# ART with PGD: Risky heredity and stratified reproduction

Ilana Löwy

Reproductive BioMedicine and Society Online (2020) 11, xxx–xxx

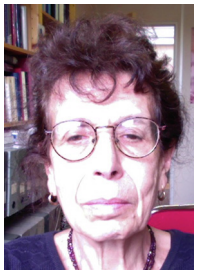
www.sciencedirect.com
www.rbmsociety.com

ORIGINAL ARTICLE

# ART with PGD: Risky heredity and stratified reproduction

## Ilana Löwy

*CERMES 3, Villejuif, France*



**Ilana Löwy** is a senior researcher emerita at INSERM, Paris (France). Trained as a biologist, she retrained as a historian of science and medicine. Her main research interests are relationships between laboratory sciences, clinical medicine and public health, with particular interest in intersection between gender studies and biomedicine in areas such as female cancers, contraception or the medicalization of pregnancy, and the history of birth defects and prenatal diagnosis, with a special focus on links between prenatal genetic testing and the rise of new genetic technologies. She is currently studying the Zika epidemic in Brazil.

Abstract Preimplantation genetic diagnosis (PGD) was developed to allow women/couples at risk of having a child with 'severe and incurable' hereditary disease to produce embryos through in-vitro fertilization, followed by implantation of embryos devoid of mutated genes, allowing the birth of children free of the pathology present in the family. This article examines the highly regulated practice of PGD in France, the highly deregulated practice of PGD in the USA and Brazil, and the extensive use of this biomedical technology in Israel, and highlights the ways that distinct national policies produce distinct definitions of risk and different norms, standards and rules. PGD, this article argues, is a situated practice. Shaped to an important extent by legal and economic constraints, it displays the ways that new technologies continuously reframe our definitions of the normal and the pathological.



**KEYWORDS:** disability, hereditary diseases, in-vitro fertilization, prenatal diagnosis, preimplantation genetic diagnosis

## Introduction

Preimplantation genetic diagnosis (PGD) — that is, the possibility to analyse the genetic composition of an embryo produced by in-vitro fertilization (IVF), and implant only those embryos with preselected traits — is one of the most debated innovations of assisted reproductive technology (ART) because of its (presumed) potential to produce 'designer babies', linked with dreams — or fears — of the manufacture of distinct 'sub-species' of human beings. However, the brave new world of human beings crafted on demand, first imagined in the 1930s (Huxley, 1932), remains restricted to the sites where it first appeared — utopian or dystopian works of art. The real-life practice of PGD is different and, as I see it, much richer and more interesting than its fictional representations. This article is based on my own research on clinical genetic and prenatal diagnosis in France, Brazil and Israel, and also on rich exchanges with colleagues in numerous countries (Löwy, 2017, 2018). It does not aspire to develop an exhaustive analysis of PGD,

*E-mail address:* ilana.lowy@cnrs.fr

https://doi.org/10.1016/j.rbms.2020.09.007
1472-6483/

but proposes a series of snapshots that illustrate its complexity.

## 'A severe and incurable condition' — But for whom?

In the early 21st century, I was making observations in an oncogenetics clinic of a major French cancer hospital. One session made a particularly strong impression on me. A young woman in the early stages of pregnancy told the oncogeneticist that her husband had familial adenomous polyposis (FAP), a hereditary dominant monogenic condition. People with FAP develop multiple adenomous polyps in their colon, usually in their late teens or early 20s. As a consequence, they are at very high risk of developing colon cancer. Before genetic testing, people from affected families underwent a colonoscopy in their late teens, and if this test revealed the presence of multiple polyps, they were advised to undergo prophylactic ablation of the affected parts of their colon. People who had this surgery often suffered from gastrointestinal problems, had to watch their diet, and, as the surgery strongly reduces but does not entirely eliminate the risk of cancer, had to be monitored for this risk. However, the preventive surgery is usually presented as an intervention that allows people with FAP to remain cancer-free, reasonably healthy and live a quasi-normal life.

Today, it is not necessary to wait until an individual at risk of FAP develops intestinal polyps to find out whether s/he is a mutation carrier. A genetic test can reveal the presence of the FAP mutation in a child or a fetus. The woman who consulted for the risk of FAP reported that her husband categorically refused to raise a child with this condition, arguing, on the basis of his own and his family's experience, that it induces intolerable suffering. His wife got pregnant twice, underwent genetic testing, found out that both fetuses were FAP-positive, and had two early abortions. Now, pregnant for the third time, she refused to be tested again because of the trauma of the two previous abortions, but also because she did not think that FAP was a sufficient reason to have an abortion. Her husband, she explained, had a good quality of life, and being a mutation carrier did not prevent him from having a fulfilling job, travelling or playing sports. She believed that this would also be true for a child with FAP. Her husband told her, however, that if she gave birth to a FAP-positive child, he would divorce her and refuse to take care of the child.

I never learned what the woman decided or what happened next. A few years later, she might have applied for permission to undergo IVF with PGD, a technology that would have spared her the trauma of repeat induced abortions. It is not certain, however, whether she would have obtained permission to undergo PGD. In France, the commission that grants such permission tends to be more restrictive than the interdisciplinary committees that grant the right for an abortion for fetal anomalies, probably because IVF with PGD (covered in France by the state health system) is much more expensive than selective termination of pregnancy. It is also not certain whether the availability of PGD for FAP would have made this woman's life easier because of an elevated chance that her husband would have put pressure on her to undergo a difficult and stressful treatment, without certainty that it would lead to the birth of a FAP-free child.

## Multiple legal frames of PGD

Bioethicists have investigated PGD extensively, mainly because of the speculation that this technology can allow parents to choose their child's traits and give birth to 'designer babies'. Fears that PGD will lead to a 'eugenic drift', promoting a tendency to eliminate all the 'flawed' traits, including minor ones, and select the 'desirable' physical and intellectual traits, started in the 1980s and were later intensified (Theodosiou and Johnson, 2011). Numerous articles in bioethics journals have discussed the risk of use of PGD for 'enhancement' of qualities of future children, a risk which — to the author's knowledge —has not materialized to date. Even in countries where this approach is totally unregulated, there are no signs of the use of PGD to promote the birth of 'designer babies'. Few parents seem willing to go through the constraints of IVF to secure the birth of a tall, dark haired, musically gifted boy. Other PGD-related issues often discussed by bioethicists are the use of this technology to produce a child who, through tissue grafting, can save the life of a severely ill sibling; the desire for people at high risk of a severe late-onset disease (e.g. Huntington disease) to give birth to a disease-free child without learning their own genetic status; and the desire of some disabled/different people (e.g. deaf people) to have a child with the same disability/difference. These examples, which have captured intense bioethical scrutiny, deal with concrete — but very rare — cases. Fewer studies are dedicated to the study of everyday uses of PGD, the reasons why women/couples who are aware that their future child is at risk of a genetic disease elect this technology, and views of the professionals who perform PGD (Soto-Lafontaine et al., 2018: 376). The important work of Sarah Franklin and Celia Roberts, 'Born and Made', provides rare insight into the experience of couples who use PGD (Franklin and Roberts, 2006). However, as this was a UK-based ethnographic study focused on a small number of cases, it did not investigate the potentially broad range of applications of this technology.

Legislation about PGD in industrialized countries varies greatly (Bayefsky, 2016; Ginoza and Rosario, 2020; Soini, 2007). PGD is allowed under specific conditions in the UK, Spain, Portugal, Norway, Sweden, Denmark and, recently, Germany (in a limited number of circumstances). It is explicitly prohibited in Italy, Ireland, Austria, Switzerland and Luxemburg. In France, the use of this technique is permitted in specific, well-defined cases (Duget and Boyer-Beviere, 2017). Article L.2131-4 of the French Public Health Code, amended by Act No. 2011-81 of 7 July 2011, authorizes the use of PGD in approved centres in certain cases under exceptional circumstances. The French legislator frames PGD as 'actions of prevention concerning the child', therefore defining it as an intervention performed exclusively in the interest of the future child. The hereditary anomaly responsible for a given disease, the French legislator adds, must be precisely identified and present in one (if dominant) or both (if recessive) parents. Permission to undergo PGD is issued by the

French Biomedicine Agency. Theoretically, the definition of PGD as an intervention in the interest of a future child precludes the conception of 'saviour children' whose cord stem cells can save an older sibling from death; however, in practice, this approach is tolerated in France in exceptional cases. Indications for PGD in France have increased gradually, although the number is still limited. In 2015, the Biomedicine Agency issued 595 permissions for PGD (Duget and Boyer-Beviere, 2017: 167).

The USA is the only industrialized country where PGD is widely tolerated but not regulated (Bayefsky, 2015, 2018). The lack of regulation of PGD in the USA is attributed to strong resistance of US physicians to governmental supervision, lack of regulation of similar clinical practices, and the proximity of PGD to the highly fraught debates on abortion. Not only is PGD unregulated by the law, it is also not bound by guidelines issued by professional associations. In the USA, the decision to accept a patient's request for PGD is left to the individual physician. Some physicians feel that they cannot refuse such a demand by personal conviction. They believe that if a woman/couple is willing to undertake the risk and cost of PGD, she/they must feel strongly about it. Other physicians in the highly competitive — and highly lucrative — field of reproductive medicine may feel pressured to offer PGD in order not to lose patients to colleagues with more liberal practices. The only 'regulation' of PGD in the USA is through its cost; the average price of an IVF cycle is estimated to be US$12,000, and PGD adds approximately 30% to this price, although the exact costs of both procedures vary considerably (Drazba et al., 2014). Families who can afford it can usually find a fertility treatment centre that will perform IVF with PGD, including for elective sex selection, reported to account for 9% of cases of PGD in the USA (Baruch et al., 2008).

## Situating PGD

New medical technologies modify our situated understanding of a disease: whether/how it is transmitted, what shapes its natural history, how dangerous it is and also its nature. Recent scientific developments made obsolete the term 'birth defects', which is now used mainly for problems generated by the birth process itself. Other health issues once classified as inborn can often be detected/predicted well before birth. Fetal medicine made visible developmental problems of the fetus; development of clinical genetics allows early detection of genetic anomalies and has made possible the prediction of risk of transmission of hereditary pathology to offspring; new therapies led to reclassification of some 'incurable' pathologies as 'curable'; and, in other cases, new studies have aggravated the prognosis of conditions once perceived as benign. Debates on the use of PGD to avoid the birth of children with a specific inborn condition are inseparably entangled with the ways that other medical technologies and approaches modify the perception of the targeted condition.

### Variable expression

Knowing that a gene is present in an embryo may provide incomplete information about the consequences of the presence of this gene. For example, there are several variants of the gene that induces FAP. If geneticists know which variant is present in a given family, they can predict with reasonable accuracy the severity of the polyposis detected in an affected fetus/child. This is not the case for other hereditary conditions, such as spinal muscular atrophy (SMA). Prenatal detection of the mutation that induces this disease indicates that the child will have SMA, but does not predict whether s/he will develop type I SMA which leads to death in early childhood, type III SMA which produces an initially mild muscular impairment which becomes more pronounced with age, or intermediary type II SMA. Families can have one child with type III SMA and another with type I SMA. As SMA is a highly variable condition, experience of life with this condition is also highly variable. Diversity of individual and family experiences is, in all probability, one of the reasons for divergent attitudes to prenatal diagnosis or PGD for this pathology. Women from affected families often feel obliged to take into consideration the fact that a family member with SMA might be strongly opposed to their wish to have a disease-free child. These women see the affected family member's opposition to selective reproduction as oppressive and, at the same time, irrefutable (Boardman, 2013, 2014). They want their future children to be healthy, but do not wish to negate the value of life of relatives with SMA or hurt them. In consequence, many women decide to eschew efforts to have disease-free children. Some refuse PGD and reject prenatal diagnosis when pregnant; other decide not to have biological children.

### Curability

To date, there is no efficient cure for SMA. Other hereditary conditions are presented as curable, and therefore outside the scope of PGD. One such disease is phenylketonuria (PKU). PKU is seen as fully curable. Specialists explain that a child diagnosed with PKU immediately after birth can adhere faithfully to a phenyl-alanine-poor diet so that s/he will not develop an intellectual impairment. When people with PKU display cognitive difficulties, such difficulties are attributed either to their individual shortcomings (the parents' and/or the affected individual's insufficient discipline and willpower to adhere to the rigorous diet), the state's/society's failings (high costs of the special PKU diet, lack of adequate support for children/people with PKU and their families) or both. In practice, outcomes for individuals with PKU vary, not only because of socio-economic and cultural factors that complicate the adherence of people with PKU to a strict diet, but also because individuals with this condition are not biologically identical: some have a higher tolerance of dietary transgressions than others. As PKU is officially labelled 'curable', PGD for PKU is not perceived as justified (Paul and Brosco, 2013). Nevertheless, a family with one child with PKU may decide that it will be too difficult to have a second child with the same condition. UK researchers described successful PGD for PKU. They received the permission of the Human Fertilization and Embryology Authority for this intervention, and hinted that other couples elected selective abortion for PKU (Verlinsky et al., 2001).

Other hereditary conditions can be seen by some prospective parents as controllable and by others as highly

problematic. This is the case for congenital adrenal hyperplasia (CAH), sickle cell anaemia and less-known pathologies such as Stickler syndrome. CAH, a recessive genetic condition, is — in principle — 'manageable', but in some cases it produces severe health problems, especially in younger children. Some French parents feel that they cannot cope with the stress of having two sick children, and ask for prenatal testing or PGD to ascertain that their second child will not have CAH. French experts are divided on the issue of whether this request is justified (Raz, 2019). Stickler syndrome is linked with ocular anomalies and dimorphic traits which may compromise the child's respiration and swallowing. It is classified as curable (or rather treatable), but people with more severe variants of this syndrome face serious difficulties in daily life. A French couple who already had one affected child with multiple health challenges were determined not to have a second child with this condition. When the woman became pregnant, she asked for permission to undergo early prenatal diagnosis of Stickler syndrome. Members of the ethics committee of the hospital where she was treated could not agree whether her request was justified, and whether Stickler syndrome corresponds to the legal definition of a 'condition of a particular gravity' (as originally defined in French Public Health Code, Law No. L2213-1 of 17 January 1975) which legitimates selective termination of pregnancy. Similar hesitations are present in debates on access to PGD in France. French ethics committees are advised to consider the parents'/family's experience but there are considerable differences in interpretations of this term, as well as in interpretation of the terms 'curability', 'treatability' and 'severity' (Merg and Schmoll, 2005). Savvy prospective French parents can elect to submit their demand to a hospital where the multi-disciplinary prenatal diagnosis committees are known to be more liberal, and to present their request in a way that will increase the chance of its acceptance.

## Preventing transmission — but of what?

PGD for late-onset conditions, especially those which are not invariably fatal (e.g. hereditary forms of cancer), may seem particularly problematic. People at high risk of cancer usually enjoy long periods of disease-free life, not all of them become sick, and those who do develop malignant tumours do not necessarily die from the disease. Nevertheless, some people with BRCA mutations — dominant mutations, transmitted by both men and women, which strongly predispose to breast and ovarian cancer — are willing to go to great lengths to avoid the transmission of a 'faulty' gene. Catherine Dekeuwer and Simone Bateman interrogated French BRCA carriers about their attitudes to PGD (Dekeuwer and Bateman, 2013). The majority of the interviewed women were not personally interested in this possibility, although all agreed that this may be a good solution for other women/couples. However, a few women strongly believed that they should do all they could to prevent transmission of the BRCA gene to their offspring.

One of the reasons given by people who wished to undergo PGD to prevent transmission of the BRCA gene was that they had witnessed the suffering caused by cancer in their families. They felt they were ultimately responsible for the possible harmful effects of a deleterious mutation on their children: not only their possible illness and death, but also the problems that their children might have to face as adults in caring for or losing a close relative, finding and keeping a partner, and making plans to have a family. Some also believed that they had a moral duty not to pass on a deleterious gene, and that they were accountable for decisions that affect both themselves and their offspring. One BRCA-positive woman explained:

I can overcome what concerns me but it is difficult to bear the fact that persons I love are ill, not well in their minds and in their bodies. You can imagine how much stronger this would be if it were my daughter, my own child.

Another woman noted that with the decision to have children, one transmits 'much more than a gene'. Some BRCA mutation carriers, Dekeuwer and Bateman explain, view PGD as a legitimate way of having children if it is primarily a means of avoiding the perpetuation of suffering in their families.

Dekeuwer and Bateman published their text in 2011, when PGD for BRCA was not allowed in France and the only solution for BRCA mutation carriers who wanted to use PGD to prevent transmission of the gene to their offspring was to undergo this procedure abroad. In 2015, a French couple received permission to undergo PGD to prevent the transmission of BRCA-1 mutation; this remains, however, an exceptional event (Duget and Boyer-Beviere, 2017: 172).

## PGD for 'minor' impairments

Legal framing of PGD almost uniformly states that the use of this technology aims to prevent the birth of a child that carry genes that induce 'severe and incurable' disease, with a strong focus on uniformly severe early-onset conditions, such as Tay Sachs disease. Variability of expression of a given hereditary condition (i.e. uncertainty about the level of severity of disease manifestations in a child who inherits the mutated gene) complicates the argument, as does the problem of transmission of late onset of severe pathologies such as cancer. However, even when a given condition is not classified as truly 'severe', some people with a given hereditary trait associate this trait with a high level of suffering, and feel strongly that they do not wish to transmit it to their offspring. Their view can be contrasted with the opinion, oft repeated by disability activists, that a negative view of disability promoted by the medical profession is at odds with the much more positive view of disability/impairment of disabled people themselves. The latter statement is undoubtedly true — for some. Strong condemnation of all the biomedical technologies which enable prospective parents to have children free of a hereditary condition made in the name of the disabled community — that is, pronouced by devoted, articulate and, not infrequently, self-designated spokepersons for this community — may silence people who have a dissent opinion and different 'experiential knowledge' (Paul and Löwy, 2018).

A rare hereditary disease, hypohidrotic ectodermal dysplasia (HED), can be classified as (relatively) mild. People with HED (mainly men as this condition is X-linked) have sparse hair, few teeth, and problems with sweating which lead to overheating during exercise and in hot weather,

and greater risk of developing a dangerously high fever. Children with HED can die from overheating, failure to thrive and infection, but the great majority survive to adulthood. Adults with this condition usually cope well physically and can lead fully autonomous lives, but many are stigmatized because they have unusual facial features and very bad teeth (the latter problem can be corrected today with dental implants — if the affected person can afford them). People with HED are frequently concerned about the transmission of this condition to offspring. Unsurprisingly, their attitudes to the transmission of their mutation are strongly coloured by their own experience of life with this disorder. Some categorically reject the possibility of transmitting HED:

> I never wanted children to go through what I've gone through. That has always been at the back of my mind ... I would not wish this on anyone at all.

One young man with HED had an intermediary position: he was in favour of PND and selective abortion for this condition, then added that he would not discourage his sister from having an affected child: 'a child's a child at the end of the day'. Other men were convinced that an abortion for HED is plainly wrong, or believed that the presence of the same condition in their offspring would produce stronger links with these children (Clarke, 2013).

Practitioners with experience of PGD who participated in focus groups on this approach explained that a condition seen as 'mild' or 'treatable' by one person can be seen as severely affecting the quality of one's life by another person. One participant told the group:

Only last week we had a discussion concerning a patient suffering from congenital hair loss. You may say that is nothing, but for the patient, this was unbelievably burdensome. She was almost suicidal because of having no hair on her entire body and she absolutely didn't want to transmit this. This is a serious disorder, of which the hospital's PGD committee said: 'well, hair loss, what's the fuss?' And that in my view is the main problem, that the patient has a completely different perception than the professional (Soto-Lafontaine et al., 2018: 378).

As people's views on the transmission of a 'defective' gene to offspring vary greatly, some experts have argued that PGD decisions should be left to prospective parents who, when well informed, are largely good guides for the use of this technology (Handside, 2010). Such a liberal position does not consider an additional and crucial variable: the affordability of PGD. In countries where the costs of (some) ART are covered by national health insurance, it is reasonable to assume that the collective will define rules of access to state-funded uses of this technology. In countries where the couple has to pay for PGD out of pocket, the generous statement 'let parents decide' means, in practice, 'let parents who can afford PGD decide' — excluding the others.

## Access to PGD: Israel and Brazil

France and the USA represent two distinct attitudes to PGD. France has strict regulations regarding access to this technology. PGD is funded by the state, but is only permitted in a small number of well-defined cases. In the USA, all those who are able to pay for PGD have unrestricted access to this technology. Israel and Brazil may be seen as further amplification of these tendencies. In Israel, a much greater number of couples have access to state-funded PGD; in Brazil, this approach is only available to a very small number of women — those at the upper end of the income scale.

Israel is probably the only country that proposes state-sponsored preconception genetic screening, not only for a single, targeted disease such as thalassaemia or sickle cell anaemia, but for a large spectrum of conditions. The unique Israeli nation-wide voluntary, free-of-charge programme of 'population genetic screening for reproductive purposes' screens for frequent and severe genetic diseases. The programme is grounded in the observation that specific groups in the Israeli population carry founder mutations (Zielenska and Löwy, 2018). The Israeli Ministry of Health established a list of hereditary conditions included in the state-sponsored genetic screening following, the Ministry claims, simple, evidence-based rules. These rules took into consideration three elements: the origin of the tested person ('eda' — roughly community — for Jews, village for Palestinian Muslims and Druses, tribe for Bedouins); the frequency of disease-producing mutations in that community; and the severity of a given hereditary pathology. All three elements are difficult to stabilize, yet each newly discovered mutation is individually scrutinized by the Israeli Society of Medical Genetics and either accepted or rejected as part of the national 'basket' of genetic tests.

Couples who plan to have children are encouraged to undergo genetic screening, often offered in primary health settings by specially trained nurses. In practice, the testing is either preconception or prenatal. Many couples, especially from families without known hereditary conditions, undergo such testing when the woman is already pregnant. If both partners are carriers of a recessive mutation, or one of them is a carrier of a dominant/sex-linked mutation, they can elect either to refrain from having children (and, in traditional arrangements, decide against a prospective wedding), conceive naturally and opt for early genetic diagnosis and selective abortion, or elect IVF with PGD. If a couple makes the latter choice, the state covers all the expenses of IVF and genetic testing until the birth of two mutation-free children. It is not surprising that many couples elect the latter possibility. PGD is widely diffused in Israel and has a very positive image among health professionals and the general population (Zuckerman et al., 2017).

Geneticists who developed the Israeli programme of genetic screening present it as an unproblematic, positive development which merely enlarges the scope of a couple's choices. The definition of 'severe and incurable' pathology included in government- sponsored testing is also perceived as non-controversial. I asked Joel Zlotogora, the main architect of the Israeli genetic screening programme, why Israel is the only country with such a programme, while France, for example, does not intend (to date) to introduce population genetic screening despite the presence of founder mutations in French sub-populations. Zlotogora — born and educated in France — answered, 'because the French are irresponsible'.

Brazil has laws and regulations which, in principle, allow access to reproductive technology, including IVF, for all

users of the national health service, Systema Unico de Saude (SUS). In practice, as is the case for many other costly medical technologies, the users of SUS have very limited access to advanced infertility treatment and only exceptionally can benefit from IVF (Alfrano, 2014). This is even more true for PGD. Not only does this approach depend on more complex technology and have a higher cost, but — as the termination of pregnancy is criminalized in Brazil — the proximity of PGD to abortion adds an additional layer of difficulty. However, Brazilian women of high socio-economic status can safely terminate an unwanted pregnancy abroad or in selected high-end clinics in Brazil. They can also get access to PGD, either through medical tourism or in a small number of specialized infertility treatment centres. As in the USA, access to PGD in Brazil is regulated by money. The main difference is that a much smaller proportion of Brazilian women can afford this technology. In the USA, some health insurance providers offer partial reimbursement of IVF and, even in the absence of such reimbursement, middle class couples willing to make important financial sacrifices can have access to PGD. Brazilian private health insurance companies do not cover the costs of IVF, and with much lower average salaries and elevated costs of ART (not lower, and sometimes higher than in the USA), IVF, and IVF with PGD, are only accessible to women of high socio-economic status. Lack of governmental will to provide infertility treatment services to lower-income couples leads to a situation where it is not possible for the vast majority of the population to access PGD, including couples at high risk of giving birth to a child with a severe hereditary condition. This development is seen by some experts as a restriction of their rights as citizens (Damian et al., 2015: 32).

In Israel, strong governmental support for PGD may have contributed to its high acceptance: if the government is willing to pay for it, the promotion of birth of 'healthy children' is more readily perceived as a good thing. In Brazil, very limited access to PGD may have had the opposite effect: the rarity of this approach, coupled with its proximity to abortion, may have accentuated its negative perception.

## PGD: irreducible ambivalence and situated dilemmas

PGD and an earlier approach, prenatal diagnosis for genetic anomaly and selective abortion, prevent the birth of children with specific traits. Situated uses of this technology reflect pre-existing assumptions about health and disease, normal and pathological. They also illustrate the complex ways that the advent of new technology can modify these assumptions (Löwy, 2011). Some disability activists strongly criticize biomedical technologies that allow prospective parents to elect to have hereditary disease/disorder-free children because they believe that they promote a negative perception of disability. Ana Peláez Narváez, an activist who was the President of the Women's Commission of the Spanish Organization of Disabled People, and President of the Women's Commission at the European Handicap Forum between 2004 and 2014, explained in a book on disability and human rights that:

- International conventions recognize the right of all persons, including handicapped persons, to have a dignified life, independent of their level of impairment.
- This right includes the rights of a future person, that is an embryo and a fetus. A eugenic abortion is thus in contradiction with international conventions of human rights.
- This rule should also be applied to PGD because it is no different in principle from a eugenic abortion (Navarez, 2009).

Navarez's position may be seen as extreme It does not take into account real-life difficulties of mothers/families who are often the main provider of care for impaired children/people, and who are aware of the fact that they cannot count on 'society' to provide the full scope of such care The probability of a radical improvement in care of disabled children/people is particularly low in countries affected by economic crisis and/or those with strong neoliberal policies Navarez's position also makes abstraction of the demand, powerfully articulated by some mutation carriers, to halt the transmission of a deleterious mutation, grounded in their understanding of responsible parenthood, a wish to spare their future child from the difficulties faced by them or their relatives, and, for some, an aspiration to avoid recriminations of their future offspring Navarez's radical rejection of PGD has, nevertheless the advantage of being fully coherent The same is not true for the views of the advocates of PGD

The main justification of PGD is the well-being of the future child. Thus, in France, the legislation explicitly states that the parents must base their joint agreement exclusively on the direct and personal interests of their future child. Several other European countries, such as Sweden, Norway and Denmark, only allow PGD for severe hereditary conditions that lead to premature death (Duget and Boyer-Beviere, 2017). In practice, indications for PGD, initially very limited, have relaxed with time. Moreover, the principle that PGD can only be employed to promote the well-being of the future child does not justify the conception of a 'saviour child', selected to be a cell donor for a dying sibling, especially when the disease which affects the older child has no genetic basis (e.g. leukaemia). In such a case, risks associated with IVF or embryo biopsy procedures are imposed upon the younger child without any benefit to that child (Wolf et al., 2003). Nevertheless, PGD to favour the birth of a child that can save a sibling is allowed/tolerated in some countries (UK, France, Spain) that regulate this approach. Moreover, in 2012, the European Court of Justice ruled in favour of an Italian couple, both carriers of genes for cystic fibrosis, and parents of a child with this condition, denied the right to undergo PGD to ensure that their child would be free of this disease, that, 'the desire not to have a sick child is a form of expression of their private and family life', thus indirectly legitimating the parental wish to raise a disease-free child (Duget and Boyer-Beviere, 2017: 173).

In 1950, discussing the eugenicists' aspirations to eliminate harmful genes from populations, the geneticist Herman Muller explained that as practically everyone carries some 'defective' genes, eugenic measures, such as forced sterilization of the 'unfit', were pointless: 'none of us can cast stones, for we are all fellow mutants together' (Paul,

1987: 325). Muller believed that, in the future, technical advances will allow us to identify carriers of particularly harmful mutations. It will then be possible to persuade them to refrain from having children. Muller correctly predicted scientists' growing capacity to identify harmful mutations, attested by the exponential increase in number of such mutations listed in On-line Mendalian Inheritance in Man. However, he did not foresee the consequences of identification of such mutations. Today, mutation carriers are not told to remain childless, but instead receive information about technical solutions which can allow them to have mutation-free children. PGD looms large among these solutions, because it makes possible the birth of biological children of a couple at high risk of genetic disease without the trauma of abortion. Nevertheless, not all affected couples are interested in this solution, and for some, the existence of a technical possibility to produce 'mutation-free children' may have aggravated their reproductive dilemmas. Moreover, and more crucially, only a fraction of those who are interested in PGD have access to this technology. Often, the main discriminating element is money.

## Conclusion

Moral dilemmas linked to the use and potential misuse of PGD are often presented in absolute and abstract terms. However, PGD is, above all, a medical technology which, like other technologies, is situated and shaped by legal, material and economic constraints. In some countries, such as Israel and — to a lesser extent — France, Scandinavian countries and the UK, the national healthcare system covers at least some of the expenses linked with PGD, and thus partly disconnects the consequences of the introduction of this approach from social status and financial considerations; however, even in these countries, individuals of high socio-economic status have a wider range of reproductive choices. Women who live in countries where PGD is permitted but who fail to obtain permission to use it, or those who live in countries where PGD is forbidden, can travel abroad for PGD if they can afford it (Bayefsky, 2016). In countries where abortion is criminalized, women of low socio-economic status with a hereditary condition in the family have no way to ascertain that they will give birth to a disease-free child, and are obliged to choose between a 'genetic lottery' and remaining childless. PGD displays the ways that biomedical technologies shape our understanding of disease, and illuminates some of the most complex dilemmas raised by ART. It also makes visible the dramatic consequences of stratified reproduction (Ginsburg and Rapp, 1995).

## Acknowledgements

The author wishes to thank Fay Gisburg, Severine Mathieu and Rayna Rapp, who organized the workshop 'Assistive Reproductive Technology: a Franco-American Comparison'; all the participants in this workshop; and Susan Lindee for her stimulating remarks on the first version of this text.

## References

Alfrano, Bianca, 2014. Reproducao assistida, infertilidades e práticas de saúde em um serviço público no Rio de Janeiro Unpublished PhD thesis. UERJ.
Baruch, S., Kaufman, D., Hudson, K., 2008. Genetic testing of embryos: practices and perspectives of US in vitro fertilization clinics. Fertility Sterililty 89 (5), 1053—1058.
Boardman, F.K., 2013. 'Knowledge is power?': The role of experiential knowledge in genetically 'risky' reproductive decisions. Sociol. Health Illn. 36 (1), 137—150.
Boardman, F.K., 2014. The expressivist objection to prenatal testing: The experiences of families living with genetic disease. Soc. Sci. Med. 197, 18—25.
Bayefsky, M., 2015. The regulatory gap for preimplantation genetic diagnosis. Hasting Center Report, January-February, 7—8. https://doi.org/10.1002/hast.412.
Bayefsky, M., 2016. Comparative preimplantation genetic diagnosis policy in Europe and the USA and its implications for a reproductive tourism. Reprod. Biomed. Soc. 3, 41—47.
Bayefsky, M., December 2018. Who should regulate preimplantation genetic diagnosis in the United States? AMA J. Ethics 20 (12), E1160—E1167.
Clarke, A., 2013. Stigma, self-esteem and reproduction: talking with men about life with hypohidrotic ectodermal dysplasia. Sociology 47 (5), 887—905.
Damian, B.B., Bonetti, T.C.S., Horovitz, D.D.G., 2015. Practices and ethical concerns regarding preimplantation diagnosis. Who regulates preimplantation genetic diagnosis in Brazil? Braz. J. Med. Biol. Res. 48 (1), 25—33.
Dekeuwer, C., Bateman, S., 2013. Much more than a gene: hereditary breast and ovarian cancer, reproductive choices and family life. Med., l Health Care Philosophy 16 (2), 231—244.
Drazba, K.T., Kelley, M., Hershberger, P.E., 2014. A qualitative inquiry of the financial concerns of couples opting to use preimplantation genetic diagnosis to prevent the transmission of known genetic disorders. J. Genetic Counsel. 23 (2), 201—211.
Duget, A.M., Boyer-Beviere, B., 2017. Preimplantation genetic diagnosis: The situation in France and in other European countries. Europ. J. Health Law 24, 160—174.
Franklin, S., Roberts, C., 2006. Born and Made: An Ethnography of Preimplantation Genetic Diagnosis. Princeton University Press, Princeton.
Ginoza, M.E., Rosario, I., 2020. Regulating preimplantation genetic testing across the world: A comparison of international policy and ethical perspectives. Cold Spring Harbour Perspect. Med. 10 a036681.
Ginsburg, F., Rapp, R. (Eds.), 1995. Conceiving the New World Order. The Global Politics of Reproduction. California University Press, Berkeley.
Handside, A., 2010. Let parents decide. Nature 464 (15), 978—979.
Huxley, A., 1932. Brave New World. Chatto and Windus, London.
Löwy, I., 2011. Tra 'anormale' e 'inaceptabile': l'evoluzione storica della diagnostica prenatale. Quaderni Storici 46 (1), 45—65.
Lowy, I., 2017. Imperfect Pregnancies: A History of Birth Defects and Prenatal Diagnosis. Johns Hopkins University Press, Baltimore.
Löwy, I., 2018. Tangled Diagnoses: Women, Prenatal Testing and Risk. Chicago University Press, Chicago.
Merg, D., Schmoll, P., 2005. Éthique de l'interruption médicale de grossesse en France. Questions posées par le dispositif des Centres pluridisciplinaires de diagnostic prénatal. Les Dossiers de l'Obstétrique 343, 21—29.
Navarez, A.P., 2009. El aborto eugenico. In: Narvaez, A.P., Rios, B. M., Gallego, M.L. (Eds.), Maternidad & Discapacid. Ediciones Cinca, Madrid, pp. 77—93.

Paul, D.B., 1987. 'Our load of mutations' revisited. J. Hist. Biol. 20 (3), 321—335.
Paul, D.P., Brosco, J.P., 2013. The PKU Paradox. A Short History of a Genetic Disease. Baltimore: Johns Hopkins University Press.
Paul, D.B., Löwy, I., 2018. On objectivity in prenatal genetic care. OBM Genetics 2 (2). https://doi.org/10.21926/obm.genet.180022.
Raz, M., 2019. La production des evidences sur l'intersexuation: Savoirs et pratiques médicales autour de l'hyperplasie congenitale des surrénales, France, 1950-2018. Unpublished PhD thesis, EHESS.
Soini, S., 2007. Preimplantation genetic diagnosis (PGD) in Europe: Diversity of legislation a challenge to the community and its citizens. Med. Law 26 (2), 309—323.
Soto-Lafontaine, M., Dondorp, W., Provoost, V., de Wert, G., 2018. Dealing with treatment and transfer requests: how PGD professionals discuss ethical challenges arising in everyday practice. Med. Health Care Philos. 21, 375—386.
Theodosiou, A.A., Johnson, M.H., 2011. The politics of human embryo research and the motivation to achieve PGD. Reproductive Bioethics On Line, 22, 457—471.
Verlinsky, Y., Rechitsky, S., Verlinsky, O., Strom, C., Kuliev, A., 2001. Preimplantation testing for phenylketonuria. Fertil. Steril. 76 (2), 346—349.
Wolf, S.M., Kahn, J.P., Wagner, J.E., 2003. Using preimplantation genetic diagnosis to create a stem cell donor: issues, guidelines limits. J. Law Med. Ethics 31, 327—339.
Zielenska, A., Löwy, I., 2018. The Golden Helix: Origins, ethnicity and genetic screening in Israel. Biosocieties 13 (2), 323—348.
Zuckerman, S., Zeevi, D.A., Gooldin, S., Altarescu, G., 2017. Acceptable applications of preimplantation genetic diagnosis (PGD) among Israeli PGD users. Eur. J. Hum. Genet. 25, 1113—1117.

*Declaration: The author reports no financial or commercial conflicts of interest.*

Received 9 February 2020; refereed 12 September 2020; accepted 29 September 2020.