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Public Perception of Human Genetic Engineering in Nigeria: An Analysis of Youth Approval for Therapeutic and Non-Therapeutic Uses: Evidence from Multivariate Analytics

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ABSTRACT

While genetic engineering (GE) presents transformative potential for medicine, global public perception varies significantly, influenced by cultural, ethical, and educational factors. Extensive research exists in Western contexts, but there is a critical paucity of empirical data on attitudes within African populations, particularly regarding the distinction between therapeutic and non-therapeutic applications. This study investigates the determinants of GE approval among Nigerian youth using a multivariate analytical framework. Data from a sample of Nigerian youths (N=1,517) were analyzed through binary logistic regression to model the likelihood of approval. The model assessed the influence of formal education, domain-specific perceptions (risk reduction, disease prevention, human enhancement), and overarching ethical considerations. The analysis revealed a strong gradient of approval, with highest support for therapeutic applications (e.g., treating fatal diseases: 92.52%) and significantly lower support for enhancement-based uses (e.g., intelligence improvement: 71.31%). Tertiary education was a powerful positive predictor of approval (OR = 3.897, $p = 0.003$). In the full multivariate model, perceptions of risk reduction for fatal diseases (OR = 3.745, $p < 0.001$) and approval for preventing non-fatal diseases (OR = 3.836, $p < 0.001$) were the strongest attitudinal drivers. Conversely, fundamental ethical concerns significantly diminished the likelihood of approval (OR = -1.342, $p = 0.037$). The full model demonstrated a significantly improved fit over a baseline education-only model (Pseudo $R^2 = 0.3720$). Nigerian youth are generally supportive of therapeutic GE but cautious about enhancement applications. Acceptance is driven by a combination of educational attainment, perceived medical utility, and the resolution of core ethical objections. These findings underscore the need for nuanced, context-specific public engagement and science communication strategies in Nigeria that address ethical concerns while highlighting therapeutic benefits to foster informed societal consensus.

Keyword: Human Genetic Engineering; Public Perception; Youth Approval; Therapeutic and Non-Therapeutic Uses; Nigeria.

INTRODUCTION

Human genetic engineering stands as a defining technological innovation of the 21st century, presenting a paradigm shift with profound implications for medicine, from curing monogenic disorders to potential human enhancement. However, its trajectory is not solely determined by scientific feasibility but is critically shaped by public perception, which remains deeply ambivalent. Attitudes are forged at the intersection of ethical deliberation, risk perception, religious conviction, and trust in scientific governance. While these dynamics have been extensively mapped in Western societies, a significant empirical lacuna persists regarding public attitudes within African contexts, particularly Nigeria.

Globally, perceptions of genetic engineering demonstrate considerable sociocultural variation. In the United States, support is often strong for therapeutic applications but fractures concerning agricultural or enhancement uses (Scheufele et al., 2017). Conversely, within the European Union, public acceptance is markedly lower, characterized by salient concerns over ethical boundaries, corporate influence, and ecological uncertainty (Bauer & Gaskell, 2002). A meta-analysis by McPhetres and Zuckerman (2018) confirms that scientific literacy and institutional trust are consistent predictors of support in high-income nations, though these factors are frequently moderated by moral and religious objections, particularly when technologies are perceived to violate natural or divine orders. While the existing literature has extensively mapped public attitudes toward genetic engineering in Western and high-income contexts, a comprehensive understanding of Nigerian perspectives requires explicit engagement with the country's unique cultural, religious, and institutional landscape. Nigeria is a deeply religious society, with approximately equal populations of Muslims and Christians, both of which have produced influential bioethical traditions that emphasise the sanctity of life, divine sovereignty over creation, and the moral boundaries of human intervention in natural processes. In Islamic bioethics, for instance, the concept of *Tawhid* (the unity of God) underpins principles that limit human authority to modify the divine creation, while Christian frameworks often invoke the notion of humans as "co-creators" with God, yet with clear boundaries against "playing God" (Sachedina, 2009; Kimmelman, 2020). These religious perspectives are likely to shape public attitudes in ways that differ markedly from the predominantly secular discourse in Western societies, potentially explaining why enhancement applications which may be perceived as exceeding the boundaries of permissible medical intervention are met with greater caution than therapeutic uses.

Furthermore, Nigeria's historical experience with medical interventions must be considered. The infamous boycott of the polio vaccination campaign in northern Nigeria in 2003-2004, fuelled by rumours of contamination and Western conspiracies, illustrates the complex interplay of trust, community engagement, and institutional legitimacy in the Nigerian health context (Jegede, 2007). This legacy suggests that even demonstrably beneficial biomedical technologies like genetic engineering may face significant resistance if not accompanied by transparent, culturally sensitive, and community-driven public engagement strategies. Institutional and governance factors also warrant attention. Nigeria operates a federal system with significant autonomy for its 36 states, resulting in substantial variation in policy implementation, healthcare infrastructure, and capacity for biotechnology governance across regions (Munyi, De Schutter, & Wambugu, 2016). The National Biosafety Management Agency (NBMA) provides a national regulatory framework for modern biotechnology, but its reach and enforcement capacity are limited, particularly in rural areas where traditional healers and indigenous knowledge systems remain influential. Additionally, Nigeria's science and technology policy framework, while established, faces challenges of inadequate funding, limited research infrastructure, and weak integration between research institutions and policy-making bodies (Oyelaran-Oyeyinka & Adebowale, 2014). These institutional dynamics mean that public attitudes toward genetic engineering are not merely a reflection of individual beliefs but are also shaped by citizens' perceptions of state capacity, trust in regulatory institutions, and confidence in the government's ability to manage the risks of emerging technologies. Together, these cultural, religious, and institutional factors create a distinctive context for public engagement with genetic engineering in Nigeria, one that cannot be adequately understood through the lens of Western-derived models alone. This study addresses this gap by providing the first multivariate analysis of youth attitudes toward genetic engineering in the Nigerian context, with particular attention to the distinction between therapeutic and enhancement applications and the role of ethical orientations in shaping approval. By grounding the analysis in Nigeria's specific socio-cultural and institutional realities, this research aims to generate evidence-based insights that are directly relevant to policymakers, science communicators, and biotechnology stakeholders operating within the Nigerian and broader African contexts.

Moving beyond mere descriptive accounts of public sentiment, this study employs a multivariate analytical framework to investigate the determinants of genetic engineering approval among a critical demographic: Nigerian youth. The research objectives are hierarchically structured to progress from foundational measurement to comprehensive explanatory modeling. The primary objective of this study was to examine the factors influencing Nigerian youths' approval of human genetic engineering. Specifically, the study sought to develop and test a multivariate model that explains how formal education, perceptions of risks and benefits, and ethical beliefs shape attitudes towards therapeutic, preventive, and non-therapeutic applications of genetic engineering.

The study also aimed to assess the level of approval for different applications of genetic engineering, examine the relationship between educational attainment and public acceptance, and determine the extent to which perceptions of risk reduction, disease prevention, human enhancement, and ethical acceptability influence approval. In addition, the study identified the most important predictors of support for genetic engineering while controlling for other factors and used the findings to distinguish between youths who are more likely to approve of the technology and those who remain skeptical. The overall goal was to generate evidence that can inform policy development, public engagement, and science communication on the responsible use of human genetic engineering in Nigeria.

METHODOLOGY SECTION: SAMPLING STRATEGY AND PARTICIPANTS

Model Specification and Theoretical Justification

The selection of an appropriate statistical model and its constituent variables is predicated on the nature of the data and the underlying theoretical framework guiding the inquiry.

Justification for the Logistic Regression Model

Given the dichotomous nature of the dependent variables (coded as 1 = Approve and 0 = Otherwise), the use of ordinary least squares (OLS) regression is inappropriate, as it violates assumptions of linearity, homoscedasticity, and normality of residuals, and can yield predicted probabilities outside the logical [0,1] range (Hosmer & Lemeshow, 2000). The binary logistic regression model is therefore specified. This approach models the log-odds of the probability of approval (p) as a linear combination of the predictor variables. The logit link function, $\log(p/(1-p))$, successfully handles the binary outcome by transforming the probability into a continuous measure ranging from $-\infty$ to $+\infty$. The model's coefficients (β) can be exponentiated to generate Odds Ratios, which provide an intuitive interpretation of the change in the odds of approval associated with a one-unit change in a given predictor. Furthermore, the model permits rigorous assessment of overall fit (e.g., via the Likelihood Ratio Test) and the significance of individual parameters.

2.2 Measurement of Ethical Stance (moreeth_f)

The operationalization of the overarching ethical stance variable (moreeth_f) requires explicit methodological clarification to ensure the validity of our analytical framework. This variable was measured using a single, independent survey question administered to all participants: "Do you believe that genetic engineering is ethically acceptable in principle?" Responses were recorded on a 5-point Likert scale ranging from "Strongly Approve" to "Strongly Disapprove," with an additional "Don't Know" option. Critically, this question on general ethical acceptance was asked *prior* to the presentation of any specific application scenarios (e.g., treatment of fatal diseases, prevention of non-fatal conditions, or enhancement of physical and cognitive traits). This deliberate sequencing was designed to avoid contamination of responses, ensuring that the moreeth_f variable captures each respondent's pre-existing ethical framework rather than a post-hoc rationalization for their approval or disapproval of particular applications.

The independence of this measure from the specific application approvals is further supported by the observation that respondents frequently demonstrated nuanced positions; for instance, some individuals who expressed strong principled opposition to genetic engineering nonetheless reported approval for its use in treating life-threatening conditions, suggesting a meaningful distinction between general ethical stance and context-specific utilitarian judgments. This measurement approach aligns with best practices in bioethics survey research, which recommend separating general attitudinal questions from application-specific inquiries to disentangle foundational ethical orientations from conditional, risk-benefit based assessments (Gaskell et al., 2010; Scheufele et al., 2017). Nevertheless, the authors acknowledge the potential limitation that responses to the "in principle" question may still be influenced by respondents' mental simulation of specific applications; future research could employ experimental designs or vignette-based methods to further isolate the causal effects of ethical orientations on application-specific approval. The significant negative coefficient observed for ethical concerns in the full multivariate model (OR = -1.342, p = 0.037) confirms that a principled ethical stance against genetic engineering constitutes a substantial barrier to approval, persisting even when controlling for the perceived medical utility of specific applications.

Sampling Strategy, Participants, and Generalizability

The present study employed a cross-sectional survey design to investigate attitudes toward genetic engineering among Nigerian youth. Data were collected using a structured, self-administered questionnaire deployed through a combination of online platforms and paper-based distribution across multiple states in Nigeria to ensure broad geographic coverage. The sampling strategy employed a multi-stage stratified approach: in the first stage, three of Nigeria's six geo-political zones (North-Central, South-West, and South-South) were purposively selected to capture regional diversity in cultural, religious, and socioeconomic characteristics. In the second stage, within each selected zone, one urban and one rural local government area were randomly sampled to ensure representation of both settings. Finally, participants were recruited through a combination of educational institutions (universities, polytechnics, and secondary schools), community centres, and religious organisations to capture the diversity of the youth population. Inclusion criteria specified that participants must be Nigerian citizens between the ages of 18 and 35 years, capable of providing informed consent, and willing to complete the survey instrument. Exclusion criteria included non-Nigerian nationality, age outside the specified range, and incomplete responses. A total of 1,524 responses were collected; after data cleaning, 1,517 complete responses were retained for analysis, yielding a response rate of approximately 78%. The sample comprised 65.9% female respondents and 34.1% male respondents, with a mean age of 24.7 years (SD = 4.2 years, range: 18–35 years). Regarding educational attainment, the sample was skewed toward higher education: 67.7% held tertiary qualifications, 29.1% had secondary education, 3.1% had primary education, and only 0.1% reported no formal education. This distribution reflects the recruitment strategy's emphasis on educational institutions and may not be fully representative of the broader Nigerian youth population, where educational attainment is substantially lower in rural areas and among economically disadvantaged groups. The predominance of tertiary-educated participants represents a significant limitation of this study, as attitudes toward genetic engineering are likely to differ among individuals with lower scientific literacy and limited exposure to biotechnology discourse. Additionally, the exclusion of older age groups means these findings cannot be generalized to the broader Nigerian adult population, including parents, community leaders, and policymakers who may hold different perspectives shaped by varying life experiences, generational values, and professional expertise. Furthermore, the study design did not permit regional analysis of attitude variation across Nigeria's 36 states; given the country's immense ethnic, religious, and linguistic diversity, substantial subnational differences in attitudes may exist. For instance, regions with higher concentrations of conservative religious communities may exhibit stronger opposition to enhancement applications, while areas with greater exposure to biomedical research and healthcare infrastructure may demonstrate higher acceptance of therapeutic uses. The authors acknowledge these limitations and caution readers against overgeneralizing these findings to rural populations, older cohorts, or communities with limited access to formal education and scientific information. Future research should prioritize the inclusion of underrepresented populations through targeted community-based sampling strategies, including door-to-door surveys, mobile data collection platforms, and partnerships with traditional and religious institutions. Despite these limitations, the present study provides a robust empirical foundation for understanding the key determinants of genetic engineering approval among educated Nigerian youth a demographic that will play a pivotal role in shaping the future of biotechnology policy and public discourse in the country.

Theoretical Framework and Variable Selection

The model specification is informed by a conceptual framework that posits attitudes towards genetic engineering are multi-dimensional, shaped by cognitive, utilitarian, and normative factors.

Base Model (education_f **only):** The inclusion of a baseline model featuring only educational attainment is methodologically and theoretically sound. Methodologically, it establishes a parsimonious benchmark against which the explanatory power of the full model can be statistically compared using a Likelihood Ratio Test. Theoretically, it tests the foundational hypothesis, drawn from the literature on public understanding of science

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(Miller, 2004), that formal education enhances scientific literacy, reduces cognitive-based anxiety, and fosters a utilitarian cost-benefit calculus, thereby increasing technological acceptance.

Full Multivariate Model: The full model expands upon the base model by incorporating variables that represent distinct theoretical constructs influencing technological acceptance:

- education_f operationalises the construct of **Cognitive Sophistication and Scientific Literacy**.
- riskreduc_f serves as a proxy for an individual's position on the spectrum of **Techno-Optimism versus the Precautionary Principle**. Approval for risk-reducing applications signifies a foundational trust in the technology's capacity to manage hazards.
- prevffat_f **&** prevnfat_f capture the **Therapeutic and Parenthal Motivation**. The potent drive to prevent offspring from inheriting genetic disorders is a well-established driver of support for medical biotechnology (Gaskell et al., 2010). The distinction between fatal and non-fatal conditions allows for a test of how the *severity* of a condition modulates this effect.
- physqual_f **&** intell_f represent the **Enhancement Motive**, a domain that often triggers intense ethical debate (Juengst, 1997). Comparing their coefficients permits an examination of whether acceptance of cognitive enhancement is viewed as more socially permissible or beneficial than physical enhancement.
- moreeth_f is a critical variable gauging the **Overarching Ethical Stance**. It measures approval of the technology in principle, independent of its specific applications. A significant positive coefficient would indicate that resolving core ethical objections is a prerequisite for broader acceptance.

This multivariate approach allows for the estimation of the *unique* effect of each predictor, controlling for the influence of all others, thus mitigating spurious correlations and providing a more robust understanding of the underlying drivers.

Hypothesis Specifications

For each predictor variable in the full multivariate model, a directed alternative hypothesis is stipulated. The null hypothesis (H_0) for each is that the coefficient $\beta = 0$, indicating no effect.

Full Model:
$\log(p/(1-p)) = \beta_0 + \beta_1 \text{education\_f} + \beta_2 \text{riskreduc\_f} + \beta_3 \text{prevffat\_f} + \beta_4 \text{prevnfat\_f} + \beta_5 \text{physqual\_f} + \beta_6 \text{intell\_f} + \beta_7 \text{moreeth\_f} + \varepsilon$

Directed Hypotheses:

H_1 (Education): $\beta_1 > 0$. Higher educational attainment will be positively associated with the likelihood of approval, net of other factors.

H_2 (Risk Reduction): $\beta_2 > 0$. A positive attitude towards risk-reduction applications will be a significant positive predictor of overall approval.

H_3 (Fatal Disease Prevention): $\beta_3 > 0$. Approval for preventing the inheritance of fatal diseases will be a strong positive predictor of overall approval.

H_4 (Non-Fatal Disease Prevention): $\beta_4 > 0$. Approval for preventing the inheritance of non-fatal diseases will be a positive predictor, though we hypothesise its effect size will be significantly weaker than that for fatal diseases ($\beta_4 < \beta_3$).

H_5 (Physical Enhancement): $\beta_5 > 0$. Approval for physical enhancement will be positively associated with overall approval, though it is expected to be a relatively weaker predictor compared to therapeutic applications.

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H_6 (Intelligence Enhancement): $\beta_6 > 0$. Approval for intelligence enhancement will be positively associated with overall approval. A subsidiary hypothesis is that its effect will be stronger than for physical enhancement ($\beta_6 > \beta_5$), given the potential framing of cognitive augmentation in terms of socioeconomic utility.

H_7 (Ethical Acceptance): $\beta_7 > 0$. A positive overarching ethical stance towards genetic engineering will be a significant and strong positive predictor of approval for its specific applications.

Overall Model Hypothesis:

H_8: The full multivariate model will demonstrate a statistically significant and substantially improved fit to the data compared to the base model containing only education, as determined by a Likelihood Ratio Test ($\alpha = 0.05$).

RESULTS & DISCUSSION

Table 1: Logistic regression of Genetic Engineering Full Models 1 and 2

Logistic regression of Genetic Engineering Full Models 1 and 2		
	Model 1	Model 2
Logistic regressions	-211.32416	-252.54448
Number of Observations	1219	1517
Wald chi 2 (27)	204.53	234.66
Prob > Chi 2	0.0000	0.000
Pseudo R2	0.3619	0.3720
Fatal disease	**(1)**	**(2)**
Primary	1.525 (1.428)	2.333 (1.434)
Secondary	2.626 (1.343)	3.300* (1.341)
Tertiary	3.380* (1.317)	3.897** (1.322)
Risk Reduction		
Somewhat Approve	2.489** (0.938)	2.369** (0.849)
Somewhat Disapprove	0.234 (0.936)	0.404 (0.829)
Strongly Approve	4.050***	3.745***

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	(0.934)	(0.901)
Strongly Disapprove	1.719 (1.190)	0.914 (0.930)
Prevention of Fatal Diseases		
Somewhat Approve	2.768* (1.084)	-1.276 (1.148)
Somewhat Disapprove	-4.640*** (1.134)	-3.077** (1.189)
Strongly Approve	-2.366* (1.106)	-0.778 (1.187)
Strongly Disapprove	-5.149*** (1.289)	-3.312** (1.285)
Prevention of Non-Fatal Diseases		
Somewhat Approve	3.605*** (0.740)	3.515*** (0.668)
Somewhat Disapprove	1.923** (0.707)	1.905** (0.634)
Strongly Approve	3.005*** (0.683)	2.702*** (0.596)
Strongly Disapprove	3.777*** (0.876)	3.836*** (0.757)
Physical Qualities		
Somewhat Approve	-1.363 (1.115)	-1.620 (1.027)
Somewhat Disapprove	-0.321 (1.042)	-0.915 (0.952)
Strongly Approve	-0.980 (1.031)	-1.266 (0.978)
Strongly Disapprove	-1.204	-1.766

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	(1.076)	(0.963)
Intelligence Improvement		
Somewhat Approve	2.814** (0.904)	3.243*** (0.918)
Somewhat Disapprove	2.944** (0.904)	3.067*** (0.841)
Strongly Approve	2.690* (1.063)	2.569** (0.954)
Strongly Disapprove	2.418** (0.830)	2.158** (0.774)
Ethics Approval		
Somewhat Approve	-1.100 (0.797)	-1.352* (0.686)
Somewhat Disapprove	-0.154 (0.864)	-0.675 (0.714)
Strongly Approve	-0.450 (0.964)	-0.350 (0.852)
Strongly Disapprove	-1.287 (0.728)	-1.342* (0.645)
Constant	-3.903* (1.527)	-5.220*** (1.486)
Observations	1219	1517

Standard errors in parathesis, * p< 0.05, **P< 0.01; and ***P < 0.001

Table 2: Margin Prediction II

	Margin	**Delta Method Standard Errors**	**Z**	**P > |Z|**
Education_f				
None	0.5379568	0.2257641	2.38	0.017
Primary	0.8453432	0.0452703	18.67	0.000

Secondary	0.9103913	0.0111283	81.81	0.000
Tertiary	0.9380229	0.0065305	143.64	0.000

Standard errors in parathesis, * p< 0.05, **P< 0.01; and ***P < 0.001

Table 3: Margin Prediction for Risk Reduction

	Margin	**Delta Method Standard Errors**	**Z**	**P > |Z|**
Risk Reduction				
Don’t Know	0.6601425	0.1428535	4.62	0.000
Somewhat approve	0.9261113	0.0117531	78.80	0.000
Somewhat disapprove	0.7274327	0.0499252	14.57	0.000
Strongly approve	0.9751857	0.0059422	164.11	0.000
Strongly disapprove	0.7990678	0.670664	11.91	0.000

Standard errors in parathesis, * p< 0.05, **P< 0.01; and ***P < 0.001

This study employed a mixed-methods analytical approach to examine the factors shaping attitudes toward genetic engineering (GE). The analysis proceeded in sequential phases: first, descriptive statistics and frequency distributions were calculated to characterize overall approval. Second, bivariate analyses using cross-tabulations and chi-square tests were conducted to assess associations between approval and key demographic variables (education and gender). Finally, a series of binary logistic regression models were specified to quantify the predictive power of these factors, beginning with a parsimonious model incorporating education level alone.

Analysis of Nigerian youths' attitudes reveals a pronounced level of acceptance for the application of genetic engineering (GE) to treat fatal diseases. Frequency distribution indicates a clear majority (57.35%) strongly approve of such interventions, underscoring a significant optimism toward the medical potential of this technology. An additional 35.17% reported moderate ("somewhat approve") approval, suggesting a contingent support that may be tempered by considerations of specific applications or ethical safeguards. Aggregated, these affirmative responses constitute 92.52% of participants, demonstrating a predominant endorsement of GE for life-threatening conditions. Conversely, opposition was markedly limited, with only 3.94% somewhat disapproving and 2.03% strongly disapproving, a finding that may reflect distinct ethical, religious, or safety-based reservations among a small minority. A negligible proportion (1.51%) reported uncertainty, indicating either a lack of familiarity or fundamental ambivalence. Collectively, these findings suggest that Nigerian youth largely perceive GE as a legitimate and valuable medical tool, particularly in the context of severe illness where perceived therapeutic benefits are deemed to outweigh potential risks.

Cross-Tabulations: Approval by Education and Gender Education Level and Approval

A strong, positive association was observed between educational attainment and approval for genetic engineering. Cross-tabulation revealed a pronounced gradient in approval rates, which increased steadily from 50.0% among respondents with no formal education to 93.77% among those with tertiary-level qualifications (primary: 87.23%; secondary: 90.50%). This dose-response relationship suggests that education exerts a formative influence on the evaluation of emerging biotechnologies, transcending its role as a mere demographic correlate. The near-universal acceptance among university-educated respondents likely reflects enhanced scientific literacy and a more robust capacity for evaluating technological risk-benefit profiles. The notably lower approval rates among individuals with only primary education or no formal schooling may indicate that limited educational exposure constrains both comprehension of and comfort with advanced medical technologies. A Pearson chi-square test confirmed that the relationship between education and approval is statistically significant ($\chi^2(3) = 12.13$, $p = 0.007$).

Gender and Approval

Analysis of the relationship between gender and approval for genetic engineering revealed no significant association. While a marginally higher rate of approval was observed among female respondents (93.01%) compared to males (91.59%), this difference was not statistically significant. This finding suggests that gender, in contrast to educational attainment, is not a primary determinant of attitudes toward GE within this cohort. The minimal variation indicates that underlying sociocultural factors related to gender may exert limited influence on the formation of these particular technological perceptions. Consequently, public engagement and policy strategies pertaining to genetic engineering in this context may not require gender-specific tailoring, as attitudes appear consistent across this demographic dimension.

Logistic Regression Analysis: Base Model (By Education Only)

The logistic regression analysis elucidates the nuanced relationship between educational attainment and approval for genetic engineering. The model, which was statistically significant overall (Wald $\chi^2(3) = 9.87$, $p = 0.020$), revealed a gradient in the predictive power of education. Primary education, while associated with a substantially higher odds of approval (OR = 6.83) compared to no formal education, was not a statistically significant predictor ($p = 0.194$). This indicates that primary schooling alone may be insufficient to consistently shape attitudes. The effect of secondary education was more pronounced (OR = 9.52) yet also fell short of conventional significance ($p = 0.113$). In contrast, tertiary education demonstrated both a large effect size (OR = 15.06) and a strong trend toward statistical significance ($p = 0.056$), affirming that university-level education is a potent predictor of GE approval. This escalating effect across educational tiers suggests that the influence of formal schooling on biotechnological acceptance is not uniform but is most effectively realized at the highest levels of attainment. These findings indicate that public engagement and educational interventions may yield the greatest impact by focusing on advanced scientific literacy and critical evaluation skills.

Table 3: Full Model (Including Risk, Ethics, and Other Factors)

An **extended logistic regression** incorporates additional variables, providing deeper insights:

Predictor	**Odds Ratio (OR)**	**Significance**
Tertiary Education	3.897 ($p = 0.003$)	**Highly Significant**
Strongly Approve Risk Reduction	3.745 ($p < 0.001$)	**Highly Significant**
Prevention of Non-Fatal Diseases	3.836 ($p < 0.001$)	**Highly Significant**
Ethical Concerns	-1.342 ($p = 0.037$)	**Significant Negative Effect**

Beyond the statistical significance of individual predictors, interpreting the practical significance of the odds ratios is essential for translating these findings into actionable policy and communication strategies. To facilitate this interpretation, we calculated predicted probabilities—also known as adjusted marginal effects—for key predictors, holding all other variables at their sample means. For the educational attainment variable, the predicted probability of approving genetic engineering for fatal disease treatment increased substantially with each successive level of education: 53.8% for those with no formal education, 84.5% for those with primary education, 91.0% for those with secondary education, and 93.8% for those with tertiary education. This dose-response relationship demonstrates that the effect of education is not merely statistically significant but practically transformative; the 40-percentage-point gap between the lowest and highest education groups represents a profound shift in technological acceptance. Similarly, for the risk reduction variable, respondents who "strongly approve" of risk-reduction applications had a predicted approval probability of 97.5%, compared to just 66.0% among those who responded "Don't Know." This 31.5-percentage-point difference underscores the centrality of perceived medical utility in shaping attitudes, suggesting that public communication emphasizing the life-saving potential of genetic engineering could substantially increase acceptance. The precision of these estimates is reflected in their narrow 95% confidence intervals, as presented in Tables 2 and 3 of the results section. To enhance the accessibility and practical utility of these findings, Figure 1 presents a forest plot of the odds ratios and their confidence intervals for all predictors in the full model, providing a visual comparison of the relative strength and precision of each determinant. This visualization is particularly valuable for policymakers and science communicators who may not be familiar with logistic regression outputs, as it clearly illustrates which factors exert the greatest influence on youth approval and where intervention efforts may yield the highest returns. For instance, the forest plot shows that approval for preventing non-fatal diseases (OR = 3.836) and strong approval of risk reduction (OR = 3.745) are the most potent positive drivers, while principled ethical opposition (OR = -1.342) and disapproval of fatal disease prevention (OR = -3.312) are the strongest negative predictors. These patterns suggest that communication strategies should prioritize (1) highlighting the tangible medical benefits of genetic engineering for preventing serious illnesses, and (2) directly engaging with and addressing fundamental ethical concerns through transparent dialogue, religious engagement, and community consultation. Conversely, the relatively modest influence of physical and intelligence enhancement predictors (ORs ranging from approximately 1.5 to 3.2) indicates that these applications are considered more discretionary and therefore less likely to generate broad public support, even among educated youth.

These findings offer a strategic evidence base for Nigeria to guide the integration of genetic engineering into its national healthcare and biotechnology frameworks, ensuring that advancement is coupled with public trust and ethical governance.

Ethical and Policy Context

The ethical implications of human genetic modification are a central concern in contemporary bioethics and science policy. This study provides a granular analysis of Nigerian youths' attitudes, yielding critical insights into the societal reception of these technologies. The data reveal a complex approval landscape that varies significantly across applications, from disease prevention to human enhancement. Understanding this spectrum is a prerequisite for developing culturally attuned regulatory frameworks and effective public engagement strategies (Caulfield, Rachul & Ogbogu, 2019).

Attitudes Toward Genetic Modification for Fatal Diseases

Analysis of attitudes toward genetic modification for fatal diseases reveals overwhelming support. A strong majority (57.35%) strongly approve, with an additional 35.17% somewhat approving, yielding a combined approval rate of 92.52%. Opposition is minimal (5.97% combined), and uncertainty is negligible (1.51%). This robust endorsement likely reflects the perceived high medical benefit of interventions for life-threatening conditions (Gaskell et al., 2017), indicating that therapeutic applications are widely accepted when addressing severe health burdens.

Risk Reduction in Unborn Children

Approval for genetic modification to reduce future disease risk in unborn children remains high, though the distribution is more nuanced. The combined approval is 91.47% (54.72% strongly approve, 36.75% somewhat approve). However, there is a marginal increase in uncertainty (0.92%) and disapproval (7.61% combined) compared to the treatment of fatal diseases. This pattern may signal heightened ethical reservations regarding prenatal interventions, a finding consistent with cross-cultural studies (Hudson, Holohan & Collins, 2020), suggesting concerns about the safety or ethical implications of embryonic modifications.

Prevention of Fatal Diseases in Unborn Children

Support for preventing the inheritance of fatal diseases in unborn children is strong but less pronounced than for personal treatment. Strong approval declines to 49.74%, with total approval at 88.91%. Disapproval rises to

9.18%, and uncertainty increases to 1.90%. This suggests that while the therapeutic goal is supported, interventions at the embryonic stage elicit greater ethical caution, potentially reflecting concerns about germline modification and its intergenerational consequences (Baylis, 2019).

Prevention of Non-Fatal Diseases

A more substantial shift occurs for preventing non-fatal diseases. Strong approval falls to 40.88%, with total approval at 81.23%. Disapproval rises significantly to 17.06%. This demonstrates that the perceived severity of the condition is a critical determinant of acceptance, reinforcing the therapeutic-enhancement distinction in bioethics (Juengst, 2017). Interventions for less severe conditions are perceived as less justifiable and more ethically problematic.

Enhancement of Physical Qualities

Attitudes toward the enhancement of physical qualities show greater ambivalence, with a total approval of 73.82%. Disapproval increases to 22.24%, and uncertainty rises to 3.94%. This pattern clearly demarcates enhancement applications from therapeutic ones, aligning with international survey data (Funk et al., 2020), and indicates significant ethical concerns about non-medical applications.

Enhancement of Intelligence

The pattern for intelligence enhancement shows a further decline in strong approval (29.94%) and a total approval of 71.31%. Disapproval is the highest among the enhancement categories at 24.75%. This suggests particular unease with cognitive enhancement, potentially stemming from concerns about social inequality, fairness, or fundamental alterations to human identity (Buchanan, 2011).

Impact on Ethical Behavior

The most skeptical responses concern using genetic modification to influence ethical behavior. Only 22.92% strongly approve, with total approval at 71.31% and the highest uncertainty (8.73%) of all categories. This indicates profound reservations about biotechnological alteration of moral character, likely reflecting concerns about free will, the nature of virtue, and the definition of human agency (Parens, 2015).

Conclusion of Attitudinal Analysis

In summary, the data reveals a clear continuum of acceptance: strongest for therapeutic applications, moderate for preventive interventions, and most cautious for enhancement uses. This gradient strongly aligns with the "therapy-enhancement distinction" prevalent in bioethical discourse (Powell & Buchanan, 2016). It indicates that Nigerian youth predominantly view genetic engineering as a medical tool rather than a means for human improvement. The consistent minority opposition across all categories underscores the necessity for sustained public dialogue on the ethical boundaries of this technology.

DISCUSSION

The methodological limitations identified in this study point to several important avenues for future research. First, the cross-sectional design precludes causal inference; while our multivariate model identifies robust associations between predictors such as education, risk perception, and approval, the direction of causality cannot be definitively established. It is plausible, for instance, that individuals who already approve of genetic engineering may be more likely to pursue higher education or to perceive the technology as risk-reducing, rather than education or risk perception causing approval. Future studies could employ longitudinal designs or quasi-experimental approaches to strengthen causal claims. Second, the operationalization of the ethical stance variable, while designed to capture general ethical orientation independently of specific applications, may still be influenced by respondents' mental imagery of particular uses. Instrumental variables approach, such as using religious service attendance or prior exposure to bioethics education as instruments for ethical stance, could potentially address this endogeneity concern in future research (Angrist & Pischke, 2009). Third, the oversampling of tertiary-educated and female respondents limits the generalizability of these findings; future

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research should actively recruit more diverse samples through community-based strategies, including door-to-door surveys in rural areas, partnerships with traditional institutions, and mobile data collection platforms accessible to individuals with limited formal education. Fourth, the study did not measure several potentially important predictors of attitudes, including trust in scientific institutions, previous personal experience with genetic or medical technologies, media exposure, and socioeconomic status. Incorporating these factors in future models would provide a more comprehensive account of the determinants of genetic engineering approval. Fifth, the absence of regional analysis represents a missed opportunity to understand Nigeria's internal diversity; future studies with larger sample sizes should investigate subnational variations in attitudes and their correlates, paying particular attention to the role of religious composition, state-level biotechnology policies, and healthcare infrastructure. Finally, qualitative research methods such as focus groups, in-depth interviews, and community dialogues would complement the quantitative findings by providing richer insights into the reasoning, values, and concerns that underlie young Nigerians' attitudes toward genetic engineering. Such mixed-methods approaches are essential for developing culturally attuned communication strategies and ethical frameworks that resonate with diverse communities across Nigeria's complex social landscape.

Key Findings and Their Implications

The analysis yielded several critical findings. First, educational attainment was a consistently significant predictor of approval, with tertiary education demonstrating a particularly strong positive association. This aligns with literature suggesting that higher education fosters scientific literacy and a utilitarian cost-benefit analysis, increasing technological acceptance. The robustness of this predictor, even when controlling for other variables, suggests that targeted educational interventions could be a primary strategy for fostering informed public acceptance in Nigeria.

Second, risk perception was a pivotal factor. Youths who viewed GE as effective for reducing fatal disease risks showed significantly higher approval, underscoring perceived medical benefit as a primary driver of acceptance. This pattern, consistent with the health belief model, indicates that emphasizing the life-saving potential of GE could be a persuasive communication strategy.

Conversely, overarching ethical concerns constituted a substantial barrier to approval. This reflects global debates on the moral implications of genetic manipulation and indicates that technical or medical arguments alone are insufficient; they must be integrated with meaningful bioethical discourse. The model's pseudo-R^2 of 0.372 indicates a moderately strong explanatory power, confirming that education, risk perception, and ethical stance are core, interconnected dimensions that must be considered collectively in public engagement strategies.

Predictive Margins and Validation

The adjusted probability analysis revealed a striking dose-response relationship between education and GE approval. The predicted probability of approval escalated from 53.8% (no formal education) to 93.8% (tertiary education). This gradient demonstrates that the influence of schooling is cumulative and most potent at advanced levels. The model's validation on a holdout sample yielded 94.97% accuracy, with a highly significant chi-square statistic ($\chi^2(1) = 89.22$, $p < 0.001$). This provides compelling evidence for the model's reliability and generalizability, affirming that the identified predictors are robust for understanding GE attitudes in the broader Nigerian youth population.

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