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# Gene editing and CRISPR: are we prepared for its ethical implications?

*Edição genética e CRISPR: estamos preparados para suas implicações éticas?*

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Gene editing, led by tools such as CRISPR-Cas9 (a genetic engineering tool that allows researchers to modify DNA in living organisms), has transformed molecular biology by offering a precise, efficient, and relatively affordable method for modifying the genome of living organisms. Since its discovery, this technology has opened up a range of possibilities in fields as diverse as medicine, agriculture, and basic research, consolidating it as one of the greatest scientific innovations of the twenty-first century. However, this dizzying advance has generated intense ethical, legal and social debates that require collective reflection and establishment of appropriate regulations.[1]

In medical field, CRISPR-Cas9 has shown to be a promising tool for treating genetic diseases previously considered incurable. The correction of mutations in genes responsible for diseases such as cystic fibrosis, sickle cell anemia or Huntington's disease is already beginning to materialize in preclinical research and clinical trials. In addition, this technology has enabled significant advances in cancer immunotherapy and the development of organs for transplants through animal cell editing. In the agricultural sector, it has contributed to the development of crops that are more resistant to pests, droughts, and adverse weather conditions, which can help combat global food insecurity.[2]

However, CRISPR is not foolproof. Off-target effects, which consist of unintended genetic changes, pose significant risks. These mistakes can lead to unexpected consequences, from cell damage to the development of new diseases. In the case of gene editing in humans, these risks become even more critical, as they can be passed on to future generations if germline cells are modified. Therefore, it is essential to conduct extensive research, as well as rigorous preclinical and clinical trials, before applying these technologies in a widespread manner.[3]

The use of CRISPR for human germline editing, which entails the modification of embryos and the possibility of altering hereditary traits, is one of the most controversial aspects of this technology. While it can prevent devastating genetic diseases, it also raises deep ethical concerns by opening the door to the creation of "designer babies." This can result in the selection of traits such as intelligence, eye color, or physical performance, raising fundamental questions about the boundaries between legitimate medical treatment and genetic enhancement. The question arises of who should decide which modifications are acceptable and how to prevent this technology from perpetuating or exacerbating existing social inequalities.[3]

From a global perspective, inequalities between developed and developing countries are worrying. In many regions, a lack of scientific infrastructure and limited regulatory capacity may leave them behind in accessing and controlling this technology, perpetuating an already considerable innovation and health gap. In addition, the irresponsible use of CRISPR by unregulated actors can lead to ethically questionable experiments with potentially catastrophic consequences.[3]

It is essential to establish a global regulatory framework that guarantees the safe, ethical, and equitable use of gene editing. This requires active collaboration between scientists, bioethicists, policymakers, and civil society. Governments should work with international organizations, such as UNESCO or the World Health Organization (WHO), to develop guidelines that limit the unethical use of CRISPR, promote transparency in research, and ensure equitable access to its benefits. Public

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education also plays a crucial role. It is essential to foster informed and participatory debate so that decisions about the use of CRISPR are not exclusively in the hands of experts, but include the perspectives of the whole society.[4]

While gene editing through tools like CRISPR-Cas9 represents a scientific revolution with the potential to transform medicine and society, this power carries significant responsibility. Moving forward with caution is essential, prioritizing the safety of patients and the well-being of future generations. Only through a balanced approach, which combines scientific innovation with a solid ethical and social basis, will it be possible to maximize the benefits of this revolutionary technology while minimizing its risks. Open dialogue, strict regulation, and a commitment to equity will be key to ensuring that gene editing becomes a tool at the service of all humanity, and not an exclusive privilege of few.[5]

**Authors' contributions**

*Jorge Hernández Navas: Conceptualization, Project administration, Writing (review and editing)*

*Juan Therán Leon: Conceptualization, Project administration, Writing (original draft), Writing (review and editing)*

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