International Journal of Applied Ethics, Vol-11 (2025), 42–49
doi:10.1017/

Research Paper

A Holistic Approach to Gene Editing for Human Enhancement

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Abstract

This article explores the ethical complexities of gene editing for human enhancement, proposing a novel combined ethical framework that integrates the precautionary principle, cost/benefit analysis, and virtue ethics. The purpose of this research is to address the inadequacies of these individual frameworks when applied in isolation and to provide a comprehensive methodology for evaluating gene editing interventions. Methodologically, the paper systematically examines each ethical framework's principles, strengths, and limitations, culminating in the development of an integrated model. The proposed framework is then applied to a theoretical case study to illustrate its practical utility. Findings reveal that while the precautionary approach ensures safety by rejecting interventions posing catastrophic or existential risks, it can overly restrict innovation. Cost/benefit analysis balances risks and benefits but struggles to address intangible ethical dimensions. Virtue ethics emphasizes human flourishing and moral character but lacks the generalizability required for policy applications. The combined framework leverages the strengths of these approaches, providing a balanced, adaptable model that aims to maximise collective well-being within certain safety constraints and in a way that aligns with broader goals of human flourishing. The study's originality lies in its holistic integration of diverse ethical perspectives, offering a robust tool for navigating the moral landscape of enhancement technologies. Limitations include challenges in operationalizing the framework across varied contexts and the need for iterative refinement as scientific knowledge evolves. Implications extend to policymaking, emphasizing equitable access, risk management, and adaptive governance to ensure ethical oversight of gene editing.

Keywords: Gene Editing, Applied Ethics, Bioethics, Human Enhancement, CRISPR.

(Received 03 12 2025; Accepted 06 26 2025)

1. Introduction

Gene editing for human enhancement, like AI, robotics, and quantum computing, is an emerging field that has enormous potential to shape our collective future. As technologies like CRISPR advance, the prospect of editing the human genome to improve physical, cognitive, or even moral traits beyond normal human capacities moves away from science fiction and into reality. Yet, with this great potential come profound ethical dilemmas. How can we ensure that these interventions are safe, equitable, and aligned with the broader goals of human flourishing? What principles should guide our decisions about which enhancements to pursue and which to reject?

This article proposes a combined framework for navigating these challenges, integrating three prevailing ethical approaches: the precautionary approach, cost/benefit analysis, and virtue ethics. While each of these frameworks offers valuable insights, I argue that their limitations become evident when applied in isolation. By uniting their strengths, the combined approach provides a robust and adaptable model for addressing the complexities of gene editing. While it could be objected that these approaches are fundamentally opposed to one another, so that combining them would result in incoherency, I hope to illustrate throughout this paper that a systematic approach which incorporates diverse perspectives has real pragmatic value.

The structure of this article reflects the stages of this argument. I begin by exploring the precautionary approach, which prioritizes risk mitigation and safety. I then turn to cost/benefit analysis, which emphasizes practical trade-offs and the maximization of well-being, followed by a virtue-led approach centred on *phronesis* (practical wisdom) and *eudaimonia* (human flourishing). Finally, I introduce the combined framework, demonstrating its application through a case study of MST gene editing for enhanced muscle strength and endurance, before briefly exploring the implications of the approach for policymaking. This analysis leads me to conclude that the combined approach not only resolves the limitations of its constituent parts but also sets a higher standard for the ethical governance of gene editing.

For the purposes of this paper, I will refer to such interventions as *enhancements*. These can be contrasted with *treatments*—the purpose of which is limited to restoring bodily functions to normal operation (as in the case of curing a debilitating genetic disease, for example).

2. The Precautionary Approach

The precautionary approach offers a vital framework for addressing the risks associated with gene A Holistic Approach to Gene Editing for Human Enhancement by International Journals. In contrast to cost/benefit analysis, which evaluates potential outcomes in terms of trade-offs, the precautionary approach prioritizes risk mitigation, particularly in the face of uncertainty and high stakes.

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✪**Cite this article:** Day S.R., A Holistic Approach to Gene Editing for Human Enhancement by International Journals, *International Journal of Applied Ethics* **11(2025)**, 42–49. https://doi.org//.

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By emphasizing safety and responsibility, this approach seeks to prevent harm before it occurs, especially when the consequences of failure could be catastrophic or irreversible.

The version of the precautionary principle that I will discuss here is specifically tailored to the context of gene A Holistic Approach to Gene Editing for Human Enhancement by International Journals and states that: This fommlation emphasizes the moral imperative to err on the side of caution when dealing with interventions that could endanger human survival or well-being on a global scale. Unlike cost/benefit analysis, which balances risks against potential benefits, this approach establishes a threshold of risk catastrophic or existential harm-that must not be crossed, regardless of the perceived benefits.

3. A Precautionary Approach to Gene Editing for Unman Enhancement

The precautionary approach is particularly relevant to gene A Holistic Approach to Gene Editing for Human Enhancement by International Journals due to the high levels of uncertainty surrounding its long-term effects, both individual and collective. Four primary areas of concern highlight the need for rigorous precautionary measures:

3.1. Unintended Genetic Effects

Gene editing involves complex interactions between genes and their environments. This is particularly true of pleiotropic genes, which affect multiple (sometimes seemingly unrelated) traits, and therefore increase the likelihood of unintended and unpredictable outcomes. Also of note here are germline interventions—those that affect gametes (e.g., eggs and sperm). Since such interventions produce heritable changes, any negative effects caused by them may also propagate across generations, amplifying the potential for unforeseen harm (Baylis et al. 2020).

3.2. Exacerbation of Social Inequities

The widespread adoption of enhancement technologies could exacerbate existing social inequalities, creating new divides between those who can afford enhancements and those who cannot. While we have not yet seen genetic enhancements enter the market, treatment options have been known to range from just under $400,000 (USD) all the way up to $3.5 million (Witkowsky et al. 2023). Additionally, normalizing certain enhancements risks altering societal values, putting undue pressure on individuals to conform to standards only achievable by undergoing genetic enhancement. This could foreseeably contribute to large numbers of people being significantly disadvantaged in competitive social contexts such as work, sport, and even dating.

3.3. Issues of Informed Consent

Some interventions will only be effective either before or during certain early stages of human development. For example, cosmetic therapies aimed at increasing height would only be possible if administered before the long growth plates fuse (Shim 2015). In such cases, it may be difficult or even impossible to prove that the affected individual is competent, sufficiently informed, and acting voluntarily, free from coercion. Subjecting minors to such interventions (and perhaps also embryos, provided they will eventually be brought to term) therefore constitutes a serious breach of autonomy and violation of self-determination.

3.4. Susceptibility to Intentional Misuse

While rare, the possibility of biological risks—such as the destabilization of ecosystems or the engineering of new targeted diseases—should not be understated. The very same knowledge, technologies, and techniques that facilitate effective genetic treatments and enhancements could also be used by malicious actors in acts of violence, terrorism, or even ethnic cleansing (Dando 2004). The irreversible nature of some gene-editing technologies magnifies these risks, making precautionary measures and safeguards essential.

The Strengths and Limitations of the Precautionary Approach

The precautionary approach provides a clear framework for addressing uncertainty in the context of high-stakes technologies. By focusing on risk avoidance, it prioritizes safety and aligns with the moral responsibility to prevent harm. It is particularly valuable for governing germline interventions, where the potential for irreversible and far-reaching consequences demands heightened caution.

However, this approach is not without limitations. Its inherent conservatism can inhibit progress by discouraging innovation, even when the risks are manageable and the potential benefits significant. Additionally, critics argue that the precautionary principle can be overly restrictive, as it does not account for situations where failing to act might also lead to harm (Rechnitzer 2020). For instance, excessive caution could delay the development of gene-editing therapies for debilitating conditions, prolonging suffering for affected individuals. Finally, by focusing solely on risk aversion, it fails to take full account of the potential benefits of human genetic enhancement that (in some instances) are the source of legitimate, noble motivations for engaging in it.

The Cost/Benefit Approach

With such limitations of the precautionary approach in mind, I now turn to a cost/benefit approach to gene editing for human enhancement. The crucial difference here is that while the precautionary approach imposes a hard limit on acceptable risks, particularly when those risks involve catastrophic or existential harm, the cost/benefit approach instead seeks to balance risks and benefits to arrive at an optimal outcome. Cost/benefit analysis is rooted in consequentialist ethics, which evaluates actions based on their outcomes. While traditional utilitarianism prioritizes happiness or pleasure, I will here emphasize a welfarist approach, which adopts a broader perspective by emphasizing well-being. Well-being encompasses not only individual happiness but also factors like physical health, social connections, and purpose, offering a more holistic basis for moral evaluation (Crisp 2021). This is because well-being accommodates the consideration of a wider and more nuanced range of costs and benefits that better captures the range of potential effects that diverse gene editing procedures may produce.

To address common criticisms of consequentialist approaches—such as their demandingness and permissiveness regarding morally contentious actions—I adopt a satisficing perspective (Slate and Pettit 1984). This approach maintains that an action is morally permissible if it results in more benefits than costs, rather than requiring the maximization of net benefit. This framing allows for the establishment of moral permissibility or impermissibility without obligating people to undergo gene editing interventions that they themselves do not desire in the name of the common good.

A Cost/Benefit Approach to Gene Editing for Human Enhancement

The cost/benefit approach evaluates gene editing by weighing its potential advantages against its risks and societal implications. Because the costs and benefits of any given intervention are context-dependent, I will only be able to generalize here. This will be done by dividing the subject matter up into four distinct categories of enhancement, namely: health, cosmetic, cognitive, and character.

Health enhancements provide the strongest case for permissibility under this approach. Interventions that increase disease resistance or improve physical robustness directly promote individual well-being, and have the potential to benefit society by reducing healthcare burdens and improving public health outcomes. For example, widespread immunity to diseases could alleviate strain on medical systems, freeing resources for other critical areas. However, the realization of these benefits depends on careful management of potential risks, such as unforeseen side effects or inequities in access. Historical examples, such as uneven vaccination distribution highlight how societal benefits do not automatically lead to equitable outcomes and highlight the need for rigorous testing and careful implementation. Cosmetic enhancements are more contentious, as their benefits are often tied to subjective perceptions of beauty shaped by cultural norms. While such interventions may improve self-esteem or social mobility for individuals, they risk perpetuating exclusionary standards and reinforcing problematic societal values. For instance, enhancements designed to align with ideals like facial symmetry may confer certain advantages but also reinforce narrow, exclusionary beauty norms. Additionally, cosmetic enhancements raise significant ethical challenges related to informed consent, particularly when interventions occur during early development stages, as seen in analogous historical cases like nonconsensual surgeries on intersex children (Brussels Collaboration 2024). In general, the individuals exposed to such involuntary cosmetic procedures report a feeling of being harmed by them, despite the good intentions of medical professionals and parents who thought they were acting in the child's best interest. Given these complexities, the cost/benefit approach suggests that cosmetic enhancements require stricter scrutiny and are generally less compelling than health-related interventions.

Enhancements targeting cognitive and character traits offer transformative potential but require careful management to ensure their benefits outweigh the risks. Cognitive enhancements, such as those improving intelligence or memory, could increase productivity and innovation, benefiting both individuals and society. However, these advantages risk exacerbating existing social inequalities, as access to such interventions may be limited by economic barriers. Similarly, character enhancements, aimed at fostering universally positive traits like empathy or resilience, could enrich individual lives and contribute to societal harmony. Yet these interventions also raise profound concerns about autonomy and authenticity, as altering personality traits may blur the line between what we might call 'genuine character growth' and external imposition. For both categories, the cost/benefit approach highlights the importance of equitable access and policies to mitigate negative externalities, ensuring these enhancements contribute to collective well-being without undermining individual rights.

The Strengths and Limitations of the Cost/Benefit Approach

The *cost/benefit* approach offers a practical and structured framework for evaluating gene editing proposals by weighing their potential advantages against associated risks. This makes it particularly valuable for identifying enhancements that maximize well-being while minimizing harm. Its evidence-based nature ensures that decisions are informed by measurable outcomes, such as health improvements or economic benefits, promoting transparency and rational decision-making. Furthermore, the approach allows for calculated risks in innovation, enabling advancements in science and technology when the potential benefits outweigh manageable harms. This flexibility ensures the framework can be applied across diverse contexts, from therapeutic interventions to elective enhancements.

However, the *cost/benefit* approach is not without its limitations. One major concern is its difficulty in addressing intangible ethical and social dimensions, such as human dignity, authenticity, or societal values. By focusing on quantifiable outcomes, it risks oversimplifying complex ethical issues, potentially overlooking the deeper moral implications of enhancement technologies. Additionally, assigning value to costs and benefits can introduce bias, privileging certain perspectives—such as economic efficiency—over equity or justice. The approach also struggles to account for long-term uncertainties, such as unforeseen ecological or generational effects, making it less effective in scenarios where risks are difficult to predict.

In summary, the cost/benefit approach provides a valuable tool for evaluating gene editing for human enhancement, particularly in contexts where outcomes are measurable and risks are well understood. However, its limitations in addressing intangible values, long-term uncertainties, and equity concerns underscore the need to complement it with other ethical frameworks, such as the precautionary and virtue-led approaches. In the following section, I will discuss the latter.

4. A Virtue-Led Approach to Gene E-diting for Human Enhancement

Like the cost/benefit approach, the recommendations of the virtue-led approach will be largely context-dependent, since the application of *phronesis* requires that we take such context into account. However, there are some general comments that can be made, drawing once again on the four categories of enhancement discussed earlier.

Health enhancements, while intuitively desirable, are approached with nuance in virtue ethics. Unlike a cost/benefit perspective, virtue theory does not consider a life with less suffering automatically better, as suffering can cultivate virtues like courage and patience. Instead, health enhancements are evaluated based on whether they align with virtues like compassion and justice. A

compassionate person would seek to prevent unnecessary illness to alleviate suffering, while a just person would recognize the unfairness of preventable illness. Contextual factors, however, are crucial; what a virtuous doctor would do in a specific situation often depends on the particular circumstances.

Cosmetic enhancements are generally viewed with scepticism through the lens of virtue ethics. Vanity is considered a vice, and cosmetic interventions motivated by it are seen as misguided. While some argue that cosmetic enhancements might overcome societal pressures or barriers, virtue ethics would critique the societal systems perpetuating these pressures rather than endorsing the enhancements themselves. The virtue-led approach advocates policies that challenge harmful beauty standards and provide counternarratives to individuals considering such interventions, emphasizing self-acceptance and authenticity.

Cognitive enhancements are more complex. From a virtue ethics perspective, enhanced cognition could improve practical wisdom and moral decision-making, contributing to *eudaimonia*. However, enhancing rationality alone is insufficient without a virtuous character to guide it. There are also trade-offs to consider, such as potential unintended consequences tied to genetic disorders like autism, where cognitive strengths are inextricably linked with social or emotional challenges (Attwood and Garnett 2023). The virtue-led approach cautions against pursuing cognitive enhancements until the relevant genetic and contextual factors are fully understood.

Character enhancements are conceptually significant from a virtue ethics perspective because they intersect with the cultivation of moral virtues by influencing genetic predispositions. However, predispositions alone are not sufficient for true virtue, as *phronesis* and lived experience are also essential elements of cultivating virtue. Ethical concerns regarding autonomy and personal identity are notable, but these can be mitigated to some extent if enhancements remain optional and aligned with individual goals. Despite their theoretical promise, pursuing character enhancements now would be reckless, as current gene-editing technology lacks the reliability and understanding needed to ensure safety and efficacy, and recklessness is a vice, not a virtue. The virtue-led approach supports cautious, context-sensitive research into character enhancements, but only if they genuinely promote human flourishing while respecting autonomy and individuality.

5. The Strengths and Limitations of the Virtue-Led Approach

The virtue-led approach offers significant strengths, particularly in its ability to centre moral deliberation on human flourishing and the cultivation of character. By encouraging the fostering of virtues through a process of applied practical wisdom, it provides a nuanced framework for navigating the ethical complexities of gene editing, emphasizing the importance of intentions, context, and the long-term well-being of individuals.

However, while the virtue-led approach offers profound insights, its practical application, particularly in policy and large-scale contexts, presents significant challenges. For example, decisions about gene editing often involve balancing the interests, attitudes, and desires of large and diverse populations. The inherently context-dependent nature of *phronesis* makes it difficult to generalize about what constitutes virtuous action across such varied circumstances. Furthermore, the focus on cultivating character can be challenging to translate into concrete policies. Regulatory frameworks require actionable guidelines, whereas virtue ethics provides a more fluid and individualized moral framework that resists codification.

It is for these reasons that virtue ethics alone cannot adequately address the scale and complexity of decisions required in the governance of gene editing. Despite its limitations, however, the virtue-led approach can play a critical role in shaping a holistic ethical framework for gene editing. When combined with the precautionary principle and cost/benefit analysis, it complements their focus on risk management and outcomes with a deeper concern for character and flourishing.In the following section, I develop this combined approach, demonstrating how it integrates the strengths of each framework to provide a comprehensive model for ethical decision-making in gene editing

6. A Combined Ethical Framework for Gene Editing

Having reviewed the precautionary, cost/benefit, and virtue-led approaches to the ethics of gene editing, I propose a combined framework that integrates the strengths of each while addressing their respective limitations. This integrated approach offers a comprehensive and adaptable ethical model, designed to guide decisions about gene A Holistic Approach to Gene Editing for Human Enhancement by International Journals in a way that prioritizes safety, maximizes well-being, and remains deeply rooted in the pursuit of human flourishing.

The combined approach unfolds in three interconnected stages, each corresponding to one of the previous frameworks. These stages are designed to work sequentially yet iteratively, allowing for continuous refinement as new information or contexts emerge.

Below, I outline the structure of the framework alongside a detailed guide to its practical application.

6.1. Stage One: Precautionary Assessment

The first stage of the combined ethical framework involves applying the precautionary approach to evaluate the risks associated with a proposed enhancement. This demands that any instance of gene A Holistic Approach to Gene Editing for Human Enhancement by International Journals presenting a risk of catastrophic or existential harm to humanity must be rejected outright. In this way, stage one acts as a safeguard, ensuring that advancements proceed only when their risks are well understood and responsibly managed.

Key steps include:

- Conducting a scientific review to identify potential risks, such as off-target effects, unintended genetic consequences, or broader societal impacts.
- Assessing whether the proposed enhancement poses catastrophic or existential threats, particularly in cases involving germline editing.
- Establishing robust regulatory mechanisms to ensure compliance with safety standards and ethical guidelines where possible.
- Rejecting proposals that ultimately fail to meet minimum safety thresholds or present unacceptable risks.

6.2. Stage Two: Cost/Benefit Analysis

Once safety from catastrophic or existential risk is assured, the framework shifts to a cost/benefit analysis to evaluate the enhancement's broader implications. This stage introduces a practical, data-driven perspective, focusing on determining whether the enhancement will produce a greater amount of well-being than harm. In this way, stage two ensures that resources are allocated effectively and enhancements are pursued for the right reasons.

Key considerations include:

- Quantifying the enhancement's potential benefits for individuals and society, such as improved health outcomes or increased productivity.
- Evaluating the likelihood and magnitude of associated costs, including economic, social, and psychological impacts.
- Identifying externalities, such as the risk of exacerbating social inequalities or creating competitive pressures.
- Endorsing and prioritizing enhancements that achieve a favourable balance of benefits over costs, particularly those addressing urgent health needs or promoting collective welfare.

Once an enhancement has met criteria imposed by stages one and two, it is deemed morally permissible. This means it meets the minimum threshold for public availability. However, given limited access to resources - such as funding, expertise, time, research materials and specialist equipment- I argue that it is worthwhile to engage in an additional stage of reasoning aimed at determining priority for development and implementation based on moral reasoning, rather than (for example) private monetary profit.

6.3. Stage Three: Virtue-Led Deliberation

The final stage integrates a virtue-led perspective, ensuring that decisions align with the aim of *eudaimonia*. This encourages us to consider whether the enhancement in question would be approved of by a rational and virtuous individual, in an effort to determine (via *phronesis*) whether it ought to be recommended given any particular contextual factors present. In this way, it goes one step further than establishing mere permissibility, serving instead as a soft guide to action.

Key actions include:

- Reflecting on the intentions and character of all those involved, guided by virtues such as prudence, justice, humility, and beneficence.
- Facilitating stakeholder engagement to incorporate diverse perspectives and values into the deliberation process.
- Evaluating whether the proposed enhancement contributes to authentic personal and societal flourishing, rather than undermining identity or moral development.
- Considering the long-term implications of the enhancement for both individuals and society, ensuring alignment with human flourishing.

Finally, I want to recognise the need for adaptability in a rapidly evolving scientific landscape. Therefore, as part of the combined approach, proposed enhancements should be regularly revisited and reevaluated from the beginning as new data, methods, or technologies emerge. This iterative approach ensures that policies remain responsive and reflective of ongoing developments.

7. The Superiority of the Combined Approach

The combined framework offers several advantages over its individual components, uniting their strengths while addressing their weaknesses. These include:

1. **Balancing Safety and Progress:** The framework ensures safety and accountability from the outset (at the precautionary stage), while also encouraging innovation and progress by considering the positive potential of human enhancement (at the cost/benefit and virtue-led stages).
2. **Comprehensiveness:** It considers risk, practical trade-offs, and moral character, providing a holistic understanding of the ethical landscape and ensuring that no critical dimension is overlooked. This helps ensure acceptability across diverse ethical perspectives.
3. **Clarity and Adaptability:** It provides an ordered, step-by-step process for evaluating enhancements, ensuring consistency while avoiding undue generalisation. Its iterative design allows for adjustments based on emerging data and shifting contexts, ensuring relevance over time.

8. Applying the Combined Approach: The Case ofMSTN Gene Editing for Enhanced Muscle Strength and Endurance

To round out the case for the combined approach, I will now demonstrate how it might function in practice through the use ofan imagined case study. This will illustrate its application and further solidify its relevance in guiding ethical decisions about gene editing for human enhancement.

This will be done by applying it to a procedure that is (in theory) possible, but which has not yet been implemented in any medical or research context to my knowledge: editing the MST gene to enhance muscle strength and endurance. The MST gene codes for myostatin, a protein that inhibits muscle growth. Reducing or disabling its function has shown dramatic results in animal models, leading to increased muscle mass and physical performance, and could be achieved in humans using CRISPR technology along with a delivery method such as a viral vector (Pfizer 2023) or lipid nanoparticles (Pozzi and Caracciolo 2023). However, the application of this therapy to humans raises significant ethical, practical, and societal concerns. A careful consideration through the lens of the combined approach ultimately leads to the conclusion that MSTN gene therapy should not be pursued, and I detail below how this verdict is reached.

8.1. Stage One: Precautionary Assessment

The precautionary principle focuses on identifying and mitigating risks that could result in catastrophic or existential harm, ensuring that only enhancements meeting stringent safety thresholds can proceed. In the case of MST gene editing for enhanced muscle strength and endurance, the therapy only targets somatic cells, meaning the edits are not heritable and therefore does not pose generational risks. In addition, the therapy would not need to be undergone during early development provided muscle tissues are actively being regulated, meaning that informed consent could (and should) be gained beforehand. However, there are two additional areas of risk that can be considered.

Unintended Genetic Effects: Myostatin regulates not only muscle growth but also metabolism and connective tissue health.

Disabling it may cause side effects such as joint stress, tendon damage, and metabolic imbalances, though these do not rise to catastrophic harm.

Exacerbation of Social Inequities: Normalizing MST editing for enhancements could exacerbate social inequalities or reinforce hannful norms around physical performance. However, these risks, while significant, do not reach the threshold of catastrophic societal destabilization required for rejection at this stage.

8.2. Stage One Verdict

The precautionary approach establishes that interventions presenting catastrophic or existential risks must not proceed. Because the proposed MS therapy affects only somatic cells and the associated genetic risks are confined to the individuals undergoing the procedure, and because the social risks are not of sufficient magnitude, it does not cross this threshold. As a result, the proposed MSTN gene therapy is permitted to advance to further stages of evaluation. This verdict highlights the first stage's role as a foundational safeguard, ensuring that only enhancements posing manageable risks are considered for further ethical analysis. However, the permissibility established at this stage is not yet sufficient for approval under the combined approach, which subjects the therapy to additional scrutiny in subsequent stages.

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8.3. Stage Two: Cost/Benefit Analysis

The second stage of the combined framework evaluates the proposed enhancement in terms of its potential benefits and costs, both for individuals and society. Unlike the precautionary approach, which sets a firm threshold for unacceptable risks, cost/benefit analysis examines whether the benefits of the enhancement outweigh its associated risks and costs to well-being.

Individual Benefits and Costs

MST editing offers significant benefits for individuals with specific medical conditions, such as muscular dystrophy or age-related muscle loss. By increasing muscle strength and endurance, the therapy could improve quality of life, physical independence, and overall well-being for affected individuals. However, for healthy individuals seeking enhancement, the potential benefits are far less compelling. While increased strength and endurance may provide short-term advantages, the associated costs include:

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- **Health Risks:** Editing the *MSTN* gene carries risks of unintended side effects, including joint strain, tendon damage, and metabolic imbalances. These risks could impair long-term health, negating the initial benefits of the therapy.
- **Opportunity Costs:** Resources invested in developing and implementing MST editing for enhancement could be better allocated to therapies targeting critical health needs, such as disease prevention or treatment.

Collective Benefits and Costs

At a societal level, MST editing could reduce healthcare costs associated with muscle-related disabilities and enhance physical productivity in certain industries. However, the broader societal costs of normalizing *MSTN* editing outweigh these potential benefits:

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- **Inequities:** Access to enhancement technologies is likely to be unequal, exacerbating social divides and creating competitive pressures for physical performance.
- **Cultural Harms:** The widespread adoption of MST editing risks reinforcing harmful societal values that prioritize physical capabilities, potentially marginalizing those who are unenhanced or unable to afford the therapy.

Stage Two Verdict

While *MSTN* gene editing clears the precautionary stage by avoiding catastrophic or existential risks, it does not satisfy the requirements of cost/benefit analysis. For an enhancement to pass this stage, its welfare benefits must outweigh its associated welfare costs, particularly when societal and ethical implications are considered.

MSTN editing fails to meet this threshold for two key reasons:

1. The benefits for healthy individuals are marginal compared to the substantial health risks and societal harms.
2. The societal costs, particularly in terms of inequity and cultural impact, outweigh the limited collective benefits.

Under the combined framework, this failure to meet cost/benefit standards prohibits the proposed therapy from advancing further, deeming it (at present) morally impermissible. This stage illustrates the additional scrutiny provided by the combined approach, ensuring that permissible interventions under the precautionary principle are further evaluated for their practical and ethical viability.

8.4. Stage Three: Virtue-Led Deliberation

The final stage of the combined framework applies a virtue-led perspective to evaluate whether the proposed enhancement aligns with eudaimonia. This stage focuses on the moral intentions and values underlying the enhancement, ensuring that it contributes to authentic flourishing rather than undermining human dignity or societal well-being. Importantly, while this stage provides critical ethical reflection, the overall judgment of the combined approach does not rely on its outcome in the case of MSTN therapy. Because the therapy fails to meet the requirements of cost/benefit analysis at Stage Two, it cannot advance regardless of the deliberation here. evertheless, this stage highlights the depth of ethical inquiry that the combined approach offers.

Key Considerations

While the therapy offers physical benefits, its motivations—rooted in competitive advantage or superficial improvement—conflict with virtues like *beneficence* and *justice*. It risks reinforcing harmful societal norms that prioritize physical traits over deeper aspects of human value, expressing the vice of *vanity*, and potentially

exacerbating inequalities and undermining long-term flourishing. This suggests a misalignment with *eudaimonia*.

Furthermore, the therapy's long-term implications for identity and social cohesion are problematic, as it could devalue unenhanced individuals and increase societal stratification, potentially conflicting with virtues like *justice* and *prudence*. Moreover, the uncertainty surrounding the therapy's broader effects implies that to go ahead with it now would be to indulge the vice of *recklessness*.

Stage Three Verdict

Ultimately, the *MSTN* gene therapy does not align with the virtue-led approach's emphasis on fostering authentic well-being and justice. A rational and virtuous individual, exercising *phronesis*, would likely reject this enhancement as inconsistent with the goals of human flourishing.

However, because the therapy has already failed the cost/benefit analysis at Stage Two, this verdict does not alter the overall outcome of the combined approach. Instead, this stage underscores the comprehensive nature of the framework, which goes beyond practical and risk-based evaluations to reflect on the deeper ethical implications of enhancement technologies.

Final Verdict: MSTN Gene Therapy

Applying the combined framework to *MSTN* gene editing reveals that while according to the precautionary approach it does not pose existential or catastrophic risk, cost/benefit analysis reveals that the costs significantly outweigh the potential benefits. Finally, the virtue-led deliberation underscores that MST editing fails to align with the deeper goals of human flourishing.

Therefore, while *MSTN* gene therapy may hold promise for specific medical applications in the future, such as combating muscular dystrophy (and should therefore be subject to iterative refinement), the combined approach leads me to conclude that its use as an enhancement should not be pursued under current circumstances. It is therefore deemed morally impermissible and should not be made publicly available.

This case study serves to exemplify the strength of the combined framework in navigating complex ethical decisions and balancing practical concerns with deeper moral considerations.

Policy Implications of the Combined Approach

Employing the combined framework in practice requires institutional and regulatory changes to ensure its principles are embedded in decision-making processes. Below, I outline some key policy implications:

1. Risk Management and Regulation

To ensure the responsible development and application of gene editing technologies, clear and enforceable safety standards must be established. This includes rigorous preclinical and clinical testing to assess long-term risks and unintended consequences. Transparency and public accountability are also crucial in fostering trust and addressing fears of misuse. Additionally, developing international guidelines will help prevent unregulated experimentation and ensure that ethical concerns are addressed on a global scale.

2. Equitable Access

For gene editing to contribute to human flourishing, equitable access must be prioritized, particularly in therapeutic contexts. Measures should be implemented to ensure that these technologies are available to all individuals, regardless of socioeconomic status. Public funding mechanisms or subsidies for health-related enhancements can help reduce disparities, ensuring that gene editing does not become a privilege reserved for the wealthy but a tool for broad societal benefit.

3. Public Engagement and Deliberation

Effective policymaking in gene editing requires inclusive, multi-stakeholder deliberations that incorporate diverse perspectives. Engaging ethicists, scientists, policymakers, and the broader public in discussions will help create ethically sound and socially acceptable policies. Additionally, promoting ethical literacy among decision-makers and the public is essential to fostering informed debate, reducing misinformation, and building consensus around gene editing regulations.

4. Ethical Oversight and Adaptive Governance

Robust oversight mechanisms are necessary to ensure that gene editing decisions align with ethical principles and societal needs. Independent ethical review boards should be established to assess proposals using the combined framework, ensuring that considerations of risk, benefit, and virtue are balanced. Furthermore, governance models must remain adaptive, allowing policies to evolve in response to advancements in scientific knowledge and shifts in societal attitudes. This flexibility will help maintain ethical integrity while accommodating future developments in gene editing.

Conclusion: The Case for a Combined Ethical Framework in Gene Editing

In this article, I have argued for a combined ethical framework for the moral evaluation of gene editing for human enhancement, which integrates the precautionary approach, cost/benefit analysis, and virtue ethics. This unified model overcomes the severe limitations of each individual framework in this context, while leveraging their respective strengths to provide a comprehensive, adaptable, and morally robust method for navigating the complex ethical landscape of enhancement technologies. The combined approach is an iterative methodology that is well equipped to deal with both the practical and societal complexities of gene editing, as demonstrated in the case study of *MSTN* gene editing, where the framework advises against pursuing the therapy given current context. Moreover, its adaptability allows for ongoing refinement, ensuring that ethical oversight remains responsive to the challenges of a rapidly evolving technological landscape.

As gene editing technologies continue to advance, their potential to reshape human lives and societies will only grow. The combined framework offers a foundation for ensuring that this

power is harnessed responsibly, promoting not only innovation but also safety, individual welfare, and collective flourishing.

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