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Perspectives and Ethical Views of the Swedish Public on the Use of Human Embryonic Stem Cells in Medical Therapy

Sunil Kumar[1,2], Ashvi Yadav[3], Patil Kumar Rath[4], Rosa Prava Verma[5], Sunnypriyatham Tirupathi[6], Hadil Shaiba[5], Hema Kanathila[1*]

[1]Department of Biotechnology, School of Bioengineering and Biosciences, Lovely Professional University, Phagwara 144411, Punjab, India.
[2]Department of Animal Biotechnology, Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University, Chennai 600051, Tamil Nadu, India.
[3]Department of Clinical Sciences, Clinical Research Centre, Skåne University Hospital, Lund University, SE 20213 Malmö, Sweden.
[4]College of Veterinary Science and AH, Odisha University of Agriculture and Technology, Bhubaneswar 751003, Odisha, India.
[5]Devansh Lab Werks, 234 Aquarius Drive, Homewood, AL 35209, USA.
[6]Microgen Health Inc., 14225 Sullyfield Cir Suite E, Chantilly, VA 20151, USA.

***E-mail** ✉ Ashviyadav.in@yahoo.com

Abstract

The development of medical therapies using human embryonic stem cells (ES cells) continues to evoke ethical debates. This study explored how the public perceives the use of ES cells for treating Parkinson's disease (PD) and other medical conditions, which considerations are prioritized in ES cell-based drug development, and whether religious beliefs influence attitudes toward ES cell applications in medicine. An online survey was conducted with a randomly selected sample of the Swedish population aged 18–87 years (n = 467). Data collected included socio-demographic information, religious perspectives, views on the moral status of embryos, and opinions regarding the use of ES cells in PD and other treatments. Logistic regression analyses were performed to estimate adjusted odds ratios (ORs) and 95% confidence intervals (CI) comparing positive versus negative attitudes toward ES cell use in drug development. Overall, participants showed favorable attitudes toward ES cell applications in therapy. Seventy percent fully endorsed using ES cells for PD treatment, whereas 40% fully agreed that ES cells are acceptable for treatment even when induced pluripotent cells provide similar efficacy. Participants for whom religion played a minor role in daily life were more likely to hold positive attitudes toward ES cell use in PD therapy (adjusted OR 6.39, 95% CI 2.78–14.71). The factor deemed most crucial in ES cell-based drug development was "ensuring access to innovative and effective treatments for diseases lacking available therapies." The findings indicate broad public support for ES cell-based drug development, particularly for providing treatments to patients without alternatives. Attitudes, however, are shaped by the specific disease targeted, personal religious views, and perceptions regarding the moral status of early embryos.

Keywords: Moral concerns, Public perceptions, Surplus embryos, Drug development, Parkinson's disease

Introduction

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Stem cells are increasingly being explored as therapeutic options for a range of currently incurable diseases [1]. Human embryonic stem cells (ES cells) are immature, pluripotent cells capable of indefinite division and differentiation into any specialized cell type [2]. ES cells are derived from blastocysts approximately five days after conception. In most cases, the embryos used for ES cell derivation are surplus embryos donated by couples undergoing in vitro fertilization (IVF). In Sweden, coupl

es undergoing IVF may choose to donate embryos either for reproductive use by other couples, for research purposes, or to discard them. It is prohibited in Sweden to create embryos specifically for research purposes. Induced pluripotent cells (iPS cells), in contrast, are generated by reprogramming specialized somatic cells [3, 4]. Both ES cells and iPS cells are being investigated for their potential in regenerative medicine, aiming to replace damaged or lost cells. Parkinson's disease (PD) represents a condition where therapeutic development has advanced the most [5]. PD is a chronic, progressive disorder that can significantly reduce an individual's independence and overall quality of life. While the exact etiology of PD remains unknown and no cure currently exists, treatment focuses on symptom management through medication and non-pharmacological interventions. Therefore, developing effective disease-modifying therapies is crucial to improving outcomes for patients and their families. A recent review by Parmar *et al.* [1] summarizes the potential and limitations of ES- and iPS-derived cell therapies for PD. Presently, three clinical trials are ongoing: two employ ES cell-derived products, and one uses iPS cell-derived products. Additionally, a case report has been published documenting a patient treated with an autologous iPS cell-derived transplant [6].

Unlike iPS cells, ES cell use raises ethical concerns because their derivation involves the destruction of early embryos. Perceptions of the embryo's moral status vary according to individual life philosophies and have been extensively debated [7–9]. Certain societal groups, including activists and religious leaders, have voiced strong opposition to ES cell use [10]. These ethical considerations have shaped legislation, such as limiting ES cell use to within 14 days to safeguard the special status of the unborn [11], and in some countries, have led to outright bans on ES cell research [5]. Moreover, the commercialization of cell-based therapies raises further concerns, as it risks treating embryos as commodities, potentially undermining respect for human life [12]. When ES- or iPS-derived therapies become available on the market, regulatory authorities and policymakers will need to determine whether commercialization should be permitted and under what conditions. Incorporating the perspectives of the public is therefore essential, a principle reinforced by the Swedish Patent Act (1967:837, 2020:541) Chapter 1, Article 1c, which stipulates that "a patent is not granted for an invention where the commercial exploitation would be contrary to public order or morality."

Previous studies have largely examined the perspectives of couples undergoing IVF. A 2014 systematic review showed that couples who chose to donate surplus embryos for research often saw it as a preferable alternative to discarding them and as a way to help others. In contrast, couples who attributed a high moral status to embryos were less willing to donate for research purposes [13]. In Sweden, a cross-sectional survey on embryo donation attitudes found that roughly half of respondents were supportive of donating embryos for research [14]. In China, 59% of IVF couples preferred to discard surplus embryos rather than donate them, citing limited information and distrust in scientific research as key reasons [15]. Similarly, a study in Latin America indicated that willingness to donate depended on the intended use: 73.6% supported donation for ES cell-based treatments, 63.8% for reproductive use by heterosexual couples, and 45.1% for single women [16]. These findings highlight that both the purpose of donation and the origin of the embryo—whether surplus or created specifically for research—play an important role in shaping attitudes [17].

A 2022 qualitative study involving members of the Swedish general population reported positive views toward the use of embryonic stem cells for PD treatment, although respondents emphasized certain conditions for approval [18]. Some participants viewed early embryo donation as ethically unproblematic, whereas others raised concerns based on the embryo's status as a "potential life." Even those holding this view often supported donation, prioritizing the potential benefit of effective PD treatments over ethical reservations. Yet, several respondents indicated that they would favor alternative approaches, such as iPS cells, if these were equally effective. These findings underline the necessity of specifying both the disease being treated and the availability of alternative therapies when exploring public attitudes toward ES cell applications.

In this context, the current study aimed to build on prior Swedish research by assessing the prevalence of attitudes and values in the general population regarding ES cell-based drug development. The study specifically focused on public opinions about the use of ES cells for medical treatment in general and for PD in particular, the factors considered most important when evaluating ES cell use, and whether the perceived importance of religion in one's life is associated with these attitudes.

Methods

Study population and data collection

This cross-sectional survey targeted a random sample of Swedish residents aged 18 years and older (n = 2,755) drawn from the Swedish State Personal Address Register, which includes all residents in Sweden. Selected individuals received an invitation letter explaining the study and providing a link to an online survey. Thirty-four letters were returned undelivered. Data collection continued until at least 400 responses were obtained. Of the 2,721 individuals successfully contacted, 467 completed the survey (17%). Non-participation was due to refusal (14), health limitations (5), lack of computer access (2), or language barriers (1). Data were collected between March and May 2021.

Research ethics

Prior to initiating data collection, the Swedish Ethical Review Authority approved this study (Dnr 2019-06539). All participants provided informed consent, and the collected data were reported in a way that ensured individual anonymity. The study followed all relevant national and international ethical guidelines and regulations.

Survey design and variables

The online questionnaire gathered demographic and background information including age, gender, country of birth (Sweden or other), occupation, highest education level (later categorized as 1 = university, 0 = all others), use of pharmaceuticals, and health literacy (sufficient versus limited) [19]. After completing these questions, participants read a brief text describing human embryonic stem cells and their potential use in treating Parkinson's disease (PD) (Additional file 1).

Next, respondents were asked to rank eight statements regarding considerations for using surplus embryos in drug development, according to perceived importance (Table 4). These statements were formulated based on insights obtained from previous qualitative interviews with patients, the general public, and IVF couples with cryopreserved embryos.

Attitudes toward the use of leftover embryos were assessed through three items on a 5-point Likert scale (1 = fully agree, 2 = highly agree, 3 = partially agree, 4 = highly disagree, 5 = fully disagree). The hypothetical scenario assumed that early embryos leftover from IVF were donated by the couple solely for research purposes, with no financial compensation. Respondents evaluated the acceptability of: (1) using surplus embryos to treat PD, (2) using them for other disease treatments, and (3) using them for treatment even if induced pluripotent (iPS) cells could provide similar outcomes. For analysis, responses were collapsed into positive attitudes (1–2) and negative attitudes (3–5).

Perceptions of the moral status of embryos a few days old were measured with the question: "The human is perceived to have a special moral position, in the sense of having rights just by being human. What moral position does a human embryo that is only a few days old have?" Four options were provided: (1) the embryo is just a lump of cells, (2) its moral status lies between a lump of cells and a human being, (3) its status is closer to a human than a lump of cells, and (4) the embryo has the same moral status as a human. Responses were dichotomized into low status (1–2) and high status (3–4).

The importance of religion in participants' lives was evaluated on a 5-point Likert scale (1 = very little importance to 5 = great importance) and subsequently dichotomized into little importance (1–3) versus high importance (4–5).

Statistical analyses

Continuous variables were summarized using means and standard deviations, while categorical variables were reported as frequencies. Differences in attitudes across the three purposes of embryo use were assessed using the Wilcoxon Signed Ranks Test. The Mann–Whitney U test and Spearman's correlation were applied to examine whether attitudes varied by age, sex, education, country of birth, health literacy, moral status of the embryo, or religious importance. Associations between religious importance and attitudes were expressed as odds ratios (ORs) with 95 percent confidence intervals (CI). Three separate binary logistic regression models were run, one for each attitude item, with negative attitude as the reference. The crude model included only religion. Model 1 further adjusted for age, sex, education, health literacy, country of birth, and pharmaceutical use. Model 2 additionally included moral status of the embryo. All analyses were conducted using SPSS version 25.

Results

Respondents in this survey ranged in age from eighteen to eighty seven years and were evenly distributed by sex. Nearly half held a university degree, and the majority (86 percent) were born in Sweden **(Table 1)**.

Table 1. Characteristics of the respondents (n = 467)

	***n* (%)**	**Mean (SD)**
Age (years)		49.9 (16.9)
18–30	75 (16.2)	
31–50	160 (34.6)	
51–65	125 (27.0)	
66–87	103 (22.2)	
Sex		
Male	235 (50.9)	
Female	227 (49.1)	
Country of birth		
Sweden	400 (86.4)	
Other	63 (13.6)	
Education		
No education	3 (0.6)	
Primary school	30 (6.5)	
Secondary school	135 (29.2)	
Vocational school	69 (14.9)	
University	226 (48.8)	
Occupation		
Working	287 (38.0)	
Retired	117 (25.3)	
Sick leave	7 (1.5)	
Parental leave	15 (3.2)	
Unemployed	21 (4.5)	
Student	44 (9.5)	
None	10 (2.2)	
Pharmaceutical use		
Daily	215 (46.4)	
1–6 times a week	31 (6.7)	
1–3 times a month	59 (12.7)	
< Once a month	124 (26.8)	
Never	34 (7.4)	
Health literacy		
Inadequate	15 (3.2)	
Problematic	143 (30.6)	
Sufficient	299 (64.0)	

Approximately half of the respondents indicated that religion held little significance in their lives, whereas only 4.4% reported that it was highly meaningful. Most respondents viewed the early embryo as merely a cluster of cells, while 3.9 percent believed it possesses the same moral status as a human being **(Table 2)**.

Table 2. Descriptive Statistics of Meaning of Religion and Perceived Moral Status of the Embryo (n = 467)

Category	**Response**	**n (%)**
Meaning of Religion in Your Life		
	Very little	226 (52.1)
	Pretty little	84 (19.4)
	Neither little nor a lot	73 (16.8)
	Pretty much	32 (7.4)

	Very much	19 (4.4)
Perceived Moral Status of Embryo		
	The embryo is just a lump of cells; it's pointless to discuss its moral standing	252 (58.1)
	The embryo has a moral position that lies in the middle of being just one lump of cells and being a human being	128 (29.5)
	The moral position of an embryo is closer to being a human being than just a lump of cells	37 (8.5)
	The embryo has the same moral status as a human being	17 (3.9)

Public attitudes toward the use of surplus embryos in medical treatment development

Overall, respondents expressed a strong positive attitude toward utilizing surplus embryos for the development of drugs (**Table 3**; lower median and mean values reflect greater positivity). Attitudes varied significantly depending on the intended use of the embryos. Participants were most supportive of using surplus embryos specifically for Parkinson's disease treatment, followed by general use of surplus embryos, and were least supportive when induced pluripotent stem cells (iPS) could achieve the same outcome. Results from the Mann–Whitney U test indicated that individuals who were less religious, male, younger, Swedish-born, and possessed adequate health literacy tended to be more favorable toward embryo use. In contrast, those who regarded embryos as human or closer to human rather than as a cluster of cells were the most opposed to their use in drug development.

Table 3. Descriptive Statistics of Respondents' (n = 435) Opinions on Using Donated Leftover IVF Embryos for Drug Development Without Financial Compensation

Statement	Median (IQR)	1 Totally agree n (%)	2 Highly agree n (%)	3 Partially agree n (%)	4 Agree to a low degree n (%)	5 Do not agree at all n (%)
Using leftover embryos for treatment of Parkinson's disease is permissible	1 (1)	306 (70.3)	89 (20.5)	20 (4.6)	6 (1.4)	14 (3.2)
It is allowable to use leftover embryos for treatment of other types of diseases	1 (1)	284 (65.3)	100 (23.0)	25 (5.7)	13 (3.0)	13 (3.0)
Using leftover embryos for treatment of diseases is acceptable, but iPS is equally effective	2 (2)	175 (40.2)	93 (21.4)	103 (23.7)	28 (6.4)	36 (8.4)

Note: Descriptive statistics are presented using medians, inter-quartile ranges (IQR), and the distribution of responses as counts and percentages (n, %).

The relationship between respondents' religious views and their attitudes toward using surplus embryos was analyzed through three separate logistic regression models for each attitude statement, as presented in **Table 4**. Participants who reported that religion had minimal significance in their lives were more inclined to support the use of surplus embryos than those who considered religion highly important. This association was most pronounced when surplus embryos were intended for treating Parkinson's disease (adjusted OR 6.39, 95 percent CI 2.78–14.71), followed by their use for other medical conditions (adjusted OR 3.47, 95 percent CI 1.56–7.71), and was least evident when embryos were used even though iPS cells were equally effective (adjusted OR 1.75, 95 percent CI 0.92–3.34).

Table 4. The association of importance of religion in life with attitudes toward using embryos for treatment of I) Parkinson's disease II) of other diseases III) of diseases, although iPS would be as efficient

	Crude model	Model 1	Model 2

	OR (95% CI)	OR (95% CI)	OR (95% CI)
Positive attitude toward using embryos for treatment of Parkinson's disease			
Importance of religion in life			
Very little, fairly little, neither little nor a lot of importance	10.74 (5.21–22.18)	9.35 (4.34–20.12)	6.39 (2.78–14.71)
Fairly high, very high importance	1.00 (ref)	1.00 (ref)	1.00 (ref)
Positive attitude toward using embryos for treatment of other diseases			
Importance of religion in life			
Very little, fairly little, neither little nor a lot of importance	6.49 (3.31–12.73)	5.41 (2.68–10.94)	3.47 (1.56–7.71)
Fairly high, very high importance	1.00 (ref)	1.00 (ref)	1.00 (ref)
Positive attitude toward using embryos for treatment of other diseases, although iPS cells are as efficient			
Importance of religion in life			
Very little, fairly little, neither little or a lot importance	2.58 (1.42–4.69)	2.29 (1.24–4.23)	1.75 (0.92–3.34)
Fairly high, very high importance	1.00 (ref)	1.00 (ref)	1.00 (ref)

Associations are expressed as odds ratios (OR) with 95 percent confidence intervals (CI), taking respondents who regarded religion as fairly or very important as the reference category (ref). The crude analysis considered only religious views, whereas Model 1 additionally accounted for age, sex, education, health literacy, country of birth, and use of medications. Model 2 further incorporated the respondent's perception of the embryo's moral status.

Detailed regression results, provided in Additional File 2, reveal that participants who regarded the embryo as merely a lump of cells or something between a lump of cells and a human were more inclined to support the use of surplus embryos for treating Parkinson's disease (adjusted OR 7.86, 95% CI 3.43–18.02). In contrast, variables such as age, sex, health literacy, and country of birth showed no significant relationship with attitudes. Further analysis demonstrated that individuals who placed little importance on religion were more likely to assign a lower moral status to the embryo (adjusted OR 4.61, 95 percent CI 2.27–9.36; Additional File 2, Table S5).

Priorities for the use of ES cells in drug development

When asked to rank key considerations for utilizing surplus embryos in drug development **(Table 5)**, respondents prioritized ensuring access to novel and effective therapies for diseases without existing treatments. The next most important factors were minimizing the risk of severe adverse effects and maintaining transparency from pharmaceutical companies involved in the process.

Table 5. Public perspectives on key considerations for using surplus embryos in drug development

Statement	Median (IQR)	Times ranked as most important (n)
Ensuring access to new and effective treatments for diseases currently lacking options	1 (2)	255
Minimizing the risk of severe side effects from medical treatments	2 (2)	23
Maintaining transparency and oversight when pharmaceutical companies are involved in developing treatments using embryonic stem cells	4 (2)	32
Legislators should take into account the diverse values in society when making decisions about embryo use in medical treatments	5 (3)	45
Patients should be informed about how their treatment was developed before deciding whether to accept it	5 (4)	17
Allowing embryos to be used in medical treatment could lead to potential misuse in the future	6 (3)	14
From a moral standpoint, it is preferable to use induced pluripotent stem cells instead of embryonic stem cells	6 (3)	25
Couples donating embryos should not receive financial compensation for their donation	6 (4)	25

Notes: Respondents ranked the statements from 1 (most important) to 8 (least important). Data are presented as medians with interquartile ranges (IQR) and the number of respondents who ranked the statement as most important (n).

Discussion

The survey respondents generally expressed a very positive attitude toward the use of ES cells for therapeutic purposes, particularly for the treatment of Parkinson's disease (PD). Their support was somewhat lower when it came to treating other conditions. However, when induced pluripotent stem (iPS) cells were presented as equally effective alternatives, respondents showed reduced enthusiasm for the use of ES cells. These findings align with results from a previous interview study conducted with members of the Swedish population [18]. One potential explanation for this pattern is that individuals with a particular interest in PD may have been more likely to participate in the survey, which could have introduced a sample bias. Another factor could be the framing of information on PD at the beginning of the survey, which may have influenced respondents' attitudes.

The most highly prioritized factor in deciding whether to use ES cells for treatment was the potential to develop effective therapies for diseases currently lacking curative options. This focus likely explains why PD treatment received higher importance than treatment for other conditions, as existing PD therapies primarily manage symptoms rather than cure the disease. These results are consistent with a prior qualitative study, where respondents did not differentiate between PD and other serious chronic diseases without curative treatments [18]. Conversely, respondents placed less importance on using iPS cells instead of ES cells for moral reasons. Although ethical considerations were acknowledged, other factors appeared more influential. Notably, 25 respondents (5.7%) identified this moral aspect as the most important, suggesting that these individuals may have stronger religious beliefs and view the early embryo as having human or near-human moral status.

This study also identified a relationship between attitudes toward using ES cells for medical treatment and respondents' religious beliefs, as well as their perceptions of the early embryo's moral status within the Swedish general population. A Swiss study similarly found that IVF couples' perceptions of the embryo's moral status and their religious convictions independently predicted their willingness to donate surplus embryos for different purposes [20]. In the present study, relatively few respondents reported that religion was important or very important in their lives (11.4%) or considered the early embryo to have human or near-human moral status (12.6%). According to the Culture Map from the World Value Survey, Sweden is among the most secular countries globally [21]. The survey also highlights that the values of migrants from countries such as Afghanistan, Iraq, and Somalia differ considerably from those of native Swedes [21]. Supporting this, Sharma *et al.* reported that Asian immigrants in the United States were less inclined to donate surplus embryos for research purposes [22]. In our study, approximately 14% of respondents were born outside Sweden, though their countries of origin were not specified.

The evaluation of religious concerns in this study can be considered a limitation, as more nuanced insights might have emerged if we had employed instruments and questions from life-view research that assess not only religious beliefs but also morally significant values and fundamental attitudes integral to a religious worldview [23, 24]. Nevertheless, the primary aim was to determine whether respondents self-identified religion as important in their lives and whether this perception was shaped by beliefs about the world and humanity, morally relevant values, or basic life attitudes—whether generally positive or negative. The instrument used did capture both beliefs and values, including views on the biological and moral status of the human embryo. Previous research has similarly assessed religious views in this manner, finding that individuals with moderate to strong religious convictions were less likely to donate embryos for research purposes [25]. Further empirical work in life- and worldview studies could provide a deeper understanding of how both cohesive and fragmented religious perspectives influence moral judgments.

It is also important to note that perspectives from other religious contexts both align with and differ from the majority view observed in this study. For example, Sivaraman and Noor examined ethical positions on ES cell use among religious leaders from various faiths in Malaysia. They found that Islamic and Hindu leaders permitted the use of surplus embryos, which they considered of lower moral significance, but prohibited the use of "research embryos." Islamic leaders further emphasized that using ES cells is permissible for health maintenance and even obligatory if it can alleviate human suffering. Buddhist leaders in the same study did not differentiate ethically between the two types of embryos, endorsing ES cell use as long as it is approached with caution and care. In contrast, Catholic leaders opposed the use of embryos entirely, whether surplus or

designated for research. These varying positions reflected differing beliefs about the moral value of the embryo and the balance between potential benefits and harms. Interestingly, the study also found diversity of opinion among leaders within the same religion, except for the Catholic leaders, whose views were consistent with official Vatican guidance [17].

Besides religious beliefs and views on the moral status of the early embryo, previous research has shown that men generally tend to have a positive attitude toward permitting embryo donation for research purposes [14, 26]. Consistent with this, the univariate analyses in the current study indicated that men expressed more favorable attitudes. However, this gender effect was not observed in the adjusted analyses. Additionally, past studies have reported that health professionals are more supportive than the general public when it comes to donating embryos for research [26]. Factors such as being scientifically inclined and having trust in experts and the healthcare system are also associated with more positive attitudes [13, 18]. A limitation of this study is that it did not evaluate respondents' trust in healthcare systems or whether they were employed in healthcare. The questionnaire also did not capture considerations related to genetic privacy for donors or issues surrounding commercialization. Another limitation is the low response rate (17%), which restricts the generalizability of the findings to the broader Swedish population. Our sample included a higher proportion of university-educated individuals compared with the general population. Nonetheless, a random sample of the public was invited, and the final participants included an equal number of men and women spanning a range of ages, education levels, and occupational backgrounds, which strengthens the study. Although some migrant groups may be underrepresented, the data still provide insights into the attitudes and values of native Swedes across diverse demographics.

Ethical debates surrounding stem cell use reflect significant moral concerns and have sometimes sparked intense discussions [27, 28]. Similar ethical debates emerged with technologies such as gene therapy, pre-implantation genetic diagnosis, whole genome sequencing, and gene editing. Like stem cell research, these innovations initially provoked vigorous ethical scrutiny in scholarly and public discourse. Early applications of some of these technologies were premature and would have benefited from more robust evidence. Yet, as scientific knowledge has advanced and the benefits and risks have become clearer, many have transitioned into mainstream medical practice. Gene therapy, for example, emerged as a promising technology over 40 years ago but faced considerable opposition, including religious critiques framing it as "Playing God" [29]. Today, gene therapy has approved treatments and numerous ongoing clinical trials, governed by standard regulatory frameworks, despite its initially controversial reception. Against this backdrop, the results of the present study are particularly notable, highlighting that the general public primarily prioritizes the potential to address medical needs and improve treatment outcomes. Moreover, the history of stem cell research demonstrates that strong moral opinions, voiced by activists or religious leaders, can influence legislation and sometimes impede the development of valuable therapies. For democratic reasons, it is essential to engage the public—beyond just the most vocal groups—as direct stakeholders. While policy should not always follow majority opinion, policymakers should integrate public perspectives into a transparent dialogue to maintain trust in researchers, healthcare systems, and the pharmaceutical industry. The findings of this study can serve as a resource for policymakers in deliberation and communication.

Conclusion

Most respondents expressed a positive attitude toward using ES cells for drug development, emphasizing the importance of providing effective treatments to patients with no current therapeutic options. However, these attitudes are influenced by the specific medical condition targeted for treatment, as well as by respondents' religious beliefs and their perception of the early embryo's moral status.

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