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Original Research Paper

Medicine

ETHICAL ASPECTS OF REGENERATIVE MEDICINE

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ABSTRACT To assess knowledge and ethical perceptions related to regenerative medicine and stem cell research among graduates, and to identify major areas of ethical controversy. **Method** A mixed-methods study was conducted using a review of the literature and a cross-sectional electronic survey. A structured questionnaire consisting of 12 items was distributed among 72 graduate respondents from healthcare and non-healthcare backgrounds. Data were analyzed using descriptive statistics and graphical representations. **Results** Awareness of regenerative medicine was high among respondents. A majority (approximately 82%) of ethically justified embryonic stem cell research is due to its potential to reduce suffering. However, ethical opinions were divided regarding somatic cell nuclear transfer and the derivation of pluripotent stem cells from fetal tissue after abortion. Ethical uncertainty was notably higher for advanced and genetically manipulative technologies. **Conclusion:** Despite ethical controversies, regenerative medicine is largely perceived as ethically acceptable when associated with significant therapeutic benefits. Fewer participants provide moral value for additional developmental milestones, including implantation as well as post-14-day embryonic formation, but the majority identify ethical relevance with the earliest stage of embryonic development, fertilization. Pluripotent as well as embryonic stem cells have a strong ethical defence, and a great deal of doubt about SCNT, along with commodification. Skepticism regarding printed tissues and disease modelling. Opinions on 3D organ printing are balanced but not yet definitive. Strengthening ethical governance, informed consent, and public education is essential to support responsible progress in this field.

KEYWORDS : Regenerative Medicine, Stem Cell Ethics, Human Embryonic Stem Cells (hesc), Organoids, Induced Pluripotent Stem Cells, Somatic Cell Nuclear Transfer (scnt), Frozen Embryos.

INTRODUCTION

Regenerative medicine is the vanguard of biomedical discovery, aiming to restore normal function in ways that conventional therapies cannot by repairing, replacing, or regenerating human cells, tissues, and organs. For diseases including spinal cord injury, cardiovascular disease, diabetes, and neurodegenerative disorders, technologies like treatment using stem cells, tissue engineering, and gene-based cellular therapies hold out the potential of revolutionary results [1].

As science continues to evolve quickly, ethical issues have become equally important to the field's future growth, influencing discussions among scientists, physicians, ethicists, legislators, and the general public. The moral standing of biological materials, especially human embryos used in embryonic stem cell (hESC) research, is a fundamental ethical issue [2].

The usage of hESCs, which are derived from pre-implantation embryos and require the death of those embryos, raises questions concerning the ethical permissibility of using embryonic sources for scientific purposes as well as the beginning of human existence [3].

Different national laws and public reactions around the world result from this argument, which contrasts an impulse to lessen suffering from medical advancement with the idea of respect for unborn human life. Informed consent and autonomy are also fundamental issues, particularly as patients are faced with more difficult choices regarding their involvement in clinical studies or treatment alternatives related to regenerative medicine. Because numerous regenerative therapies are experimental, it is crucial to make sure people are aware of the possible risks, advantages, and uncertainties [4].

However, the integrity of consent in regenerative medicine is called into question by the widespread use of untested treatments that are marketed without strict clinical scrutiny. Autonomous decision-making could be undermined if patients are subjected to deceptive promises along with financial obligations without strong proof of effectiveness [5]. When patients fail to recognize the exploratory nature of novel regenerative treatments and confuse taking part in research with assured therapeutic benefit. Researchers contend that in the absence of clear communication and stringent ethical supervision, people may consent to procedures based on false impressions of their effectiveness or safety in regenerative medicine [6].

Other ethical conundrums include equity and access to regenerative medicines, and there are gaps between patients who can afford regenerative therapies compared to those who cannot, because many of them are expensive and might not be accepted by traditional insurance plans. Concerns over justice and the fair distribution of medical resources are heightened by the high price of customized cell products along with the lack of universal coverage [7].

Discussions also focus on how affordability affects access to new treatments worldwide and whether public healthcare systems should pay for costly regeneration treatments. Furthermore, the commercialization of regenerative medicine creates moral conflicts between patient welfare, profit, and innovation. Premature commercialization of inadequately vetted drugs may be encouraged by pressure to bring innovative therapies to market, putting patients at risk [8].

To protect public trust in regenerative medicine, associations of professionals, along with regulatory bodies such as the U.S. Food and Drug Administration (FDA), have emphasized the importance of evidence-based practice of regenerative medicine and responsible clinical translation. The ethical difficulty of striking a balance between innovation and patient protection has been shown by the various regulatory measures used by different nations, ranging from strict control to lax frameworks [9, 10].

Furthermore, post-trial obligations, including participant monitoring over an extended period of time and open reporting of negative occurrences, are also covered by ethical reflection in regenerative medicine [11].

Post-trial care in regenerative medicine is ethically necessary due to the irreversible nature of some advanced therapies (such as organoid implantation), but existing regulations are still developing to guarantee that these protections are strong and consistently implemented. Ethical issues continue to be crucial to the development of regenerative medicine since it directly addresses concepts of human identity, agency, and life itself [12].

Nordin A et al reported that the targets in four embryonic tissues and found "popular, and yet there is little clarity of how as well why, so we remain skeptical" [13].

With the above literature review, we are able to understand that facts on regenerative medicine are understudied. We conduct this current study to determine the main areas of ethical dispute and to evaluate graduates' ethical views and information on regenerative medicine and stem cell research.

MATERIALS AND METHODS

Study Design

A mixed-methods study comprising:

- Review of existing literature on ethical issues in regenerative medicine.
- A cross-sectional electronic survey.

Study Population

- Sample size: 72 respondents.
- Participants: Graduates from healthcare and non-healthcare backgrounds

Gender distribution

- Females: 43 (60%)
- Males: 29 (40%)

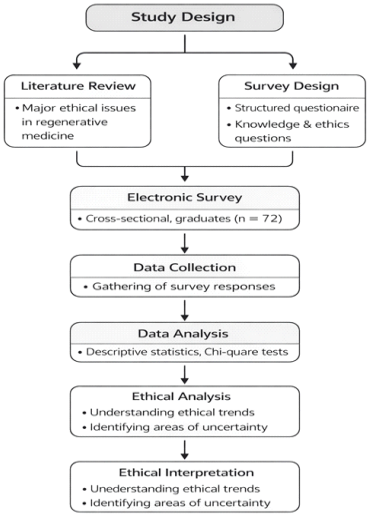


Figure 1: Diagrammatic Representation of Methodology

Study Venue

School of Public Health, SRM Institute of Science and Technology, Chennai, India

Ethical clearance

As this study is retrospective, based on the electronic data, a review of the literature and ethical clearance were not required. However, this study was conducted under the supervision of the Head of the School of Public Health, SRM Institute of Science and Technology, and the research committee.

Conflicts-None
Funding-None

Inclusion Criteria

- Graduates willing to participate and provide informed consent.

Exclusion Criteria

- Incomplete responses.
- Non-consenting participants.

Data Collection Tool

A structured questionnaire with 12 items assessing:

- Knowledge of regenerative medicine.
- Ethical acceptability of embryonic stem cell research.
- Opinions on embryo donation, organoids, 3D bio printing, somatic cell nuclear transfer, and fetal tissue use.

The questionnaire was distributed electronically via WhatsApp.

Data Analysis

- Data were entered into Excel.
- Responses were summarized using frequencies and percentages.
- Results were tabulated.
- Ethical uncertainty was assessed using "Don't know" responses.
- Statistical Evaluation of Knowledge and Ethical Perceptions in Regenerative Medicine was presented as Chi-square with significance of <0.05.

RESULTS

Table 1. Sociodemographic Characteristics of Study Participants (n = 72)

Demographic Variables	Category	N (%)
Gender	Female	43 (60.0)
	Male	29 (40.0)
Educational background	Healthcare	38 (52.8)
	Non-healthcare	34 (47.2)

The **demographic features** of a study sample (N = 72), broken down by gender and educational background, are shown in **Table 1**. There are **29 participants (40%) who are male and 43 participants (60%) who are female**. In terms of educational background, the **healthcare industry** accounts for a larger percentage of participants **(38, 52.8%)** than the **non-healthcare** industry **(34, 47.2%).**

Table 2. Knowledge of Regenerative Medicine among Respondents

Questions	Response	N (%)
Knowledge of regenerative medicine	Yes	66 (91.7)
	No	6 (8.3)
Awareness of human embryonic cell use	Yes	60 (83.3)
	No	4 (5.6)
	Don't know	8 (11.1)

With a total sample size of 72, **Table 2** displays participants' answers about their **awareness of the usage of human embryonic cells and their knowledge about regenerative medicine**. Just six participants (8.3%) said they did not know anything about regenerative medicine, whereas a **significant majority of participants (66, 91.7%) were familiar with the subject of regenerative medicine**. In a similar vein, understanding about the usage of human embryonic cells seems to be rather high. Of the participants, 60 (83.3%) said they were aware of the use of embryonic cells in regenerative medicine. However, **8 people (11.1%) chose "Don't know,"** indicating some degree of ambiguity or poor comprehension regarding embryonic stem cell uses, while **4 participants (5.6%) reported a limited awareness**.

Participants' opinions regarding the **ethical acceptability** of particular biomedical practices are shown in **Table 3**, along with choices for reacting. **"Yes," "No," and "Not sure." 30 respondents** said "yes," thirty-three said "no," and nine said "don't know" about embryonic stem cells. **47 participants said "yes,"** 17 said "no," and 8 said "don't know" in reference to **frozen embryos**. Just **14 people said "yes" to Somatic Cell Nuclear Transfer (SCNT)**, 22 said "no," and a sizable 36 said, "don't know." **38 people said "Yes,"** 18 said "No," and 16 said "Don't know" in response to the question of **Fetal Tissue Following Abortion**, indicating a moderate level of acceptability but clear ethical hesitation.

Table 3: Respondents' Ethical Acceptability of Stem Cell and Regenerative Practices

Ethical Practice	Yes	No	Don't know
Embryonic stem cells	30	33	9
Frozen embryos	47	17	8
Somatic Cell Nuclear Transfer (SCNT)	14	22	36
Fetal tissue after abortion	38	18	16

Participants' answers about the **developmental stage at which moral status, as well as ethical considerations,** can arise are shown in **Table 4. Gamete fertilization** was selected by the **majority of respondents (48; 66.7%)** as the pertinent developmental step. Comparatively fewer answers were obtained for selections of 2–3 days (4; 5.6%), **7–14 days (9; 12.5%),** as well as 15 days and beyond (1; 1.4%). Furthermore, **nine participants (12.5%) indicated uncertainty** by responding with "Don't know."

Table 4. Perception of the Beginning of Human Life

Developmental Stage	N (%)
Fertilization of gametes	48 (66.7)
2–3 days	4 (5.6)
7–14 days	9 (12.5)
15 days onwards	1 (1.4)
Don't know	9 (12.5)

Participants' answers to a **binary question (Yes/No/Don't know)** are shown in **Table 5. 59 participants (81.9%) chose " Yes " for all of the answers,** indicating substantial agreement or acceptance of the study's statement. However, nine people (12.5%) chose "No," indicating a minority opposing viewpoint. Furthermore, **4 individuals (5.6%) chose "Don't know,"** indicating a lack of clarity or minimal doubt about the matter.

Table 5. Justification of Embryonic Stem Cell Research

Response	N (%)
Yes	59 (81.9)
No	9 (12.5)
Don't know	4 (5.6)

The respondents' **degree of unknowns** ("Don't know") about the different uses of sophisticated biotechnologies, as well as regenerative medicine, is shown in **Table 6. Somatic cell nuclear transfer** had the highest degree of uncertainty (50.0%), promptly followed by body part **commodity (48.6%) and disease modeling with organoids (41.7%). 3D organ printing was shown to have moderate uncertainty (33.3%), whereas printable organ tissue had the lowest, but still significant, uncertainty (30.6%).**

Table 6. Ethical Uncertainty Related to Regenerative Medicine Applications

Application	Don't know n (%)
Somatic cell nuclear transfer	36 (50.0)
Commodification of body parts	35 (48.6)
Disease modelling using organoids	30 (41.7)
Printable organ tissue	22 (30.6)
3D organ printing	24 (33.3)

Table 7: Statistical Evaluation of Knowledge and Ethical Perceptions in Regenerative Medicine

Questions	Observ	Expect	Residu	Chi square
	N	n	n	
Knowledge of Regenerative Medicine				
True	1	24.0	-23.0	$\chi2 = 110.58$; df =2; p = 0.000*
False	66	24.0	42.0	
Don't know	5	24.0	-19.0	
Human Embryo Cells for Research for Regenerative				
Yes	60	24.0	36.0	$\chi2 = 81.33$; df =2; p = 0.000*
No	4	24.0	-20.0	
Don't know	8	24.0	-16.0	
Development of an Embryo				
Fertilization of	48	14.2	33.8	$\chi2 = 103.86$; df =4; p = 0.000*
2-3 days	4	14.2	-10.2	
7-14 days	9	14.2	-5.2	
15 days	1	14.2	-13.2	
don't know	9	14.2	-5.2	
Ethical to Use Human Embryonic Cells				
Yes	30	24.0	6.0	$\chi2 = 14.25$; df =2; p = 0.0001*
No	33	24.0	9.0	
Don't know	9	24.0	-15.0	
Ethical to Donate the Frozen Embryos				
Yes	47	24.0	23.0	$\chi2 = 34.75$; df =2; p = 0.000*
No	17	24.0	-7.0	
Don't know	8	24.0	-16.0	
Justified Embryonic Stem Cell				
Yes	59	24.0	35.0	$\chi2 = 77.08$; df =2; p = 0.000*
No	9	24.0	-15.0	
Don't know	4	24.0	-20.0	
Commodification of Body Parts				
Yes	14	24.0	-10.0	$\chi2 = 9.25$; df =2; p = 0.010*
No	23	24.0	-1.0	
Don't know	35	24.0	11.0	
Disease Modelling				
True	4	24.0	-20.0	2 = 26.33; df =2;
False	38	24.0	14.0	
Don't know	30	24.0	6.0	
Printable Organ Tissue				
True	15	23.7	-8.7	$\chi2 = 7.803$; df =2; p = 0.020*
False	34	23.7	10.3	
Don't know	22	23.7	-1.7	
3D Organ Printing				
True	29	24.0	5.0	$\chi2 = 2..083$; df =2; p = 0.353
False	19	24.0	-5.0	
Don't know	24	24.0	0.0	
Ethical to Create Embryos in Somatic Cell Nuclear Transfer				
Yes	14	24.0	-10.0	$\chi2 = 10.33$; df =2; p = 0.06
No	22	24.0	-2.0	
Don't know	36	24.0	12.0	
Ethical to Derive Pluripotent Stem Cells				
Yes	38	24.0	14.0	$\chi2 = 12.33$; df =2; p = 0.002*
No	18	24.0	-6.0	
Don't know	16	24.0	-8.0	

*Statistically Significant

The **chi-square (χ^2) goodness-of-fit test findings** comparing observed and expected frequencies across many regenerative medicine and embryo research topics are shown in **Table 7**. The **difference between expected and actual responses on knowledge of regenerative medicine** was statistically significant ($\chi^2 = 110.58$, **df = 2, p = 0.000).** Responses were significantly skewed from the expected equal distribution, as evidenced by the huge positive residual for "False" (42.0) and the big negative residual for "True" (−23.0). This implies that participants' awareness levels were not spread equally.

A substantial difference was also observed in the account of **awareness of human embryonic stem cell research (² = 81.33, df = 2, p = 0.000)**. While "No" as well as "Don't know" were less prevalent in comparison to predictions, the considerable positive residual **with "Yes" (36.0) shows significantly higher awareness than anticipated.** The responses to questions on the **embryo's developmental stage** at the onset of development deviated significantly beyond the expected frequency ($\chi^2 = 103.86, df = 4, p = 0.000$). Gamete fertilization had a **high positive residual (33.8),** suggesting that the idea that life begins at fertilization is widely held.

A statistically significant outcome ($\chi^2 = 14.25, df = 2, p = 0.0001$) was found in an **ethical use of human embryonic cells.** The residuals show that there was less doubt ("Don't know") and more ethical approval ("Yes") along with opposition ("No") than anticipated. There were notable variations in the ethical approval of frozen embryo donation ($\chi^2 = 34.75, df = 2, p = 0.000$). There is significant support for giving frozen embryos supporting research, as indicated by the substantial positive residual for **"Yes" (23.0).**

A statistically significant difference ($\chi^2 = 77.08, df = 2, p = 0.000$) had been discovered **in support of embryonic stem cells**. The respondents strongly justified the use of embryonic stem cells, as seen by the huge positive residual with **"Yes" (35.0),** along with the negative results for "No" (−15.0) as well as "Don't know" (−20.0). There was an important difference in the **commodification of bodily parts (² = 9.25, df = 2, p = 0.010).** Although fewer respondents in comparison favored commodification, a favorable residual with "Don't know" (11.0) indicates that perceptions of commercialization are dominated by uncertainty.

Significant variance was seen in the **disease modeling (² = 26.33, df = 2, p = 0.000).** While "True" answers were lower than anticipated, the large positive residual for "False" (14.0) suggests skepticism as well as a lack of evidence for illness modeling. A statistically significant result was reported for the **printable organ tissue (² = 7.803, df = 2, p = 0.020).** Modest positive residuals for "False" (10.3) along with negative residuals for "True" (−8.7) indicate a limited or cautious adoption of this application. There was no statistically significant difference in the 3D organ printing (² = 2.083, df = 2, p = 0.353). Responses were relatively evenly distributed, indicating balanced perceptions and no dominant opinion.

The results from the **ethical generation of embryos using SCNT** were close to but fell short of statistical significance (² = 10.33, df = 2, p = 0.06). A high "Don't know" residual (12.0) indicates a lack of clarity regarding the **creation of embryos linked to cloning.** There had been a significant difference in the ethical derivation of **pluripotent stem cells (² = 12.33, df = 2, p = 0.002).** Pluripotent stem cell derivation is ethically supported by positive residuals supporting "Yes" (14.0).

DISCUSSION

According to the results of our current study, **the majority of participants (60.0%) were female**, which is consistent with more general patterns seen in social science and health research, where women are frequently overrepresented in survey-based studies. Research by **Maga WI et al** has shown that gender-specific demands impact the resource-constrained environment of health-seeking. The present investigation looks at 98.5% of the questionnaires, which showed responsiveness [14].

The current study revealed that slightly more than **half of the sample had a healthcare educational background (52.8%),** suggesting that many individuals may have formal training or work experience in health-related professions. The study's results are not restricted to a purely professional or specialized understanding of health issues because a sizable portion of participants **(47.2%) are not in the medical field. Zalli E et al** reported that in social and health research, including varied educational backgrounds, helps ensure that attitudes, knowledge, and behaviours are understood from multiple perspectives. The process of learning values, attitudes, abilities, and knowledge [15].

The current study's findings, which indicated that **91.7% of participants know regenerative medicine**, are consistent with historical global trends that indicate the public is becoming more aware of modern biomedical technology, stem cell research, and regenerative medicine. **Wani, S.N et al** presented that the expansion of clinical trials, media coverage, and academic discourse has significantly improved public familiarity with regenerative medicine concepts. For the purpose to assist regenerate heart tissue, induced pluripotent stem cells can be utilized in conjunction with regenerative medicine [16].

According to the examination's findings, 83.3% of participants are aware of the way human embryonic cells are being utilized, which indicates that knowledge about the genesis of neural stem cells has spread widely. Human embryonic stem cells (hESCs) have been the subject of extensive ethical debate in both public and scientific arenas, which has raised awareness. However, 11.1% of respondents indicated they were unsure about the precise origins of stem cells employed in regenerative medicine. **Sun T et al** study found that their 92% of the study participants have significant knowledge of the various laws governing human rights, and recognize that the destruction of human embryos was and continues to be a significant problem. 92% of participants knew a moderate amount about stem cells [17].

Our current investigation revealed that the conflicting opinions of embryonic stem cells are a reflection of current ethical discussions about the moral standing of human embryos around the world. Pre-implantation embryos are usually destroyed to utilize stem cells from an embryo, which raises questions regarding the beginning of human life that are based on cultural, intellectual, and religious views. Recent research by **Foreman AL et al** showed that ethical pluralism continues to shape public attitudes toward embryonic stem cell research, explaining the near-equal distribution between approval and disapproval observed in this study. In certain situations, human embryonic stem cells (also known as advanced human embryo models) might intensify ethical concerns by causing research on embryos and stem cells to persist and reflect [18].

According to the current investigation, the public's belief that extra embryos from in vitro fertilization (IVF) would otherwise be thrown away may account for the greater acceptability of frozen embryonic use (47 "Yes"). Recent analyses by **Akins BW et al** suggest that individuals often view the use of frozen embryos for research as more ethically acceptable when framed as contributing to medical progress rather than destruction without benefit. Families thinking about IVF and the in vitro fertilization (IVF) sector. In the end, the acknowledgment of fetal personhood. 47. See id. (a subgroup with a significant vaccine reluctance) [19].

According to our research, somatic cell nuclear transfer (SCNT) exhibits the greatest percentage of "Don't know" answers (36), indicating significant ambiguity. SCNT, which is frequently linked to cloning technology, is still a contentious ethical as well as scientific issue. Literature from recent years by **Moura MT et al** shows that public understanding of SCNT is generally limited, and misconceptions about reproductive cloning versus therapeutic cloning persist. The cloning efficiency of SCNT employing endoderm nuclei was

significantly lower, and the technology is still technically complex [20].

According to this study, there was some criticism and a lack of clarity, but there was also a moderate level of support (38 "Yes") for the use of fetal tissue following abortion. **Criscione M et al** study reported that the ambiguity on the laws governing prenatal homicide, their belief that 38 weeks is ethically different, and ethical concerns surrounding fetal tissue research are deeply connected to abortion debates, bodily autonomy, and respect for human remains. As a result of stump bleeding, the following an early miscarriage and bleeding from another source if the therapy choice is made because of doubts regarding the right patient [21].

According to the results of this study, 66.7% of participants believe that fertilization has ethical significance, which is consistent with long-held philosophical and theological beliefs that hold that human life begins at conception. **Cherry MJ et al** described that the contemporary bioethical discourse recognizes that beliefs about the moral status of embryos are often rooted in metaphysical, cultural, and theological frameworks. A lower moral standing, making abortion ethically acceptable, is acknowledged by Christians in the development of a human embryo, "a fundamental worry [22].
According to the well-known "14-day guideline" in embryo analysis, a significant percentage of respondents (12.5%) during this study chose 7–14 days. In vitro embryo research is prohibited after 14 days of development, before the creation of the primitive streak, a crucial indicator of one's own growth. This regulation was first put in place in the last decades of the twentieth century. **Luijkx DG et al** reported that the cleavage, blastocyst creation with a growth potential similar to that of human embryos, the establishment of the amniotic sac, and the posterior primitive streak are important milestones [23].

According to our most recent study, just 5.6 percent of participants thought the two-to-three-day stage was ethically meaningful. At this point, the embryo is made up of a small number of undifferentiated cells, which is equivalent to early fragmentation. When determining moral status, others distinguish between fertilization as well as subsequent stages like implantation, even gastrulation, according to bioethics. **Anifandis G et al** reported that the idea that, as previously stated, life begins with fertilization, the PS appears, gastrulation takes place, and a person's moral standing has been the focus of bioethics [24].

The large majority of "Yes" answers (81.9%) to ethical considerations in our current study indicates substantial support or acceptability among participants. In a study by **Zhang J et al** related to regenerative medicine and biomedical ethics, high agreement rates often reflect increasing public awareness, trust in scientific innovation, or alignment with perceived medical benefits. The universal shared values of society are reflected in ethical values propelling medical AI's technological advancement [25].

According to our research, there was no statistically significant disparity between the expected and actual responses on regenerative medicine knowledge (^{2} = 110.58, df = 2, p = 0.000). The awareness of human embryonic stem cell research also showed a significant difference (^{2} = 81.33, df = 2, p = 0.000). The significant positive residual for "Yes" (36.0) indicates significantly better awareness than expected, even though "No" and "Don't know" were underrepresented compared to projections. **Aboalola D et al** described that the higher awareness of embryonic stem cell research aligns with findings that media attention and ethical debates have amplified public visibility of this field. Raising awareness of stem cell therapy is necessary due to the lack of understanding and safety concerns surrounding it. Given that students and medical professionals are more knowledgeable about stem cells [26].

According to responses with the perception throughout this study, the growth rate of the embryo's stages at the beginning of development differed significantly from expected frequencies (χ^2 = 103.86, df = 4, p = 0.000). A statistically significant outcome (χ^2 = 14.25, df = 2, p = 0.0001) was found in an ethical use of human embryonic cells. The residuals demonstrate that ethical consent ("Yes") and some resistance ("No") were higher than anticipated, but uncertainty ("Don't know") proved shorter than anticipated. Recent revisions by **Park SJ et al** in-stem cell guidelines emphasize careful ethical oversight when research involves embryos beyond specific developmental thresholds. Given the current status of hESC clinical trials, it is important to note that every stage involving the transfer of stem cells is subject to certain ethical criteria [27].
The ethical approval of frozen embryo donation varied significantly, according to the current study (^{2} = 34.75, df = 2, p = 0.000). The substantial positive residue for "Yes" (23.0) indicates that there is strong support for providing frozen embryos to fund research. In favor of embryonic stem cells for use, a statistically significant difference was discovered (^{2} = 77.08, df = 2, p = 0.000). The respondents provided good justifications for "Yes" (35.0), "No" (−15.0), and "Don't know" (−20.0). **Marei HE et al** reported that these in vitro models of cells (iPSCs) represent crucial stages of early organ transplantation, damage healing, and degeneration, and this distinction also calls into question widely held beliefs [28].

The commercialization of body parts varied significantly (^{2} = 9.25, df = 2, p = 0.010). The positive residual for "Don't know" (11.0) was present, although fewer respondents supported commodification. The illness modeling showed significant variance (^{2} = 26.33, df = 2, p = 0 000). In contrast to "True" responses, "False" responses had a sizable positive residual (14.0). The printed organ tissue (^{2} = 7.803, df = 2, p = 0.020) as well as the ethical creation of pluripotent stem cells (^{2} = 12.33, df = 2, p = 0.002) differed statistically significantly. **Srirattana K et al** study described that through Somatic Cell Nuclear Transfer (SCNT), in the mammalian oocytes, the somatic cells can be differentiated and reprogrammed into a totipotent state [29].

CONCLUSION

Our current findings conclude that females formed the majority of the sample, and there was a relatively balanced representation between those with health-related education and those without. Strong general awareness of regenerative medicine and relatively high awareness of embryonic stem cell use, though a small proportion of participants remain uncertain or uninformed. A clear majority consensus, with more than four-fifths of respondents agreeing. A divided opinion, with slightly more participants opposing than supporting the ethical acceptability of embryonic stem cell use. Most participants associate ethical significance with the earliest stage of embryonic development, fertilization, while fewer attribute moral status to later developmental milestones such as implantation or post-14-day embryonic development. The presence of uncertainty reflects ongoing ethical ambiguity or limited knowledge about embryological stages and their regulatory implications. A considerable knowledge gap across all applications, with at least one-third of respondents uncertain about each topic, notably, more complex or ethically controversial technologies (e.g., somatic cell nuclear transfer) show the highest levels of uncertainty.

The chi-square analysis demonstrates structured ethical perspectives toward regenerative medicine applications. Key findings include:

Strong ethical justification for embryonic stem cells and

pluripotent stem cells. Significant uncertainty regarding commodification and SCNT.

Skepticism or cautious attitudes toward disease modelling and printable tissues.

Balanced but not yet crystallized views on 3D organ printing.

LIMITATIONS

Small sample size.

REFERENCES

1. Tahir F, Tahir A. Regenerative medicine and stem cell therapy: advancements and future potential. Wah Academia Journal of Health and Nutrition. 2025 Mar 31;1(1):19-30. https://doi.org/10.63954/WAJHN.1.1.5.3.2025
2. Writing Group of the ESHRE Ethics Committee, Pennings G, Dondorp W, Popovic M, Chuva de Sousa Lopes S, Mertes H. Ethical considerations on the moral status of the embryo and embryo-like structures. Human Reproduction. 2024 Nov;39(11):2387-91. https://doi.org/10.1093/humrep/deae228
3. Alhata RS, Dari SS. Patentability of Human Embryonic Stem Cells in India. Russian Law Journal. 2023;11(3):2020-31.https://doi.org/10.52783/rlj.v11i3.1987
4. Harris AR, Walker MJ, Gilbert F. Ethical and regulatory issues of stem cell-derived 3-dimensional organoid and tissue therapy for personalised regenerative medicine. BMC Medicine. 2022 Dec 27;20(1):499. https://doi.org/10.1186/s12916-022-02710-9.
5. Jayaram P, Danilkowicz RM, Yuan X. Ethical and regulatory considerations related to regenerative medicine. HSS Journal®. 2025 Nov;21(4):463-8. https://doi.org/10.1177/15563316251361511.
6. de Kanter AF, Jongsma KR, Verhaar MC, Bredenoord AL. The ethical implications of tissue engineering for regenerative purposes: a systematic review. Tissue Engineering Part B: Reviews. 2023 Apr 1;29(2):167-87. https://doi.org/10.1089/ten.teb.2022.0033
7. Qiu T, Pochopie M, Hanna E, Liang S, Wang Y, Han R, Toumi M, Aballea S. Challenges in the market access of regenerative medicines, and implications for manufacturers and decision-makers: a systematic review. Regenerative Medicine. 2022 Mar 1;17(3):119-39. https://doi.org/10.2217/rme-2021-0083
8. Takahashi T, Donahue RP, Nordberg RC, Hu JC, Currall SC, Athanasiou KA. Commercialization of regenerative-medicine therapies. Nature Reviews Bioengineering. 2023 Dec;1(12):906-29. https://doi.org/10.1038/s44222-023-00095-9
9. Beetler DJ, Di Florio DN, Law EW, Groen CM, Windebank AJ, Peterson QP, Fairweather D. The evolving regulatory landscape in regenerative medicine. Molecular aspects of medicine. 2023 Jun 1;91:101138. https://doi.org/10.1016/j.mam.2022.101138
10. Musyuni P, Mangla B, Javed S, Kumar P, Ahsan W. Regulatory challenges and opportunities in cell-based therapies: overcoming barriers to advancement and patient care. Regenerative Medicine. 2025 Nov 2;20(11):609-24. https://doi.org/10.1080/17460751.2025.2580888
11. Harris A, Gilbert F. Need for greater post-trial support for clinical trial participants assessing high-risk, irreversible treatments. Journal of Medical Ethics. 2025 Apr 1;51(4):268-73. https://doi.org/10.1136/jme-2023-109719
12. de Jongh D, Massey EK, Cronin AJ, Schermer MH, Bunnik EM, VANGUARD Consortium. Early-phase clinical trials of bio-artificial organ technology: a systematic review of ethical issues. Transplant International. 2022 Oct 31;35:10751. https://doi.org/10.3389/ti.2022.10751
13. Nordin A. Transcription Factors and Where to Find Them: Mechanisms and Methods of Mapping Transcription Factor Regulation. Linköping University Electronic Press; 2026 Jan 27. https://doi.org/10.3384/9789181183887
14. Maga WI, Santas T, Igbaba SO. Exploring Gender-Responsive Communication Strategies in Enhancing Healthcare Delivery: Insights from Akwanga and Wamba LGAs, Nasarawa State. Jalingo Journal of Social and Management Sciences. 2025 Apr 23;6(3):226-38. https://www.researchgate.net/publication/391427590_Exploring_Gender-Responsive_Communication_Strategies_in_Enhancing_Healthcare_Delivery_Insights_from_Akwanga_and_Wamba_LGAs_Nasarawa_State
15. Zalli E. Globalization and education: exploring the exchange of ideas, values, and traditions in promoting cultural understanding and global citizenship. Interdisciplinary Journal of Research and Development. 2024 Apr 23;11(1 S1):55. https://doi.org/10.56345/ijrdv11n1s109
16. Wani, S.N., Zahoor, I., Tantray, J., Venkateshwarlu, G., Tiwari, P., Eqbal, S., Faiyazuddin, M., and Syed, A.A., 2025. Regenerative Medicine: A Promising Approach to Addressing the Global Healthcare Challenges and Promoting Sustainability. In Design and Processing of Green Materials: Exploring Sustainable Applications in Medical and Pharmaceutical Sciences (pp. 157-179). Cham: Springer Nature Switzerland. https://link.springer.com/chapter/10.1007/978-3-031-91790-5_6
17. Sun T. A study on the attitudes of urban residents in China towards the preservation of embryonic stem cells. In Third International Conference on Biological Engineering and Medical Science (ICBioMed2023) 2024 Jan 8 (Vol. 12924, pp. 892-899). SPIE. https://doi.org/10.1117/12.3013161
18. Foreman AL, Liddell K, Franklin S, Jackson E, Rozeik C, Niakan KK. Human embryo models: the importance of national policy and governance review. Current opinion in genetics & development. 2023 Oct 1; 82:102103. https://doi.org/10.1016/j.gde.2023.102103
19. Akins BW, Bursuc VA. Addressing the Supply of Frozen Embryos in a Post-Dobbs America. University of Florida Journal of Law & Public Policy. 2025;35(2):1.
20. https://scholarship.law.ufl.edu/jlpp/vol35/iss2/1?utm_source=scholarship.law.ufl.edu%2Fjlpp%2Fvol35%2Fiss2%2F1&utm_medium=PDF&utm_campaign=PDFCoverPages
20. Moura MT. Cloning by SCNT: Integrating technical and biology-driven advances. In Somatic Cell Nuclear Transfer Technology 2023 Apr 12 (pp. 1-35). New York, NY: Springer US. https://doi.org/10.1007/978-1-0716-3064-8_1
21. Criscione M, Baldini GM, Sanna E, Saderi L, Sotgiu G, Palumbo M, Petrillo M, Capobianco G. Tubal Stump Ectopic Pregnancy After IVF-ET in Patients Who Underwent Salpingectomy or Adnexectomy: A Qualitative Systematic Review. Medicina. 2025 Dec 31;62(1):83. https://doi.org/10.3390/medicina62010083
22. Cherry MJ. Foundations of Christian Bioethics: Metaphysical, Conceptual, and Biblical. Christian Bioethics: Non-Ecumenical Studies in Medical Morality. 2023 Mar 1;29(1):1-0. https://doi.org/10.1093/cb/cbad001
23. Luijkx DG, Ashtar L, de Graeff N, Coonen E, Giselbrecht S, de Wert GM, Vrij EJ, Grant R, Pereira Daoud AM. Beyond integration: towards benchmarks for developmental potential in human stem cell-derived embryo models. Human Reproduction Update. 2026 Jan 5: dmaf033. https://doi.org/10.1093/humupd/dmaf033
24. Anifandis G, Sutovsky P, Turek PJ, Chavez SL, Kunej T, Messini CI, Schon SB, Mavroforou A, Adashi EY, Krawetz SA. Bioethics in human embryology: the double-edged sword of embryo research. Systems biology in reproductive medicine. 2022 May 4;68(3):169-79. https://doi.org/10.1080/19396368.2022.2052771
25. Zhang J, Zhang ZM. Ethics and governance of trustworthy medical artificial intelligence. BMC medical informatics and decision making. 2023 Jan 13;23(1):7. https://doi.org/10.1186/s12911-023-02103-9
26. Aboalola D, Ramadan M, Baadhaim M, Alsiary R, Badraiq H, Alghamdi T, Zakri S, Aboulola N, Falatah T, Malibari D. Public awareness and understanding of stem cell treatments available in Saudi Arabia and their trust in hospitals and research centers involved in stem cell research—a cross-sectional study. Frontiers in public health. 2024 Apr 2;12:1364809. https://doi.org/10.3389/fpubh.2024.1364809
27. Park SJ, Kim YY, Han JY, Kim SW, Kim H, Ku SY. Advancements in human embryonic stem cell research: clinical applications and ethical issues. Tissue Engineering and Regenerative Medicine. 2024 Apr;21(3):379-94. https://doi.org/10.1007/s13770-024-00627-3
28. Marei HE. Stem cell and synthetic embryo models: advances, applications, and ethical considerations. Stem Cell Reviews and Reports. 2025 Aug;21(6):1648-68. https://doi.org/10.1007/s12015-025-10890-z
29. Srirattana K, Kaneda M, Parnpai R. Strategies to improve the efficiency of somatic cell nuclear transfer. International journal of molecular sciences. 2022 Feb 10;23(4):1969. https://doi.org/10.3390/ijms23041969