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Designer Babies: Revealing the Ethical and Social Implications of Genetic Engineering in Human Embryos

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Abstract: ***The idea of "designer babies" was born as a result of advances in genetic engineering, which made it possible to create and modify the genetic makeup of human embryos. The advent of CRISPR-Cas9 technology revolutionized genetic editing, offering scientists a more efficient way to target specific genes and make modifications compared to previous methods. This breakthrough, combined with pre-implantation genetic diagnosis (PGD) and in vitro fertilization (IVF), has opened up possibilities for advancements in the field of designer babies. However, it is crucial to recognize that genetic engineering is still evolving and numerous technical, ethical, and safety challenges must be addressed before designer babies can become a commonplace practice. This article highlights the ethical considerations involved in using CRISPR-Cas9, PGD, and IVF in the pursuit of designer babies and regulatory frameworks and policy considerations surrounding these reproductive techniques. It also acknowledges the potential benefits, such as the prevention of genetic diseases, but underscores the significance of responsible research and regulation to ensure that these technologies are employed ethically and in line with societal values.***

Keywords: Designer babies, CRISPR-Cas9, Pre-implantation Genetic Diagnosis, In Vitro Fertilization, Human embryos, Genetic Engineering, Ethical Considerations, Social Implications, Regulatory Frameworks, Case Studies.

1. Introduction

Designer babies refers to babies whose genetic makeup has been intentionally modified or enhanced through genetic engineering techniques. This concept involves altering the genetic material of an embryo or foetus to introduce specific traits or characteristics before birth. Advancements in genetic engineering and technologies such as CRISPR-Cas9 have opened up possibilities for modifying specific genes. The potential benefits of designer babies include the prevention of genetic diseases, the enhancement of desirable traits, and the potential to improve overall human health and well-being. For example, genetic modifications could be used to eliminate or reduce the risk of certain hereditary conditions or predispositions to diseases. On the other hand, there are several ethical concerns associated with designer babies. Some argue that it could lead to a society where genetic enhancement creates a divide between the "genetically privileged" and the "naturally born". There are concerns about the potential for eugenics, where certain traits are favoured over others, leading to discrimination or devaluation of individuals who do not possess those traits. Due to these ethical concerns, there are legal and regulatory frameworks in place in many countries that restrict or prohibit genetic modifications for non-medical purposes, such as enhancing traits or creating "designer babies". The focus of genetic research and technology is primarily on medical applications aimed at treating or preventing genetic disorders rather than enhancing traits.

2. How Designer Babies are Created?

Designer babies are created through a process called genetic engineering or genetic modification. This process involves manipulating the genetic material, specifically the DNA, of an embryo to enhance or modify certain traits.

Steps involved in creating Designer Babies:
In-vitro fertilization (IVF): In-vitro fertilization (IVF) is a medical procedure that involves fertilizing an egg with sperm outside the human body in a laboratory setting. Eggs are collected from the mother and sperm from the father. These are then fertilized in a laboratory dish to create embryos [15].

Pre-implantation genetic diagnosis (PGD): Pre-implantation Genetic Diagnosis (PGD) is a reproductive technology used in conjunction with in vitro fertilization (IVF) that allows for the genetic screening of embryos before they are implanted in the womb. This step involves the selection of embryos created through in vitro fertilization (IVF) for genetic screening [16]. After a few days of development, when the embryos are at the 8-cell stage, a few cells are removed for genetic testing. The embryos are analyzed to identify specific genetic traits or conditions. Only embryos with the desired traits would be selected for further development.

Genetic modification: Genetic modification, also known as genetic engineering, involves intentionally altering an

organism's genetic material to introduce or modify specific genes or traits. Once the desired embryos have been identified through PGD, specific genetic modifications can be made. This can be done through various techniques, including gene editing technologies such as CRISPR-Cas9. The specific genes responsible for the desired traits are altered or replaced. After the genetic modifications, the embryos are re-evaluated to determine which ones have successfully incorporated the desired changes. Only the selected embryos are then chosen for implantation.

Embryo implantation: After genetic modifications are made, the selected embryos would be cultured in a laboratory to allow them to develop further. The development process would be closely monitored to ensure the viability and health of the embryos. Once the embryos have reached a certain stage of development, they can be transferred into the womb of the intended parent or surrogate mother for pregnancy.

Pregnancy and Birth: The pregnancy would proceed as in a normal IVF pregnancy, with regular monitoring and medical care. The baby would be born and would potentially possess the desired genetic modifications.

3. Potential Benefits of Designer Babies

Designer babies have the potential to bring forth various advantages. These include the prevention of genetic diseases, Saviour siblings, enhanced mental abilities, personalised medicine, the ability to select physical traits, and potentially increasing life expectancy. While these benefits are speculative, they highlight the potential advantages associated with designer babies.

Eliminating genetic diseases:
Designer babies have the potential to eliminate genetic diseases by selectively modifying disease-causing genes. Conditions like cystic fibrosis, sickle cell anaemia, and Huntington's disease could be significantly reduced or eradicated through genetic engineering techniques. By targeting and modifying these faulty genes, we could pave the way for healthier future generations, free from the burden of these inherited disorders. One prominent benefit of designer babies achieved through pre-implantation genetic diagnosis (PGD) is the potential to eliminate genetic diseases. PGD involves screening embryos created through in vitro fertilization (IVF) for specific genetic disorders before implantation. This could bring about a significant improvement in the quality of life for individuals and families affected by genetic diseases [18].

Saviour Siblings:
Saviour siblings, also known as designer babies, are children conceived through in vitro fertilization (IVF) with the specific intention of serving as a donor for an existing sibling suffering from a life-threatening condition. The selection process involves screening embryos using pre-implantation genetic diagnosis (PGD) to identify those with compatible tissue or organ matches [1]. These selected embryos are then implanted into the mother's uterus, resulting in the birth of a Saviour sibling.

Improving Mental and Cognitive abilities:
The ability to think and learn could be revolutionised by designer babies. We could improve people's IQ, memory, focusing ability, and creativity by intentionally altering the genes involved [18]. Imagine a society where people have enhanced cognitive talents that allow them to understand complex concepts easily and perform well in a variety of occupations. This could unleash enormous possibilities for individual development, academic progress, and scientific discovery, advancing civilization into an era of improved cognitive power.

Enhancing physical traits:
Designer babies offer the opportunity to improve their physical traits in accordance with parental choices. Parents may have the opportunity to choose specific characteristics such as eye colour, hair colour and texture, skin tone, height, and even facial features for their child [6]. This potential customization of physical attributes could provide a sense of control and personalization, allowing parents to shape their child's appearance based on their preferences.

Personalized Medicine:
Personalized medicine holds great potential in the context of designer babies. Personalized medicine can contribute to the development of targeted therapies and treatments. By analyzing an individual's genetic profile, doctors can identify the most suitable medications, dosages, or interventions for specific conditions or diseases. This approach can potentially increase the effectiveness of medical treatments while minimizing adverse reactions or side effects, as personalized medicine takes into account an individual's unique genetic factors and responses to various interventions.

4. Ethical Concerns and Considerations

Numerous ethical questions are raised by the idea of "designer babies", which refers to genetically altering embryos or choosing particular traits. While they offer potential benefits, such as the prevention of genetic disorders and enhanced characteristics, the ethical considerations surrounding designer babies are significant. These include concerns about equity, consent and autonomy, unintended consequences, slippery slope, commodification of children, medicalization of reproduction, and ethical considerations for genetic editing. Engaging in open and inclusive discussions about these issues is crucial to ensuring that decisions in this area prioritize individual well-being, autonomy, and societal implications.

Consent and Autonomy:
Consent and autonomy are fundamental ethical considerations when discussing designer babies or any form of genetic modification. The ability to make decisions about our own bodies and genetic makeup is a cornerstone of individual autonomy. Genetic modifications made to embryos raise questions about informed consent. Since the modifications are performed before the individual is born and able to give consent, it becomes a decision made on behalf of someone else. This challenges the principle of autonomy, as the child may be subjected to genetic alterations they never consented to and may not agree with

in the future. Respecting individual autonomy requires careful consideration of the rights and agency of the individuals who will be directly affected by these decisions, including their right to self-determination and control over their own genetic identities. This raises ethical concerns about the autonomy and rights of the unborn child [18].

Commodification of Children:
The creation of saviour siblings may be seen as treating children as commodities or objects to fulfill the needs of others. Commodification opens the door to potential exploitation of vulnerable populations. Birth parents, surrogate mothers, and donors who could be focused on financial gain rather than genuine care and concern for the child's well-being. It raises concerns about the instrumentalization of children, reducing them to means rather than recognizing their inherent value and rights.

Unintended Consequences:
Unintended consequences are a significant ethical concern associated with designer babies. Genetic modifications, although intended to enhance certain traits or prevent disorders, can have unforeseen effects. The complexity of genetic interactions and the limited understanding of the human genome mean that making precise alterations could lead to unintended consequences for the individual and potentially future generations. The long-term implications of such unintended consequences raise questions about the ethical responsibility of altering the genetic makeup of individuals without fully comprehending the potential risks and ramifications. These unintended consequences could result in the form of unexpected health issues, genetic abnormalities, or alterations in traits that were not intended to be modified. Proper scientific research, rigorous testing, and ongoing monitoring are crucial to minimizing the likelihood of unintended consequences and ensuring the well-being of individuals affected by genetic modifications.

Slippery Slope:
According to the slippery slope argument, it will be challenging to set boundaries and stop the pursuit of extreme or socially constructed conceptions of perfection once we begin the process of genetically altering embryos to choose specific traits. The worry is that the initial goals of enhancing health or eliminating genetic disorders will eventually end up in a culture obsessed with producing "ideal" or genetically superior people. The slippery slope argument suggests caution and careful analysis of the potential outcomes that may result from continuously pushing the limits of genetic modification [2], [6].

Stigmatization and Discrimination:
The idea of designer babies raises serious ethical issues related to discrimination and stigmatization. People who naturally exhibit particular features may become stigmatized if those traits are viewed as undesirable or if they are preferred over others. By dividing people between those who have undergone genetic modification and those who have not, this could increase negative biases and prejudices in society. Discrimination of this kind might harm people's self-esteem, mental health, and social connections, eventually reducing the values of inclusion and equality [6]. It is essential to take these possible effects into account and to make sure that any advances in genetic technology do not result in the marginalization or devaluation of particular people or groups.

Medicalization of reproduction:
The concept of designer babies raises concerns about the medicalization of reproduction, where the process of creating a child becomes heavily influenced by technological interventions. Instead of procreation being a natural and intimate act, it could be transformed into a clinical procedure aimed at manufacturing customized individuals. This shift brings forth ethical questions about the commodification of human life as well as the potential devaluation of natural reproductive processes and the intimate relationships involved. The medicalization of reproduction in designer babies challenges our fundamental understanding of what it means to bring new life into the world and raises concerns about the potential erosion of human connection and the intrinsic value of human diversity.

Ethical Considerations for Gene Editing:
The technical challenges and ethical considerations associated with gene editing, such as the potential for off-target effects and the risk of inadvertently introducing harmful mutations, need to be carefully addressed before widespread implementation.

5. Social Implications of Designer Babies

Designer babies, the concept of genetically modifying embryos to enhance desired traits, pose significant social implications. The ability to select specific traits like intelligence, physical appearance, or athletic ability could result in a society divided between those who can afford such enhancements and those who cannot, deepening socioeconomic disparities. Furthermore, it challenges fundamental principles of equality, as it raises questions about the value we place on inherent diversity and the potential for discrimination against those who are perceived as "naturally" inferior. The concept also poses ethical dilemmas, as it raises concerns about the commodification of human life, the potential loss of individuality, and the unintended consequences of tampering with the complex interplay of genes. Additionally, it may lead to a shift in societal norms, where certain traits become the standard, potentially undermining the appreciation for natural variation and diminishing the concept of human uniqueness. Thus, the social implications of designer babies encompass a complex interplay between health benefits, ethical considerations, socioeconomic disparities, genetic diversity, and cultural values.

Socioeconomic inequality:
The concept of designer babies, which involves using genetic engineering techniques to modify the genetic makeup of embryos, has significant social implications, including the potential for socioeconomic inequality [18]. The availability and affordability of these genetic technologies could create disparities between those who can afford such interventions and those who cannot. This may result in a two-tiered society divided along genetic lines, where access to enhancement technologies becomes a

privilege reserved for the wealthy. As a result, socioeconomic inequality could be further deepened, impacting the opportunities and outcomes of individuals and potentially widening existing social disparities.

Reinforcement of Stereotypes:
One potential social implication of designer babies is the reinforcement of stereotypes. If parents can selectively choose specific traits for their children, it raises concerns that they may prioritize certain traits based on societal stereotypes or prejudices. This could perpetuate existing biases and reinforce societal norms regarding beauty standards, intelligence, or other characteristics. By intentionally designing children to fit into preconceived notions of what is desirable, there is a risk of perpetuating inequality and limiting individual expression and diversity.

Pressure and Expectations:
The concept of designer babies introduces the potential for increased societal pressure and expectations. If parents have the ability to select specific traits for their children, there may be a growing expectation for individuals to conform to a predetermined standard of physical appearance, intelligence, or other desired attributes [6]. This could create a culture where natural variations are less accepted, and individuals feel compelled to live up to artificially imposed ideals. The pressure to meet these expectations may lead to a loss of individual autonomy, self-identity, and personal expression. Moreover, it may undermine the appreciation for the diversity of human characteristics and diminish the value of natural variations in appearance and abilities. As technology advances and societal attitudes evolve, it is crucial to carefully consider the psychological and social impacts of such pressure and expectations on individuals and society as a whole.

Impact on Personal Identity and Self-Esteem:
Designer babies could potentially affect a person's sense of self and identity. If individuals are genetically engineered to possess certain traits, it may raise questions about the authenticity of their achievements and abilities. It could also lead to social stigmatization and feelings of inadequacy for those who are not genetically modified.

Impact on diversity:
Genetic diversity plays a crucial role in the adaptability and resilience of a species, enabling it to respond to changing environments and new challenges. Designer babies have the potential to impact genetic diversity within the human population. Altering the genetic makeup of humans through selective breeding or genetic modification could have unforeseen consequences for the human gene pool. It might disrupt natural evolutionary processes, potentially reducing genetic diversity and making the population more vulnerable to certain diseases or environmental changes.

6. Regulatory Frameworks

Many countries have regulatory frameworks governing assisted reproductive technologies (ART) and human genetic modification. These regulations often vary significantly between countries, reflecting cultural, ethical, and legal perspectives.

United Kingdom:
The United Kingdom has a specific regulatory framework called the Human Fertilization and Embryology Authority (HFEA). The Human Fertilization and Embryology Authority (HFEA) is a regulatory body in the United Kingdom that oversees the use of assisted reproductive technologies (ART) and the storage and use of human embryos. Its primary role is to ensure the ethical and safe use of these technologies. The HFEA operates under the Human Fertilization and Embryology Act, which outlines the legal framework for assisted reproduction in the UK [8]. This act prohibits the selection of embryos for non-medical purposes, such as choosing specific traits like eye colour, intelligence, or athleticism. However, it's worth noting that the HFEA does permit the use of ART techniques for medical purposes. For example, pre-implantation genetic diagnosis (PGD) is allowed in cases where there is a risk of serious genetic diseases or chromosomal abnormalities. The HFEA closely monitors and regulates fertility clinics, research involving embryos, and the use of ART techniques to ensure they adhere to the legal and ethical standards set by the Human Fertilization and Embryology Act [17].

United States:
The United States does not have specific federal regulations governing designer babies [3]. However, the Food and Drug Administration (FDA) has authority over assisted reproductive technologies (ART) and requires clinics to comply with certain safety and ethical guidelines. The use of gene editing technologies such as CRISPR on human embryos for non-medical purposes is currently not allowed, but gene editing for certain medical purposes is under ongoing discussion [13].

Canada:
AHRA stands for Assisted Human Reproduction Act, which is Canadian legislation governing assisted reproductive technologies and related practices. It was enacted to regulate activities such as in vitro fertilization (IVF), surrogacy, and sperm or egg donation. Under AHRA, the creation of designer babies would be subject to several ethical considerations and legal restrictions [5]. It prohibits the use of assisted reproduction for sex selection unless it is for medical purposes related to the prevention of a sex-linked genetic disorder. The legislation also sets guidelines for the screening and testing of embryos, ensuring that the procedures are carried out for specific medical reasons and not for non-medical reasons, such as selecting physical or cognitive traits. Additionally, AHRA prohibits the creation of embryos for any purpose other than reproductive or research purposes [12].

Germany:
The Embryo Protection Act (Embryonenschutzgesetz) [10] and the Genetic Diagnosis Act (Gendiagnostikgesetz) [11] are two significant pieces of legislation in Germany that address reproductive technologies, genetic testing, and related ethical considerations. The Embryo Protection Act regulates reproductive technologies and genetic manipulation. It prohibits the creation of embryos for any purpose other than reproduction, and it prohibits the alteration of embryos' genetic material, except for medical reasons. The Genetic Diagnosis Act governs genetic testing

and diagnosis. It sets standards for genetic testing, counselling, and the use of genetic information, including restrictions on prenatal genetic testing.

Australia:
In Australia, the regulation of designer babies falls under the purview of the federal and state governments. The main regulatory body overseeing assisted reproductive technologies and related issues is the Australian Health Ethics Committee (AHEC), which operates under the National Health and Medical Research Council (NHMRC) [9]. These regulations are designed to address the ethical considerations associated with altering or selecting traits in embryos. Prioritizing the well-being of the child, informed consent is a key requirement, ensuring individuals have a thorough understanding of the procedures, potential risks, and benefits involved. There is typically a prohibition on selecting certain non-medical traits to prevent potential harm or discrimination. The focus of these regulations is often on medical benefits rather than solely enhancing non-medical characteristics.

7. Case Studies

Lulu and Nana Case:
Lulu and Nana are the pseudonyms of the first gene-edited human babies, who were born in China in 2018. He Jiankui, a Chinese scientist and biophysicist, gained international attention in late 2018 when he claimed to have created the world's first genetically edited babies using CRISPR-Cas9 technology. He Jiankui conducted his research at the Southern University of Science and Technology in Shenzhen, China. In November 2018, he announced the birth of twin girls, "Lulu and Nana", whose genomes he claimed to have edited to make them resistant to HIV infection [14]. He also revealed that a third pregnancy was underway using the same genetic modification.

This announcement sparked widespread condemnation and concern within the scientific community and among the general public. Many scientists and bioethicists criticized He Jiankui for several reasons:

Lack of Transparency: He Jiankui's research was conducted secretly and without proper oversight or approval from relevant scientific and ethical bodies. He Jiankui did not disclose his work until after the births of the twin girls, and it was revealed that the parents were not fully aware of the risks and potential consequences of the gene-editing procedure. This lack of transparency raised concerns about the safety and ethical implications of his work.

Inadequate Justification: At the time of He Jiankui's experiment, there were already proven methods to prevent HIV transmission, such as antiretroviral medications and safer sex practices. These methods had been successful in reducing the transmission of HIV and were widely available. Therefore, the necessity of genetic modification to confer HIV resistance was questionable.

Potential Harms: The long-term consequences of genetic modifications in humans are not yet fully understood. Altering the genome can have unforeseen effects on various aspects of human biology and development, including physical health, mental health, and overall well-being. The potential risks and unintended consequences of such modifications raised concerns about the well-being and safety of the edited individuals. It is essential to thoroughly study and understand these potential long-term effects before applying genetic editing techniques to human embryos.

He Jiankui was convicted of "illegal medical practice" for conducting the experiment without the proper approvals. He was sentenced to three years in prison and fined 3 million Yuan (about $430,000). He was also ordered to pay compensation to the two women who participated in the experiment. The sentence was handed down by the Shenzhen Nanshan District People's Court. He Jiankui is now free from prison, but he is still banned from conducting any scientific research.

Molly Nash Case:
The Molly Nash case [1], [19] is a well-known ethical debate about the use of preimplantation genetic diagnosis (PGD) to create a "saviour sibling". Molly was born in 1994 with Fanconi anaemia, a rare genetic condition that can lead to bone marrow failure, leukaemia, and other serious health problems. Her parents, Lisa and Jack Nash, were told that she had a 50% chance of passing the disease on to any future children.

In 1999, the parents decided to use PGD to try to have a second child who would be a perfect bone marrow match for Molly. The parents decision to use PGD was made after they had already tried to have a second child naturally. They had two miscarriages, and they were told that their chances of having a successful pregnancy without PGD were very low. They used PGD to select an embryo that was free of Fanconi anaemia and also a tissue match for Molly. Lisa and Jack Nash used PGD at the University of Minnesota. The procedure was performed by Dr. John Wagner, who is a professor of paediatrics at the university. In 2000, Molly Nash's younger brother, Adam, was born. Adam was a perfect bone marrow match for Molly, and he donated umbilical cord blood to her when she was 6 years old. The transplant was successful, and Molly is now living a healthy life.

The Molly Nash case has been the subject of much debate and discussion. Some people believe that Lisa and Jack Nash were wrong to use PGD to create a "saviour sibling". Others believe that Lisa and Jack Nash were simply doing what they could to save their daughter's life. The Molly Nash case has also raised important ethical questions about the use of PGD. These questions include:

Is it ethical to create a child for the sole purpose of saving another child's life?

What are the limits of what we can do with PGD?

How do we balance the potential benefits of PGD with its risks and ethical concerns?

8. Conclusion

We conclude that modifying the genes of human embryos should only be done for medical purposes, not to change physical traits or other things that are not related to health. It's also important not to use this technology to prevent diseases that already have good treatments available, like what happened with Lulu and Nana's case. We should be careful and think about the ethical issues involved in making unnecessary changes to genes. By following these guidelines, we can use genetic modification responsibly and in a way that benefits everyone.

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