Maximum number of children per sperm donor based on false paternity rate

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Abstract

Purpose The aim of this study is to estimate the weight of each relevant factor in such unions of inadvertent consanguinity and to determine a “reasonable” limit for the number of children per donor, matching the probability of inadvertent consanguinity arising from the use of sperm donor in assisted reproduction with that of such a union arising from false paternity.

Methods In this study, we applied to Spanish data a mathematical model of consanguineous unions, taking into account the following factors: maximum number of live births/donor, fertility rate, average number of births per donor in a pregnancy, donor success rate, matings per phenotype, number of newborns/year, and number of donors needed in the population/year and births by false paternity.

Results In Spain, the number of inadvertent unions between descendants of the same donor in Spain has been estimated at 0.4/year (one every two and a half years), although this frequency decreases as the reference population increases. On the other hand, the frequency of unions between family

members due to false paternity has been estimated at 6.1/year. Thus, only 6% of such unions are due to the use of donor sperm.

Conclusion A total of 25 children per sperm donor are needed to align the probability of inadvertent consanguinity arising from the use of assisted reproduction with that due to false paternity. Therefore, we consider this number to be the maximum “reasonable” number of children born per donor in Spain.

Keywords Maximum number of children per donor · False paternity · Consanguinity · Unions between family members

Introduction

Spain is the third leading country in Europe for cycles of artificial reproduction techniques (ART) with sperm donors [1]. ART are subject to strict legislation, under Act 14/2006 of 26 May. One of the aspects on which the law places most emphasis is the maximum number of children allowable per donor, in order to limit the number of unions between descendants of a single donor who are unaware of this fact (inadvertent consanguinity). This limit is currently six children, but no objective justification has been offered for this figure, although when the Act was being drafted, there already existed several statistical models that made it possible to estimate the number of unions per year between descendants from the same donor [2]. This legal limit varies significantly between countries or regions, ranging from one child per donor in Taiwan to 25 per 800,000 inhabitants in the USA [3].

A European consensus group recently published a document analysing the importance of various aspects of the question (ethical, social, psychological, genetic, logistic,

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economic, etc.), placing the issue in a global context and concluded that the limit should be between 10 and 100 [4].

Another factor that can give rise to inadvertent consanguineous unions is that of false paternity. In France, Serre et al. [5] showed, using the latest statistical model published in this field [6], that consanguineous unions due to false paternity are much more numerous than those between descendants of a single gamete donor.

The aim of this study is to estimate the weight of each of these factors in inadvertent consanguineous unions in Spain and to determine a “reasonable” limit to the number of children allowed per donor that will bring the probable number of inadvertent consanguineous unions from this cause into line with that estimated to arise from false paternity.

Materials and methods

The number of potential unions between descendants of a donor can be estimated using the model developed by Wang et al. [6]. This model is available online at the following link:

<http://homepage.ntu.edu.tw/~ckhsiao/ARTweb/maximumk.htm>

The model takes into consideration not only unions between half siblings but also those between half uncle and niece, half aunt and nephew, and half first cousins. The values assigned to the variables required by the model were as follows:

- Maximum number of live births per donor (k), 6. This is the maximum number of children that may be generated with sperm from the same donor, under Act 16/2006 of 26 May on assisted reproduction techniques.
- Total fertility rate (f). This variable indicates the average number of children that would be born per woman if all lived to the end of their childbearing years and bore children in accordance with the fertility rate prevailing at each age. The f value we use for the Spanish population is that corresponding to data for 2014, namely 1.32 [7].
- Average number of children born per donor in a pregnancy (n), 1.
- Success rate (S), 100%. We assume that all donors achieve the same success rate in ART. By applying this value, we maximise the number of potential unions among a donor's descendants.
- Mating factor by phenotype (C). This variable reflects the fact that unions tend to take place between couples with certain phenotype characteristics. The factor of assortative mating for phenotype (C) can take different values according to the factors considered. We assigned a value of 9 because this is the mean value used by Wang et al. (2007); it was also employed by Serre et al. (2013).

Among the factors considered in this respect are BMI, IQ, and ear length.

- Average number of newborns per year (A), 426303. This is the figure recorded for the Spanish population in 2014 [8].
- Number of donors per year needed in the population (D). This value can be estimated from the records held at ART clinics. In our case, the value of D for the Spanish population was obtained from the Spanish Fertility Society (SEF) register (2013, latest data published [9]) taking into account the number of cycles of donor artificial insemination (DAI) and of IVF/ICSI in which donor sperm was used. The number of pregnancies recorded for fresh cycles and for those with cryopreserved embryos is 2197 for FIV/ICSI cycles and 2552 for DAI cycles (after adjusting the total number of pregnancies using semen donor to the activity of the participating centres, taking into account that SEF registration is voluntary and that only 50% of FIV/ICSI cycles and 50% of DAI cycles are recorded). Hence, a total of 4749 pregnancies were produced in which donor sperm was used. As each donor is limited to a maximum of six children, 791 donors are needed to meet the demand of the Spanish population. In this study, therefore, a value of 800 was assumed for D .

After defining these variables, we then estimated the influence of the number of unions between descendants of the same donor, in the following scenarios:

- An increase in the population served, and therefore a greater number of births derived from donor sperm.
- An increase in the number of children allowed to each donor.

Different rates of false paternity. False paternity occurs when a child is identified as being biologically fathered by someone other than the man who believes he is the father. According to the review by Bellis et al. [10], this rate ranges from 0.8 to 30%, with a median of 3%.

The results obtained can be represented graphically, with the Y axis showing the expected number of unions between descendants and the X axis showing the variable to be analysed.

Results

As shown in Fig. 1, among the Spanish population, with 426,303 births per year and assuming the existence of the 800 donors needed to meet the demand for donor sperm, the probability of an inadvertent union between the descendants of a donor is 0.4 per year. However, this value decreases as the

Fig. 1 Number of unions between descendants from the same donor, as the population attended increases

population served increases and, equivalently, as the number of births per year increases.

The number of unions between descendants of the same donor increases with the maximum number of children allowed per donor (Fig. 2). Similarly, as shown in Fig. 3, the number of unions between descendants increases with the rate of false paternities. Thus, given an estimated false paternity rate of 3%, the number of consanguineous unions from this cause would be 6.1 per year. In the scenario we analyse that in ART, up to 25 children per donor would be allowable before this number of consanguineous unions was reached (Fig. 2).

In Spain, under these assumptions, there would be 6.5 inadvertent consanguineous unions per year, and the use of ART based on donor sperm would be responsible for only 6% of these unions, the remaining 94% being due to situations of false paternity.

Discussion

Our application to Spain of the model proposed by Wang et al. [6] for estimating the risk of consanguineous unions between descendants of a single sperm donor shows that this risk is very low in our country. Moreover, the risk of consanguinity in the general population is much higher due to cases of false paternity than to the use of donated gametes in assisted reproduction.

The direct relation between an increase in the maximum number of children allowed per donor and the number of unions between descendants from the same donor has been described by Wang et al. [6] and by others [2]. Application of these models has shown that this risk is very low, and

therefore, countries like the USA allow up to 25 children per donor per 800,000 inhabitants [11]. If this ASRM [11] recommendation was implemented in Spain, with a population of almost 46.5 million, a donor in this country could potentially have 1451 descendants. A recent review of the maximum number of children advisable per donor has shown that the risk of consanguinity among descendants is not the most important factor determining this limit and that other factors of a psycho-social nature should also be taken into account [4].

No international agreement currently exists to limit the number of children allowed per donor, and criteria in this respect vary widely, as shown by Janssens et al. [3] in a review of this question. One possible approach would be to establish this limit such that the risk of consanguinity due to the use of donated gametes equalled that due to cases of false paternity. Our study shows that this would be the case in Spain with a limit of 25 live births per donor, a figure similar to that currently allowed in Denmark and the Netherlands. Indeed, if we take into consideration the origin of couples or women who make use of donor sperm, the limit could be higher still. In Spain, a large number of cycles are performed for couples from other countries [12, 13], and therefore, there is less probability of unions between a donor's descendants.

In a similar study conducted in France [5], it was estimated that 2.94 consanguineous unions per year are due to DAI, a figure that is higher than our estimate (0.4 unions/year). We believe this difference is due to three factors. First, the population in France is larger than in Spain, which means that the absolute number of such unions will be correspondingly greater. Second, the number of children per donor allowed is higher in France than in Spain (10 vs. 6), and as we have shown, this is a determinant factor in the number of consanguineous unions (Fig. 2).

Fig. 2 Number of unions between descendants from the same donor, as the number of children allowed per donor increases

Fig. 3 Number of unions due to situations of false paternity

Finally, there are more sperm donors in Spain, because here, donors receive a reimbursement to defray the costs incurred.

With respect to the number of unions due to false paternity, we recorded lower values than those reported by Serre et al. [5] for France (6 vs. 12). This could be explained by the absolute number of births in each country. In France, this value is almost double that found in Spain. In other words, Spain has half the population and half the number of births, and hence half the number of consanguineous unions due to false paternity.

Finally, it is interesting to note that the proliferation of sperm banks tends to increase the number of consanguineous unions between descendants of donors. As we have shown, with increasing numbers of users of a sperm bank, the number of possible unions decreases, as the dispersion of the users increases. In contrast, if there were a sperm bank in each province in which ART is conducted, donor sperm would be distributed to women in that province. Thus, the samples provided by donors to the sperm bank in question would be distributed within a relatively small area, and so the probability of a union between the descendants of those donors would be higher. Accordingly, donations should be concentrated in large sperm banks in order to facilitate the distribution of samples to clinics that are remote from each other. On the other hand, although such a policy would decrease the probability of unions between donor descendants, it could also reduce the traceability of the process. Aware of this phenomenon regarding the distribution of gametes among regions and countries, European health authorities have implemented a unique donation number system, termed EUROCET128 [14], following the publication of EU Directive 2015/565 of the Commission on 8 April 2015.

We also emphasise that the traceability and control of donor children can only be achieved when ART are performed by authorised staff and clinics. The increasingly common practice of donor sperm being sent, illegally, to Spanish patients from foreign banks is an attack on the assistential quality of assisted reproduction in Spain. This practice harms not only the women or couples receiving the sample (because it is less safe and less effective) but also other users of these techniques, because there is no record or control of the children born of these donors.

In conclusion, the application of statistical models shows that the risk of consanguineous unions from the use of donor sperm is low in the current environment. In inadvertent consanguineous unions, a much more decisive factor than the use of donated gametes in ART is the rate of false paternity. In addition, our results show that it would be advisable to create large sperm banks, distributing samples over wide geographical areas. We suggest that 25 children per donor would be a “reasonable” limit to the number of children per donor allowed in Spain.

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