Research

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Perceptions of gene and cell therapy among medical students in south-east Nigeria: Focus on paediatric medicine

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Background. Gene and cell therapies are revolutionising paediatric medicine, offering new treatment options for genetic and metabolic conditions. However, in resource-limited settings, gaps in training and curriculum development may prevent future healthcare providers from fully utilising these advances.
Objective. To explore the knowledge, attitudes, confidence and perceived relevance of gene and cell therapy among 5th-year medical students in Nigeria.
Methods. A cross-sectional descriptive study was conducted among 5th-year medical students at a Nigerian medical school using a structured, self-administered questionnaire. Data were collected on demographics, knowledge, attitudes (measured on a Likert scale), perceived relevance, confidence levels and preferred educational formats. Descriptive statistics were used for analysis.
Results. Sixty-nine students (mean age 23.3 years; 65.2% male) completed the survey. Only 41% reported receiving formal instruction on gene or cell therapy, and 23% had attended relevant workshops. While nearly all respondents (98.6%) correctly identified gene therapy's mechanism and its application in severe combined immunodeficiency disease (SCID), 75.4% believed it is still experimental in Nigeria. Most students (92.7%) viewed gene and cell therapy as relevant to paediatric care, yet only 7.2% felt very confident in their understanding. Preferred learning formats included guest lectures (60.9%), case-based learning (58.0%), and simulations (42.0%). The majority (66.7%) supported incorporating gene therapy into both paediatric rotations and elective courses. The most commonly cited barrier was a lack of funding and infrastructure (62.3%).
Conclusion. While medical students in this setting are knowledgeable and positively inclined toward gene and cell therapy, their confidence and practical preparedness remain low. Educational strategies that emphasise experiential learning and systemic investments in faculty and infrastructure are urgently needed. These findings support the development of context-sensitive genomic education frameworks in low- and middle-income countries (LMICs). Although students demonstrated strong awareness and positive attitudes toward gene and cell therapy, their confidence and readiness for clinical application remain low. Educational strategies that emphasise hands-on learning, alongside investments in faculty development and infrastructure, are urgently needed. These findings highlight the importance of developing context-specific gene and cell therapy education frameworks for LMICs.

Keywords: perception, gene therapy, cell therapy, medical students, resource-limited setting

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Gene and cell therapies have brought transformative advances to modern medicine, particularly in the treatment of complex genetic and metabolic disorders. In paediatric care, these innovations hold significant promise for conditions such as spinal muscular atrophy, sickle cell disease, primary immunodeficiencies and various inherited retinal and metabolic disorders.[1,2] As these therapies become more clinically relevant, there is a growing need for healthcare systems and medical education programmes to prepare future physicians to engage with them effectively.

While high-income countries have made considerable progress in integrating genomic medicine into both clinical practice and medical curricula, many resource-limited settings continue to face substantial gaps.[3] In Nigeria, as in several other low- and middle-income countries (LMICs), the availability of gene and cell therapy services is limited, constrained further by a shortage of trained professionals and inadequate curriculum coverage of these rapidly evolving fields.[4]

Medical students, particularly those in their clinical training years, are well-positioned to benefit from early exposure to gene and cell therapy concepts.[5] Their understanding, attitudes, and perceptions of the relevance of these therapies can significantly influence how they apply genomic technologies in future practice. However, there are limited data on how prepared students in low-resource settings are to engage with such advances.

This study aims to address that gap by assessing the knowledge, attitudes, confidence, and perceived relevance of gene and cell therapy in paediatric practice among 5th-year medical students at a Nigerian medical school. Findings from this research may inform curriculum development, guide continuing medical education initiatives and support policy planning for gene and cell therapy in similar resource-constrained settings.

Significance of the study

The integration of gene and cell therapy into clinical practice is transforming paediatric disease management worldwide.[5] However, in many resource-limited settings, future healthcare providers, particularly medical students, often lack adequate knowledge and preparedness to engage with these

emerging therapies.[6] Building a strong foundational understanding of gene and cell therapy at the undergraduate level is essential to support the ethical implementation of these technologies and to promote equitable access across diverse healthcare systems.[7,8]

This study provides critical evidence to inform curriculum development and capacity-building efforts in genomic medicine. By identifying existing knowledge gaps, misconceptions and educational needs, the findings may guide the design of targeted training programmes. Additionally, the results may serve as a baseline for broader national or regional assessments and contribute to policymaking efforts aimed at improving gene and cell therapy literacy and reforming medical education in Nigeria.

Methods

This study evaluates the knowledge, attitudes, and perceived relevance of gene and cell therapy in paediatric medicine among 5th-year medical students.

Specific objectives include:

1. To assess students' baseline knowledge of gene and cell therapy.
2. To explore students' attitudes and acceptance of gene and cell therapy, particularly in paediatric contexts.
3. To determine students' perceptions regarding integrating gene and cell therapy into undergraduate medical education.
4. To identify preferred learning methods for gene and cell therapy education.

Study design and setting

This was a cross-sectional descriptive study to assess knowledge, attitudes, perceived relevance and educational preferences related to gene and cell therapy among medical students. The study was conducted at the Faculty of Clinical Medicine, Enugu State University of Science and Technology (ESUT), Nigeria.

Study population and sampling

The target population included all 5th-year medical students enrolled at ESUT during the study period. This cohort was selected owing to their advanced clinical exposure and training, which made them well-positioned to provide informed perspectives on the topic. All 5th-year medical students were invited to participate, as the cohort size was considered manageable and inclusive of all individuals relevant to the study objectives.

Data collection

Data were collected using a structured questionnaire developed in Google Forms. The survey was administered in English, the primary language of instruction. The 20-item instrument was divided into four sections:

Section A: Demographic questions (items 1 - 5)

This section gathered participant background information, including age, gender, previous exposure to gene or cell therapy (through formal teaching or workshops) and interest in specialising in paediatrics

Section B: Knowledge-based items (items 6 - 10)

These questions assessed participants' understanding of gene and cell therapy, including therapeutic mechanisms, current paediatric applications, regulatory considerations and the status of such therapies in Nigeria.

Section C: Attitudinal statements (items 11 - 15)

This section measured attitudes using a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The criterion mean was set at 3. Items explored views on the clinical value of gene therapy, ethical concerns, willingness to use it in practice and support for its inclusion in the medical curriculum.

Section D: Relevance and educational preferences (items 16 - 20)

Students were asked about the relevance of gene and cell therapy to paediatric care, their confidence in understanding the topic, preferred learning formats (e.g. simulations, guest lectures) and perceived barriers to curricular integration.

A structured, self-administered questionnaire was developed by the researcher based on the study objectives and a review of relevant literature on gene and cell therapy awareness and attitudes.

Prior to the main study, a pilot test involving 20 medical students (not included in the final sample) was conducted to assess the questionnaire's clarity, acceptability and internal consistency. Reliability analysis using the split-half method produced Cronbach's alpha values of 0.755 and 0.789 for the first and second halves, respectively, with a correlation coefficient of 0.744 between the halves, indicating good internal consistency of responses.

In April 2025, the questionnaire link was distributed via WhatsApp to all eligible students. The invitation described the study's purpose and highlighted the voluntary and anonymous nature of participation. A consent statement appeared at the start of the form, and students who agreed completed and submitted their responses electronically through the platform.

Data analysis

Completed responses were downloaded and analysed using IBM SPSS Statistics version 25 (IBM Corp., USA). Descriptive statistics, including frequencies, percentages, means and standard deviations, were calculated to summarise the findings.

Ethics

Ethical approval was obtained from the Health Research Ethics Committee (HREC) of Enugu State University Teaching Hospital (ESUTH), Parklane (ref. no. ESUT/HREC/2025/04/041). No identifiable data were collected. All information was stored securely on password-protected devices.

Results

Demographics

A total of 69 students completed the survey, representing a response rate of 66% (N=102). The mean age of respondents was 23.3 years, with a range of 19 to 35 years. The gender distribution was 65.2% male and 34.8% female (see Supplementary Table 1).

Exposure to gene and cell therapy

Among the respondents, 41% reported having received formal instruction on gene or cell therapy during their medical training (Supplementary Fig. 1), while 23% had attended external workshops or courses related to genetics or genomics (Supplementary Fig. 2). When asked about their specialty preference, 13% indicated an interest in paediatrics, 24.6% were not interested and the majority (62.3%) were undecided or indifferent (Supplementary Fig. 3).

As shown in Table 1, most respondents demonstrated a strong baseline understanding of gene and cell therapy. Nearly all participants (98.6%) correctly identified the primary mechanism of gene therapy as the replacement of faulty genes and accurately recognised severe combined immunodeficiency (SCID) as a paediatric condition currently treated with such therapy. A large majority (94.2%) acknowledged the importance of ethical and legal oversight in the application of gene therapy, and 95.7% correctly described cell therapy as the transplantation of healthy cells to repair or replace damaged tissues. However, 75.4% of respondents believed that gene therapy remains experimental in Nigeria.

As presented in Table 2, respondents generally held positive attitudes toward gene therapy. Students largely agreed that it represents a significant advancement in modern medicine (mean 4.62 on a 5-point scale) and expressed a high level of openness to its use in future clinical practice (mean 4.28). There was moderate acknowledgment of ethical concerns related to gene therapy (mean 3.88). Strong support was also recorded for the inclusion of gene therapy in the medical school curriculum (mean 4.42), and many students reported a willingness to enrol in elective courses on the topic (mean 3.93).

As shown in Table 3, a substantial majority of respondents (92.7%) believed that gene and cell therapy is relevant to paediatric medicine. Despite this, overall confidence in understanding gene therapy was low: 42% of students reported not feeling confident, and only 7.2% described themselves as very confident in their knowledge. When asked about preferred learning methods, students favoured guest lectures by experts (60.9%), case-based learning (58%) and simulation-based approaches (42%). The majority (66.7%) supported incorporating gene and cell therapy into both paediatric rotations and dedicated elective courses. The most frequently cited barrier to integration was the lack of funding and infrastructure, identified by 62.3% of respondents.

Table 1. Students' baseline knowledge of gene and cell therapy

	n (%)
Gene therapy primarily works by:	
Replacing faulty genes	68 (98.6)
Killing harmful bacteria	0 (0.0)
Improving vaccine response	1 (1.4)
Enhancing blood flow	0 (0.0)
Which of the following paediatric conditions is gene therapy currently used for?	
Malaria	0 (0.0)
Severe combined immunodeficiency (SCID)	68 (98.6)
Neonatal jaundice	0 (0.0)
Rickets	1 (1.4)
Gene therapy can be applied without any ethical or legal oversight	
False	65 (94.2)
True	4 (5.8)
Cell therapy is best described as:	
Using chemicals to alter DNA	3 (4.3)
Transplanting healthy cells to repair or replace damaged ones	66 (95.7)
Immunisation with live vaccines	0 (0.0)
Use of X-rays to activate genes	0 (0.0)
Gene therapy is still experimental in Nigeria	
False	17 (24.6)
True	52 (75.4)

Discussion

This study offers important insights into the preparedness of senior medical students in a resource-limited setting to engage with gene and cell therapy, particularly within the context of paediatric care. Overall, participants demonstrated positive attitudes toward the clinical relevance of gene therapy and supported its integration into undergraduate medical curricula.

These findings are consistent with previous studies,[9-11] which have reported that medical students often view gene therapy as a significant and emerging topic, but one with which they have minimal experience in clinical application. Notably, over 98% of respondents in this study correctly identified the mechanism of gene therapy and its current clinical application in SCID. This suggests that foundational concepts are being successfully conveyed, even within curricula that may not extensively cover advanced gene and cell therapy content.

Similarly, Alotaibi and Cordero[12] found that while students possessed a solid understanding of genetic principles, their knowledge of real-world clinical applications remained limited, a finding that reflects the current study's results.

However, despite this solid understanding of the basic concepts, practical exposure and confidence remained limited. Only 41% of respondents reported receiving any formal instruction on gene or cell therapy, and fewer than 1 in 4 had attended relevant workshops or courses. This gap between theoretical knowledge and clinical preparedness reflects a broader global trend in which medical education often struggles to keep pace with fast-evolving healthcare technologies and innovations.[13,14]

Similar findings have been reported in studies from more developed settings, where students expressed enthusiasm for gene therapy but lacked confidence in applying it clinically.[9,14] The low self-reported confidence observed in this study, with only 7.2% of participants feeling very confident,

Table 2. Students' perceptions regarding the integration of gene and cell therapy into undergraduate medical education

	Strongly disagree, *n* (%)	Disagree, *n* (%)	Indifferent, *n* (%)	Agree, *n* (%)	Strongly agree, *n* (%)	Mean (SD)
1. I believe gene therapy is an important advancement in modern medicine.	4 (5.8)	0 (0.0)	0 (0.0)	10 (14.5)	55 (79.7)	4.62 (0.97)
2. I am open to using gene therapy in future clinical practice.	4 (5.8)	0 (0.0)	8 (11.6)	18 (26.1)	39 (56.5)	4.28 (1.07)
3. I am concerned about the ethical implications of gene therapy	3 (4.3)	5 (7.2)	15 (21.7)	20 (29.0)	26 (37.7)	3.88 (1.13)
4. Gene therapy should be taught more comprehensively in medical school.	3 (4.3)	1 (1.4)	4 (5.8)	17 (24.6)	44 (63.8)	4.42 (0.99)
5. I would take an elective course on gene/cell therapy if available.	2 (2.9)	3 (4.3)	16 (23.2)	25 (36.2)	23 (33.3)	3.93 (1.00)

Table 3. Preferred learning methods for gene and cell therapy education among the respondents

	n (%)
1. **Do you believe gene and cell therapy is relevant in pediatric medicine?**	
Extremely	27 (39.1)
Very	37 (53.6)
Moderately	4 (5.8)
Slightly	1 (1.4)
Not at all	0 (0.0)
2. **How confident are you in your current understanding of gene therapy?**	
Extremely confident	0 (0.0)
Very confident	5 (7.2)
Moderately confident	18 (26.1)
Slightly confident	17 (24.6)
Not confident	29 (42.0)
3. **Which of the following would you prefer for learning gene therapy content?**	
Guest lectures by experts	42 (60.9)
Interactive online modules	21 (30.4)
Case-based learning during paediatrics posting	40 (58.0)
Research electives	28 (40.6)
Simulation-based learning	29 (42.0)
4. **Should gene and cell therapy be integrated into paediatric rotations or taught as a separate elective?**	
As a separate elective	19 (27.5)
Both	46 (66.7)
In pediatric rotations	2 (2.9)
Not sure	2 (2.9)
Not necessary	0 (0.0)
5. **What is the biggest barrier to integrating gene therapy into medical education in Nigeria?**	
Curriculum overload	5 (7.2)
Lack of faculty expertise	19 (27.5)
Lack of funding and infrastructure	43 (62.3)
Low student interest	1 (1.4)
All of the above	1 (1.4)

raises important concerns about students' readiness to translate knowledge into practice. These findings underscore the need for more robust, practice-oriented training strategies in medical education.

Preferred learning modalities, such as guest lectures, case-based learning, and simulation-based experiences, reflect students' desire for interactive, clinically grounded instruction rather than traditional didactic teaching. A similar trend was observed in a study conducted in Saudi Arabia,[15] where medical students gave high ratings to interactive formats like case-based discussions and simulations, underscoring a clear preference for hands-on, applied learning.

The most commonly reported barrier, lack of funding and infrastructure (62.3%), highlights the systemic constraints facing medical schools in many LMICs. This finding is consistent with a previous review, which noted that, beyond high costs, many LMICs lack critical components, such as public health infrastructure, laboratory capacity and trained personnel needed to support the delivery of advanced therapies.[16]

These structural challenges may limit access to up-to-date learning resources, qualified instructors and essential hands-on training tools like clinical simulation tools and lab-based modules. Addressing these gaps may require targeted curriculum reforms and sustained investment in faculty development to enhance institutional readiness and better prepare students for future clinical demands.

Ethical considerations also emerged as a key theme, with nearly 88% of students expressing some level of concern about the implications of gene therapy. A similar finding was observed in a survey by Xiang *et al*.,[17] which explored attitudes toward gene therapy among medical students and postgraduates in China; the majority of participants expressed ethical reservations about its clinical use.[17]

These findings point to a growing awareness of the ethical complexities surrounding consent, regulatory oversight and equitable access in the application of gene and cell therapy. They further underscore the importance of integrating bioethics as a core element of genetics education in medical training.

Finally, the predominance of male respondents in this study reflects longstanding enrolment patterns observed across many medical schools in Nigeria and sub-Saharan Africa, where male students continue to represent a greater proportion of medical students.[18,19] Sociocultural factors such as early marriage, religious norms, and traditional gender expectations have been suggested as contributing to this imbalance.[20,21]

Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance understanding and engagement with gene and cell therapy among medical students, especially in resource-limited settings:

1. **Curriculum enhancement.** Incorporate modular and interactive genomics content, including case-based learning, clinical simulations and research electives, within both core and elective rotations to build students' confidence and practical understanding of gene and cell therapy.
2. **Practical exposure.** Facilitate student attachments or elective placements in genetic and molecular biology laboratories where research on gene and cell therapy is being conducted. Such opportunities would bridge the gap between theory and practice, fostering early research interest among medical students.
3. **Faculty and institutional development.** Invest in faculty capacity building, laboratory infrastructure, and regional collaborations to support sustainable integration of gene and cell therapy education across medical schools in resource-limited settings.
4. **Future research directions could**:
   - Evaluate the impact of targeted genetics modules or laboratory attachments on students' knowledge and attitudes over time.
   - Conduct multi-institutional or regional comparative studies to assess variations in awareness and readiness for gene and cell therapy education.
   - Explore faculty perspectives, curriculum barriers and resource needs for implementing genomics education in developing-country contexts.

Conclusion

This study demonstrates that while 5th-year medical students are familiar with gene and cell therapy and have a positive attitude toward it, substantial gaps remain in practical training opportunities and curricular integration.

Low confidence levels and perceived systemic barriers may limit the translation of this knowledge into clinical competence. These findings support the development of educational frameworks tailored to the needs of LMICs for gene and cell therapy.

Limitations

Although the response rate was relatively high at 66%, the study did not capture the views of the entire class cohort (*N*=102). It is possible that students with a stronger interest in gene and cell therapy, or those more confident in their understanding, were more likely to participate. This introduces the potential for non-response bias, which may have led to an overrepresentation of favourable attitudes and higher knowledge scores.

While WhatsApp served as a practical and widely accessible distribution tool, its use may have introduced sampling bias as a result of varying levels of student engagement with the platform. This could have influenced both response rates and the representativeness of the sample.

Finally, as a cross-sectional study, this research captures perceptions at a single point in time. Causality cannot be established, and longitudinal studies would be needed to explore changes in knowledge, attitudes or confidence over time. In addition, the findings represent the perceptions of 5th-year medical students from a single institution and, while valuable within this context, may not be generalisable to all medical students in other settings or countries.

Data availability statement. Data are available from the corresponding author on reasonable request, subject to ethical and institutional requirements.

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Author contributions. This study was conducted in collaboration with all authors. IKN conceptualised the study. IKN, INA and JTOO drafted the methodology. ICC, CD and NNO supervised the data collection and reviewed the manuscript draft. IKN and FO performed the statistical analysis and wrote the results srction. INA, JTOO, ICC, CD and NNO wrote the discussion. IKN and FO wrote the abstract and contributed to the discussion. All authors reviewed the final manuscript.

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