Article Review

Gene and Germline Editing in Maternal and Reproductive Health: A Narrative Review of Ethical Dilemmas and Scientific Advances

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Abstract
Introduction: In Utero Genetic Editing (IUGE) is an emerging technology intended to modify the fetal genome to prevent or treat genetic disorders before birth. While it presents significant medical potential, it raises complex ethical, legal, and regulatory challenges. Current interventions remain largely animal-based, with human applications at theoretical or preclinical stages.
Methods: This review examines ethical guidelines, legal frameworks, and regulatory perspectives globally and in Indonesia. Sources included WHO, the Indonesian Obstetrics and Gynecology Association (POGI), Indonesian health laws, and journals such as the American Journal of Obstetrics and Gynecology (AJOG). Literature was drawn from PubMed, WHO databases, Indonesian archives, and AJOG publications (2015–2025).
Results: WHO emphasized precaution and transparency, while POGI stressed maternal–fetal safety under strict oversight. Indonesia lacks specific regulation, requiring interventions to respect safety and human dignity. The United States and European Union maintain restrictive regulations, including embryo research bans.
Conclusion: IUGE is promising for reproductive health but remains ethically and legally unresolved, requiring clearer frameworks before clinical translation.

Keywords: In Utero Genetic Editing, ethics, regulation, fetal therapy, bioethics

Pengeditan Gen dan Garis Keturunan dalam Kesehatan Ibu dan Reproduksi: Sebuah Ulasan Naratif Dilema Etis dan Kemajuan Ilmiah

Abstrak
Pendahuluan: In Utero Genetic Editing (IUGE) merupakan teknologi baru untuk memodifikasi genom janin guna mencegah atau mengobati kelainan genetik sejak sebelum lahir. Teknologi ini menjanjikan manfaat medis, namun menimbulkan tantangan etik, hukum, dan regulasi. Hingga kini, sebagian besar intervensi masih berbasis penelitian hewan, sementara aplikasi pada manusia berada pada tahap teoritis atau pra-klinis.
Metode: Kajian ini menelaah pedoman etik, kerangka hukum, dan regulasi dari perspektif global dan Indonesia. Sumber mencakup WHO, Perkumpulan Obstetri dan Ginekologi Indonesia (POGI), peraturan kesehatan nasional, serta jurnal internasional seperti American Journal of Obstetrics and Gynecology (AJOG). Literatur diperoleh dari PubMed, basis data WHO, arsip hukum Indonesia, dan publikasi AJOG (2015–2025).
Hasil: WHO menekankan prinsip kehati-hatian dan transparansi, sementara POGI menegaskan keselamatan ibu–janin dengan pengawasan ketat. Indonesia belum memiliki regulasi khusus, tetapi mensyaratkan intervensi genetik menjaga keselamatan dan martabat manusia. Negara seperti Amerika Serikat dan Uni Eropa menetapkan aturan restriktif, termasuk larangan riset embrio.
Kesimpulan: IUGE berpotensi meningkatkan kesehatan reproduksi, namun memerlukan regulasi yang lebih jelas sebelum penerapan klinis.

Kata kunci: *In Utero Genetic Editing*, etika, regulasi, terapi janin, bioetika

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Introduction

In Utero Genetic Editing (IUGE) is an approach that offers prenatal treatment for genetic disorders by utilizing fetal immune tolerance and stem cell accessibility. Several studies have shown that it enables lasting gene correction and is optimal during early gestation. Despite its potential, ethical concerns persist, specifically regarding maternal safety and enhancement use, necessitating frameworks that balance maternal autonomy with fetal benefit. In Indonesia, regulatory and ethical discussions on IUGE remain limited, with no specific guidelines that address its application in maternal and reproductive health. Therefore, this review aims to analyze current ethical frameworks and scientific developments in IUGE, with a focus on maternal health implications.

Methods

This article was carried out as a narrative review to provide an integrative analysis of ethical frameworks, legal contexts, and scientific developments related to IUGE. Literature searches were performed across multiple databases, including PubMed, World Health Organization (WHO) digital library, Indonesian legal and regulatory archives, and international journals, including American Journal of Obstetrics and Gynecology (AJOG). The search strategy covered from 2015 to 2025 to capture both foundational studies and the most recent developments in the field.

Keywords used were “In Utero Gene Editing,” “maternal ethics,” “germline regulation,” and “bioethics.” Boolean operators were applied to refine results, combining ethical, legal, and scientific terms to ensure comprehensive coverage. Publications were included when addressing the clinical potential, ethical or legal implications, or regulatory frameworks relevant to IUGE. Articles without relevance to maternal and reproductive health, or those lacking clear methodological descriptions, were excluded.

In addition to peer-reviewed scientific literature, national guidelines such as the Indonesian Society of Obstetrics and Gynecology (POGI) ethical codes and Indonesian health law documents were examined to provide local context. International perspectives were incorporated from WHO recommendations and comparative legal frameworks in the United States, the European Union, and China. The final selection was synthesized qualitatively, with particular emphasis on identifying regulatory gaps in Indonesia and observing areas where animal studies dominate current evidence.

Review

In Utero Gene Editing

IUGE was a significant method in obstetrics aimed at correcting genetic disorders before birth. By editing fetal genes during gestation, IUGE sought to prevent disease onset. This field had gained attention due to ethical concerns related to safety, long-term effects, and potential risks to both fetus and mother.[1]

Genome Editing Platforms in IUGE: Molecular Mechanisms and Delivery Considerations

IUGE leverages several genome editing platforms, each with unique mechanisms and suitability for fetal applications. Clustered Regularly Interspaced Short Palindromic Repeats-associated protein 9 (CRISPR-Cas9) emerged as the most promising due to its simplicity, adaptability, and multiplexing capability.[2]

CRISPR-Cas9

CRISPR-Cas9 was a bacterial-derived genome editing system that used a short guide RNA (gRNA) to direct the Cas9 nuclease to specific DNA sequences, creating double-strand breaks. These breaks were subsequently repaired by the cell through either non-homologous end joining (NHEJ), an error-prone process that could introduce insertions or deletions, or homology-directed repair (HDR), a template-based mechanism enabling precise sequence modifications.

Zinc Finger Nucleases (ZFNs) and Transcription Activator-Like Effector Nucleases (TALENs)

Zinc Finger Nucleases (ZFNs) and Transcription Activator-Like Effector Nucleases (TALENs) were protein-based tools that induced double-strand breaks (DSBs) using engineered DNA-binding domains. While TALENs offered greater specificity than ZFNs, both required complex design, were large in size, and had limited scalability for multiplex genome editing applications.

Base Editors

To overcome DSB-associated risks, base editors and prime editors allowed single-base edits and precise gene modifications without DSBs. These were particularly advantageous in fetal tissues, where HDR was inefficient and genomic stability was critical.

Delivery System

Based on the results of this study, effective delivery remained a major challenge. AAV (Adeno-Associated Virus) vectors were commonly used due to their tissue specificity and low immunogenicity, though these vectors had limited capacity. Lipid nanoparticles (LNPs) and poly (lactic-co-glycolic acid) (PLGA) based nanoparticles offered non-viral alternatives with favorable safety profiles. Recent studies demonstrated successful in utero delivery using PLGA

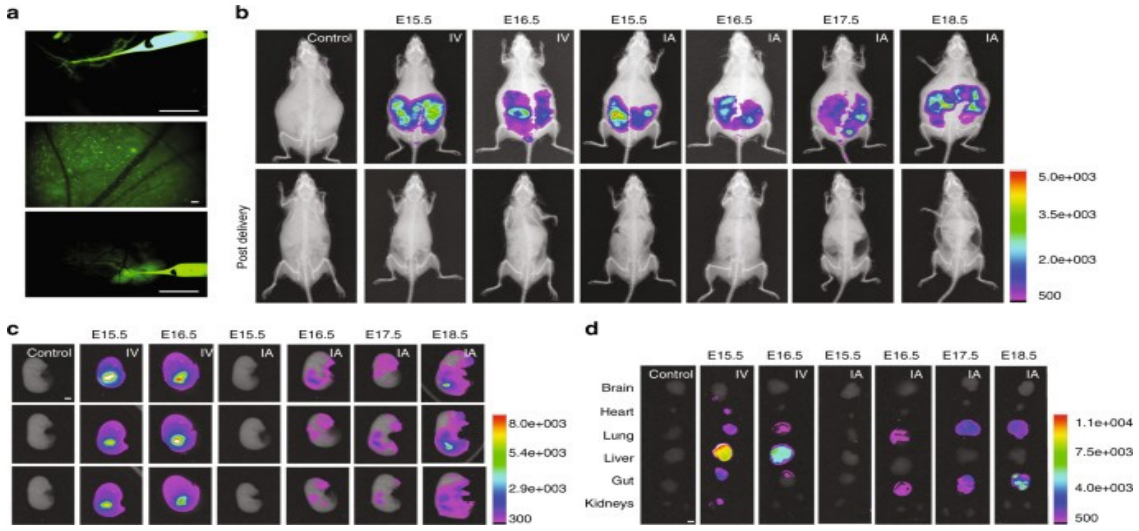


Figure 1 (a) Fluorescent Imaging of Fetal Tissue Shows Successful Delivery of Gene-Editing Components (b) Bioluminescent Imaging of Pregnant Mice at Different Embryonic Stages (c) Organ-Specific Fluorescence Imaging, Showing Gene-Editing Agent Accumulation in Fetal Organs, Particularly the Liver and Kidneys. (d) Further Organ-Level Analysis of Gene Delivery Across the Brain, Heart, Lungs, Liver, Gut, and Kidneys Demonstrated Targeted Gene Editing in Specific Tissues.[4]

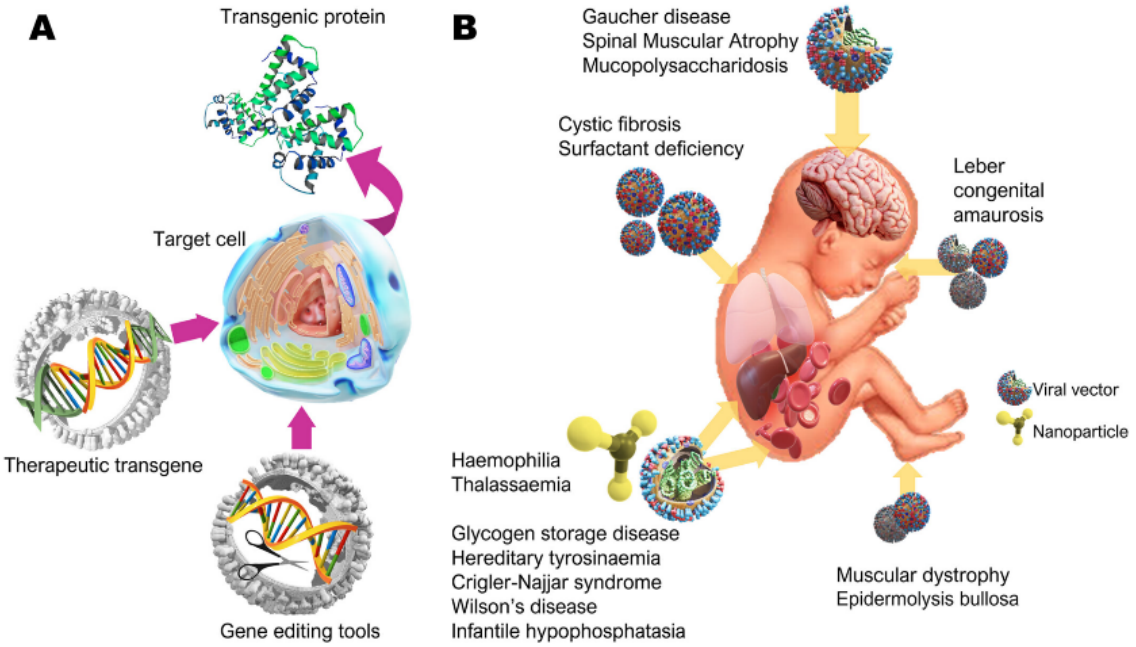


Figure 2 (A) Gene Addition and Gene Editing Therapies Used Viral or Non-Viral Vectors to Deliver Transgenes that Were Engineered with Cell-Specific or Ubiquitous Promoters or Nucleases and Template RNAs. Target Cells Produce the Corrected Protein after Transduction. (B) Many Disease Models had been Partially or Completely Rescued in Utero by Targeting Specific Organs Directly (Intracerebral, Intrahepatic, Intraocular, and Intra-Amnion Routes) or Through Systemic Delivery (Intravenous and Intraperitoneal Routes). Gene Therapy Delivery Methods Included Several Vectors (Viral and Nanoparticle-Based).[5]

nanoparticles containing fluorescent dyes, with selective fetal uptake and no maternal accumulation.

Animal studies confirmed that fetal gene editing through intra-amniotic or intravenous routes was feasible and safe when guided by ultrasound. These results supported the clinical potential of IUGE for correcting genetic disorders before birth, although further optimization in delivery efficiency and long-term safety was essential.[3]

Before clinical use, the safety and efficacy of IUGE must be validated in animal models due to risks during critical fetal development. IUGE included ex vivo methods, namely editing isolated cells before reintroduction, and in vivo methods, which delivered agents directly into the fetus. Ex vivo allowed precise control, while in vivo offered real-time intervention. Fetal therapy also included maternal treatment to improve outcomes. Although somatic editing was less ethically contentious, germline modifications remained highly debated due to potential heritable risks. Ensuring vector safety, editing accuracy, and minimal immune response was vital for successful and ethical application (Fig. 3).

IUGE presented immunological and procedural risks to the mother, including immune reactions from viral vectors like AAV and potential complications such as infection or bleeding, similar to other invasive fetal procedures. Pre-existing maternal antibodies neutralized therapy, though early gestation timing could reduce this risk. Beyond physical health, mothers encountered psychological stress from uncertainty, potential guilt, and the complexity of decision-making in experimental settings. Ethical frameworks

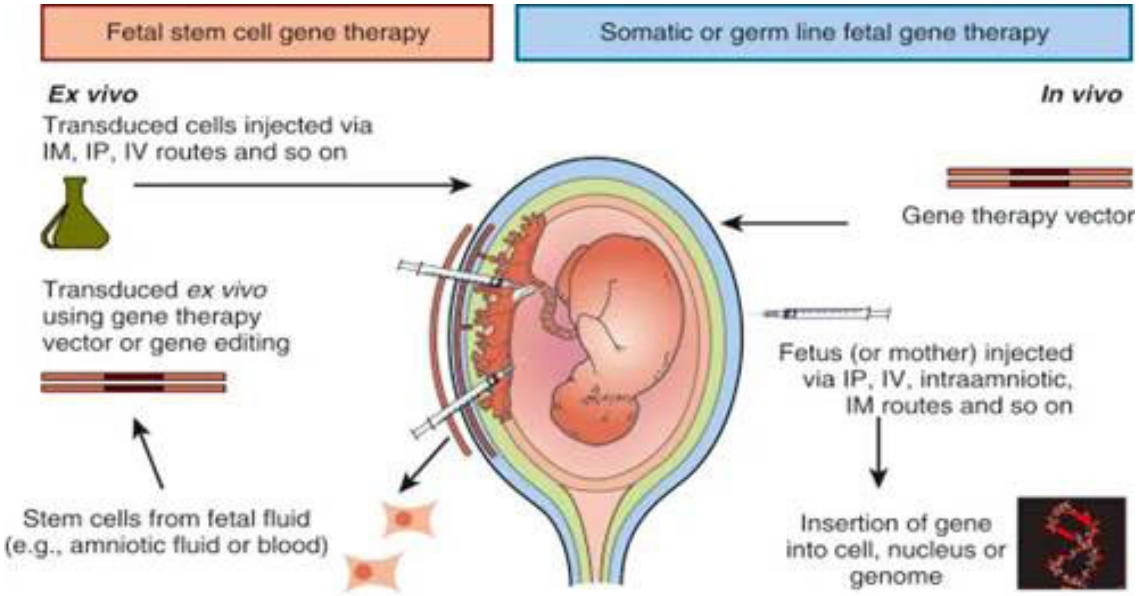


Figure 3 Gene Therapy was Delivered to the Fetus Through a Variety of Means. One Strategy, Known as Somatic Gene Therapy, Required Injecting the Vector Directly into the Fetus or Mother Using Ultrasound Guidance. Alternatively, Fetal Stem Cells could be Collected from Fetal Fluid through Ultrasound-Guided Sampling, Genetically Repaired in a Laboratory with Exposure to the Gene Therapy Vector, and then Reintroduced into the Fetus Through Ultrasound-Guided Injection. Injections could be Administered Intramuscularly (IM), Intraperitoneally (IP), or Intravascularly.[6]

emphasized maternal autonomy, requiring nondirective counseling to ensure informed decisions.[7]

As pregnancy comprised both the mother and fetus, ethical considerations must balance maternal rights with fetal interests in any IUGE intervention. IUGE presented immunological and procedural risks to the mother, including immune reactions from viral vectors like AAV and potential complications such as infection or bleeding, similar to other invasive fetal procedures.[7] Pre-existing maternal antibodies could neutralize therapy, though early gestation timing reduced this risk. Beyond physical health, mothers faced psychological stress from uncertainty, potential guilt, and the complexity of decision-making in experimental settings. Ethical frameworks emphasized maternal autonomy, requiring nondirective counseling to ensure informed decisions. As pregnancy involved both the mother and fetus, ethical considerations must balance maternal rights with fetal interests in any IUGE intervention.[8]

Recent Studies and Findings

Preexisting Maternal Immunity to AAV but Not Cas9 Impairs IUGE in Mice (2024)[9]

This study demonstrated successful treatment of hereditary tyrosinemia type (HT1) and mucopolysaccharidosis type I (MPS I) in mice using AAV or adenovirus-delivered base editors, aided by fetal immune immaturity. However, high maternal IgG against AAV impaired efficacy. Maternal immune status and proper timing were essential considerations for effective and safe IUGE application before birth.

Developing an Approach for IUGE: Lessons Learned (2024)[10]

In utero CRISPR/Cas9 was used to target CFTR gene in fetal sheep for cystic fibrosis treatment. While delivery was safe with no adverse effects, it failed to produce genetic edits. Results showed the need to optimize CRISPR design, delivery methods, and target selection for effective IUGE.

In Utero Nanoparticle Delivery for Site-Specific Genome Editing (2018)[11]

This study explored IUGE to correct HT1 in mice by delivering CRISPR-Cas9 into the fetal liver, leading to fumarylacetoacetate hydrolase (FAH) gene correction, improved liver function, and enhanced survival without adverse fetal effects. Riley et al. (2024) used lipid nanoparticles (LNPs) to deliver base editors with ~15% efficiency and low off-target risks, though biodistribution was inconsistent. Ricciardi et al. (2018) applied Adeno-Associated Virus serotype 9 (AAV9) for liver disorder correction, achieving high editing rates but raising concerns over maternal immunity, inflammation, and vector scalability. Breckenfelder et al. (2024) attempted translation to sheep for CFTR gene editing but failed, due to species differences in lung development, vector uptake, and early immune responses. Off-target risks remained a concern despite reassuring sequencing data. Collectively, these studies showed IUGE's promise and also emphasized the challenges of gene delivery, species translation, safety, as well as ethics. This demanded cautious progression, multi-species validation, and strong regulatory frameworks before clinical application.

The choice of genome editing platform played an essential role in determining the feasibility, precision, and safety of potential IUGE interventions (Table 1*)*. CRISPR technology, despite its ease of use and cost-effectiveness, carried off-target risks, while ZFN offered high precision at the expense of

Table 1 Genome Editing Platforms and the Characteristics

Editing Platform	Mechanism of Action	Advantages	Disadvantages	Example Application
CRISPR *(Clustered Regularly Interspaced Short Palindromic Repeats)*	Uses Cas9 enzyme to cut DNA at specific sites guided by gRNA	Low cost, easy to use, highly precise (with proper gRNA)	Off-target risk, ethical issues	Correction of genes causing blood disorders
ZFN *(Zinc Finger Nucleases)*	Engineered proteins that cut DNA at specific sites	High precision, customizable	Expensive production, complex design	Therapy for rare genetic diseases
Base Editing	Alters a single DNA base without cutting double-stranded DNA	Minimizes DNA damage, high efficiency for point mutations	Limited to certain base conversions, still emerging technology	Correction of single-nucleotide mutations in inherited diseases
Prime Editing	Combines CRISPR and reverse transcriptase to precisely edit DNA	Can perform multiple DNA modifications (insertions, deletions, substitutions)	Still in development, requires optimization	Potential therapy for various genetic disorders

complexity and cost. Emerging approaches such as base editing and prime editing hold promise for minimizing DNA damage and expanding the scope of permissible modifications, though remaining in relatively early stages of development. A comparative understanding of these platforms facilitated informed decision-making in both study and potential clinical translation.

Ethical Issue

The ethical landscape of gene editing, specifically germline modifications, was complex, raising concerns about human dignity, embryo status, and impacts on future generations. Both AJOG and WHO stressed the need for strict regulation and public discourse.[12] In Indonesia, ethical guidelines from POGI emphasized informed consent and prohibited genetic modification of gametes or embryos without substantial medical justification. While not explicitly defined, this term was generally understood by ethics committees as referring to interventions for life-threatening or severely debilitating conditions. Indonesian medical ethics were consistent with principles of beneficence and non-maleficence. Germline editing raised ethical tensions between reproductive autonomy and potential harm to future offspring. Although genome editing could empower parental choice by reducing heritable disease risk, it also invited concerns about societal consequences, identity, and the definition of ethical parenthood. This necessitated cautious, well-regulated application grounded in ethical deliberation. [13]

Ethical and Regulatory Perspectives

The possibility of editing the human genome raised serious ethical concerns about the responsibility to future generations, as well as the potential implications of manipulating our genetic code. Despite the potential benefits, the prospect of heritable genome editing treatments raised concerns and potential hazards.

Common Objections to Human Germline Genome Editing

Disrespect of Human DNA as a Human Heritage

A common ethical objection to germline genome editing was the belief that human DNA, as a shared heritage of humanity, must remain unaltered. However, biologically, the genome was dynamic, with natural mutations occurring each generation and driving evolutionary adaptation.[14] Editing disease-causing variants to match common, non-pathogenic sequences was seen as an act of beneficence rather than a violation of genetic legacy. The ethical debate centered on whether preserving harmful mutations was more valuable than correction to reduce suffering. Therefore, therapeutic genome editing could be viewed as a responsible means of improving health.[15]

Religious Concerns and the Role of Creation[16]

Religious views on germline genome editing differed, often supporting therapy but opposing embryo destruction. Ethical concerns intensified with enhancement, seen as “playing God.” While future techniques could ease conflicts, deep moral beliefs, specifically among religious communities, continued to shape public acceptance and influence global regulatory approaches to gene editing.

Lack of Informed Consent for Future Generations Affected by the Edits[17]

Informed consent was central to ethical study, but complex in fetal genome editing, as the fetus could not consent. Parental consent was required, yet inherited changes

raised intergenerational concerns. Ethical frameworks must address long-term risks, specifically for enhancements or novel edits that could affect future generations without their consent.

Negative Impact on Individuals with Disabilities[18]

The principle of justice was crucial in genome editing, particularly regarding disabilities. Advocacy groups argued that conditions, such as autism or deafness, represented diversity, not defects to be "corrected." Editing such traits risked reinforcing stigma and devaluing certain lives. Even mutations like sickle cell, often seen as harmful, offered adaptive advantages. Therefore, beneficence must be balanced against potential social exclusion. Language also shapes perception, terms including "mutation" or "correction" could marginalize, while neutral phrases such as "conversion to a reference sequence" promoted inclusivity. Public education was essential to reframe genome editing as a tool for health, not for enforcing genetic norms.

Perceptions of Parental Negligence[19]

Genome editing raised ethical tensions between reproductive autonomy and societal pressure. Parents could feel obligated to use these technologies to prevent disease, risking judgment or blame. This blurred the line between choice and duty, raising concerns about equity, coercion, and the erosion of parental freedom.

Ethical Considerations Beyond Disease Prevention[20]

Traditional bioethics separated therapy from enhancement, favoring disease treatment. However, this distinction blurred when preventive measures, such as mastectomy for BRCA1, were accepted, raising questions about editing embryos for similar risks. Ethical evaluation must balance beneficence and non-maleficence, considering societal impacts such as stigma, accessibility, and the medicalization of diversity.

Blurred Lines between Treatment, Prevention, and Enhancement[21]

Genomic advances merged treatment and enhancement, as preventive edits like PCSK9 mimic natural variations yet are viewed therapeutically. However, disease risk was probabilistic, not guaranteed, raising justice concerns, specifically when access was limited to the wealthy. Ethical policies must ensure fairness, transparency, and equitable benefit distribution.

Concerns Over Human Enhancement[22]

While somatic gene therapies were widely accepted, germline enhancements raised ethical concerns involving justice and non-maleficence. Selecting traits, including intelligence, could create unfair advantages, echoing issues such as doping in sports. These enhancements risked disrupting social balance, reinforcing inequality, and conflicting with democratic values of fairness and inclusion.

Commodification of Children and Parental Pressures[15]

Germline genome editing challenged autonomy, particularly that of the future child. Genetically shaping children to meet parental or societal expectations risked their commodifying and undermining unconditional acceptance. As editing became normalized, social pressure coerced parents into using it, creating ethical tensions between autonomy, justice, and genuine reproductive freedom.

Social Inequality and Accessibility[23]

The principle of justice was threatened when only wealthy individuals or nations could access genome editing, risking a biologically privileged class and widening social inequality. Stratified access eroded social cohesion and global equity, potentially leading to discrimination based on genetic enhancement and undermining fairness in healthcare and opportunity.

Unpredictable Risks of Novel Genetic Variants[24]

From a non-maleficence perspective, human germline editing, particularly with untested sequences, posed serious risks, including off-target effects and chromosomal abnormalities. Unlike correcting known variants, experimental edits caused lasting harm. Given their heritability, even minor errors carried a multigenerational impact, demanding strict preclinical testing, long-term monitoring, and robust regulatory oversight.

Long-Term and Multigenerational Consequences

Heritable genome editing affects future generations who could not consent yet must live with its consequences, challenging autonomy and non-maleficence. Unintended harms influenced health, identity, and reproductive choices. Ethical frameworks must address not only immediate effects but also the long-term, intergenerational burdens and responsibilities that such interventions could impose.

Potential for State and Criminal Misuse

The potential misuse of genome editing by state or criminal actors raised serious ethical concerns, echoing historical abuses, such as coercive sterilization and selective reproduction. Such misuse threatened non-maleficence and justice, risking harm and oppression. Proactive global governance was essential to prevent the weaponization and unethical exploitation of genetic technologies.

Ethical Awareness and Acceptability in Indonesia

In Indonesia, public and professional awareness of genome editing ethics remained low. A 2021 survey showed support for therapeutic use but strong hesitation toward enhancement. Attitudes varied by gender, age, religion, and education. This knowledge gap undermined informed consent and autonomy, showing the urgent need for national bioethics education and public discourse.

Scientific Contributions and the Role of AJOG[25]

Although AJOG did not issue formal regulations, it influenced clinical studies through publications, such as CRISPR/Cas9 for cystic fibrosis in fetal models. While advancing beneficence, this showed the risk of scientific progress outpacing ethical and legal frameworks without proper regulatory alignment.

WHO Governance and Ethical Framework

Unlike academic journals, WHO had taken a regulatory leadership role, issuing ethical guidelines on human genome editing in 2021. Emphasizing justice and non-maleficence, the framework promoted oversight, transparency, and global cooperation to prevent exploitation and ensure ethical governance across borders and diverse regulatory environments.

Indonesia's Regulatory Context[13]

Indonesia lacked specific legislation on human germline genome editing. Existing

guidance from the Health Law and POGI's 2017 code permitted modifications only with "substantial medical justification," a term not clearly defined. While BPOM's 2024 regulation on genetically modified foods showed growing biotech oversight, no targeted policy on IUGE left regulatory gaps and ethical uncertainty. This absence of explicit regulation placed significant ethical decision-making in the hands of professional associations, such as POGI, which led to variability and inconsistency in clinical practice.

International Regulatory Comparisons

The United States National Academies of Sciences and Medicine (NAS/NAM) allowed heritable genome editing only under strict conditions, prioritizing autonomy and oversight. Europe's Oviedo Convention prohibited germline edits, emphasizing non-maleficence and justice, while China tightened rules post-He Jiankui, balancing state control and public trust. These differences reflected cultural values, emphasizing the need for global ethical standards.

Autonomy vs. Social Consequences

Genome editing presented a complex dilemma for reproductive autonomy. While parents could seek to prevent disease, societal pressures distorted free choice, undermining consent. The NAS/NAM also questioned privileging genetic relatedness over other family structures, showing the need for justice-driven policies that respected reproductive diversity and individual rights.

Legal Perspectives and Parental Liability

In the U.S., parental use of genome editing was evaluated under "intermediate scrutiny," balancing public interest with autonomy. However, legal uncertainty raised concerns, "could declining editing lead to negligence claims?" Such scenarios risk criminalizing reproductive choices, emphasizing the need for clear ethical and legal boundaries to protect autonomy.

Disability Justice and Slippery Slope Dynamics

Critics of germline editing warn of a "slippery slope" from disease prevention to genetic enhancement, fearing it could reinforce ableism. Editing for traits, such as deafness or autism, risks stigmatizing disability and reducing diversity. The ethical debate balances reproductive autonomy with disability rights' concerns about devaluing certain lives. The heritability and irreversibility of germline editing heighten these ethical risks, necessitating strong safeguards. The WHO advocates for a cautious, equitable approach. The tension lies in balancing parental freedom with respect for disability and protection from social exclusion.

Integrated Ethical Synthesis

For reproductive health, genome editing demands a principled approach that is beneficent, safe, just, and autonomous. Its ethical use requires regulation, equity, and respect for disability rights. Indonesia must build a clear national framework that aligns with global standards and local values, focusing on medical justification, oversight, and public bioethical awareness. Global regulations for IUGE are very different, with varying laws, oversight, and enforcement (Table 2). The WHO recommends a moratorium on clinical germline interventions, while the European Union has a strict ban. China has partial regulations but struggles with enforcement. Indonesia currently lacks specific IUGE laws, relying on general health guidelines, which can lead to inconsistencies. Knowing these regulatory

Table 2 Comparative Regulations on IUGE in Different Countries/Institutions

Country/Institution	Regulatory Status	Scope of Regulation	Special Notes
WHO *(World Health Organization)*	Global recommendation, not legally binding	Precautionary principle, transparency, public consent	Emphasizes temporary moratorium on clinical germline editing
Indonesia	No specific regulation	Health Law, POGI guidelines	Decisions largely depend on professional judgment, risk of inconsistency
European Union (EU)	Very strict	Prohibits research and therapy on human germline editing	Regulations vary among member states, but most prohibit
China	Partial regulation	Governs research, but past violations occurred (CRISPR babies case)	Law enforcement has been under international scrutiny
NAS/NAM *(US National Academies of Sciences and Medicine)*	Scientific recommendations	Allows basic research; therapy only if proven safe and effective	Must undergo public approval and strict risk assessment

differences is vital for creating national and international policy.

Conclusion

In conclusion, while gene editing offers great potential for improving maternal and reproductive health, its ethical complexities must not be overlooked. A balanced, inclusive approach, grounded in continuous dialogue, is essential to align innovation with societal values. Future IUGE policies must adopt a dual-subject framework that equally upholds maternal autonomy and well-being. Due to the ethical complexity, a moratorium is advocated for germline editing in clinical settings until a clear national framework is established. This article contributes by integrating global ethical discourse with a critical analysis of Indonesia's regulatory gaps, showing the urgency of establishing explicit national guidelines. By providing a comparative overview of international regulations and genome editing platforms, it offers a practical reference for policymakers, healthcare professionals, and bioethics committees in shaping context-specific, ethically sound policies. Future studies and regulatory efforts must proceed in tandem with public engagement.

Conflict of Interest

The authors declare no potential conflict of interest.

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