genetic testing of the embryos, before implanting one healthy embryo (if available) into the uterus. The typical patient whose eggs are frozen for clinical reasons is in a heterosexual relationship, and will undertake two or more cycles. The rate of egg thaw in this group is very high, because the goal of the treatment is to achieve a pregnancy, and not to keep eggs stored for any length of time.

Profile of an IEF patient: a patient whose eggs are frozen for incidental reasons would have been going through a standard IVF cycle but had to have her eggs frozen for an unexpected reason, usually because there were no spermatozoa available on the day of egg collection. This may be because the partner was unable arrive at the clinic for some reason, because he was unable to produce a sample, or because, unexpectedly, the semen sample produced on the day contained no usable sperm cells. The women in this group are all in heterosexual relationships, aged on average 35.5 years old, and freeze approximately 9 eggs. These women only undergo one cycle of freezing, because even this cycle was unintentional and necessitated by unforeseen circumstances. There is a high rate of thaw, although thawing of eggs may be delayed if the partner needs treatment, or may even be abandoned altogether if sperm cells cannot be found and the couple is unwilling to use donor spermatozoa.

Looking at the last two HFEA reports (*2016, 2018*), it can be seen that our data shed light on some of the most pressing questions posed by the national figures, and highlight some of the realities of egg freezing unintentionally obscured by the HFEA's headline figures. Firstly, our analysis gives four clear and distinct categories of reasons why patients might freeze their eggs. Secondly, we show that while women who freeze their eggs for 'social' reasons are predominantly single, patients whose eggs are frozen for clinical or incidental reasons are most likely to be in heterosexual relationships, thereby explaining the existence within the national data of a large percentage of egg-freezing patients with a male partner. Thirdly, by showing that a large majority of the thawed eggs in our sample come from CEF and IEF cycles, we provide a clear explanation for why the national figures from 2016 show that, 'Of the thawed egg cycles performed, well over half used eggs which had been frozen for less than a year' (*HFEA, 2016*: 27).

Indeed, the differences with regard to the current status of eggs between the different categories of egg freezing are possibly the most striking findings of this analysis. If we look at each of the two largest categories in more detail, we can see that while almost all of the eggs from SEF cycles (92.8%) between 2012 and 2016 are still in storage, almost all of the eggs from CEF cycles (90.2%) have already been thawed to attempt conception. These distinct differences should prompt a rethink of assumptions and further detailed analyses in order to reach a better understanding of subsequent success rates or pregnancy outcomes for egg-freezing patients from different categories.

This study has some limitations that impact how the data can be used and understood. Firstly, it must be noted once again that this study analyses records from one clinic only, the LWC in Harley Street, and cannot therefore be generalized. Whilst the LWC is one of the clinics providing the highest number of egg-freezing cycles in the UK, it is fair to assume that no single clinic can be truly representative of national patterns. Indeed, there are some important differences between our data and the HFEA's national figures with regard to, for example, the age distribution and relationship status of egg-freezing patients. In fact, it is safe to assume that the proportion of the different categories we have identified will be varied among different clinics providing egg freezing in the UK. For example, some NHS IVF clinics will be providing a much higher proportion of medical egg-freezing cycles, and the freezing and 'batching' of eggs in CEF cycles will be practised by some clinics and not others. Furthermore, because the LWC Harley Street is a London-based clinic with a higher than average proportion of single women patients, it is possible that some of the year-on-year increase in the number of egg-freezing cycles can be explained by the LWC capturing a larger proportion of the UK egg-freezing market rather than reflecting the real rate of increase of the practice nationally, although it is difficult to be exact about this because of the discrepancies in how an egg-freezing cycle was defined in the two HFEA reports of *2016* and *2018* (for a discussion of this see *Gurtin, 2018*).

Secondly, the current study may be criticized for being too UK-focused. This is indeed correct, but we would argue that the strength of the analysis comes from its specificity and detail, and therefore the possibilities provided to look behind broader headline figures. Internationally speaking, there will no doubt be important differences in

the practice of egg freezing, including its legality, popularity and patterns of use. For example, there may be other categories of egg freezing (such as, for example, ethical egg freezing, whereby a patient may prefer to freeze eggs rather than embryos during an IVF treatment cycle to minimize the potential for 'unused' or 'discarded' embryos due to ethical reasons) that are not present in our data set but may prove important in other national contexts. Similarly, it would be fair to expect that the demographic characteristics of egg-freezing patients will vary and show different patterns depending on the particularities of different national and regulatory contexts. For example, the average age of egg-freezing patients in the UK is likely to be higher than the average age of egg-freezing patients in the USA, influenced not only by the different cultural contexts in the two countries, but also directly by the HFEA's restrictive 10-year storage limit for frozen eggs. However, despite national specificities, the data presented is nevertheless extremely useful in alerting us to the heterogeneity of egg-freezing patients and categories and should encourage other clinics, and national bodies collecting fertility treatment data, to examine the constitution of their own egg-freezing patient populations.

A third limitation of this study is that it makes use of existing records to create a quantitative and numerical analysis, and does not provide qualitative details regarding women's own opinions and experiences of egg freezing. Without doubt, it would be extremely valuable to elicit women's own views regarding their reasons for egg freezing and to receive their responses to the categories presented here. To this end, some of the authors of the current paper are currently engaged in qualitative studies of women's experiences of egg freezing and hope to report from these in due course.

Even taking these limitations into account, the analysis presented here provides a strong case for the hitherto unrecognized heterogeneity of egg-freezing practices and the importance of recognizing different categories of egg freezing. This leads us to make some recommendations regarding clinical and national data collection on egg freezing and regulation in the future.

The current HFEA data should be understood as comprising a mixture of the four categories presented in this paper, and thus the picture with regard to any one category may be blurred or even obscured by data conflation. For example, it is likely that many of the children born from frozen–thawed eggs are not actually born to 'social' egg freezers but to freezers from other categories (in particular, CEF and IEF). As such, the real number of children born to women who have deliberately postponed motherhood by freezing their eggs is likely to be far lower even than the very low figures provided by the HFEA, which stated that 60 children had been born from thawed eggs by 2013. This is important because it suggests that we need more detailed analysis at the national level, not only to understand the relative outcomes or success rates for egg-freezing patients from different groups, but also to provide more accurate information to potential users. Such data would also help to create clinical and ethical parameters to ensure that egg freezing is practised 'for better, not worse' (*Mertes and Pennings, 2011*).

Future data collection, including by the HFEA and by clinics, should record details about the reason for egg freezing, in order to provide clearer information regarding both the trajectories and outcomes of eggs frozen for different reasons by different patient groups. We would recommend that the categories identified in this paper become standard in the collection and analysis of future egg-freezing data, and that other clinics or countries supplement these categories as required by different patient populations. For example, if substantial numbers of women report freezing eggs for ethical reasons in a given country, ethical egg freezing (EEF) could become an additional category for use in data collection and analysis.

We argue that dividing the different categories of egg freezing will help women considering this procedure to gain a much more accurate and relevant understanding of egg freezing as it applies to their situation, including its prevalence among women like themselves and its success rate as judged by subsequent pregnancies and live births among such a group. From an ethical perspective, this is important for enabling potential patients to make sound, empirically-based decisions about whether or not (or when) to freeze their eggs, and to be able to give truly informed consent for such complex treatments (see also *Jackson, 2017*).

As one of the most interesting aspects to emerge from the current analysis is the different length of pre-thaw storage among egg-freezing patients from different categories, an analysis of 10 years of egg-thaw data from the LWC has also been undertaken, which will be published separately. This analysis will provide much greater detail on the demographic characteristics of patients thawing their eggs, including comparisons between age and relationship status at time of freeze and time of thaw for patients from each of the different freezing categories identified here. Because the great majority of SEF patients still had their eggs in storage, it would be extremely interesting to find out more about the intentions and opinions of these women. In the UK, frozen eggs can be stored for a maximum of 10 years and it would be particularly important to elicit the views and opinions of women whose stored eggs are nearing this time limit (see *Jackson, 2016*).

Although the current paper reports on a retrospective and quantitative analysis, we recognize that it is extremely important that the women who make up the figures and data we report on have a chance to tell their own stories and have their voices heard. As such, the lead author is conducting a range of interviews with women who have frozen their eggs, and in some cases have already come back to thaw them to attempt conception, and is committed to presenting their perspectives as evidenced through such qualitative research. Egg freezing is still a new technology, with its social impact yet to be understood; ultimately, it is the thoughts, feelings and experiences of its 'social pioneers' – the early cohort of women who have decided to freeze their eggs – that will prove the most illuminating and meaningful.

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SUPPLEMENTARY MATERIALS

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