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LEGAL REGULATIONS IN THE APPLICATION OF STEM CELLS

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Abstract. *The rapid development of regenerative medicine and the use of stem cells has been accompanied by significant ethical, social, and legal challenges. While scientific research continues to advance, legal frameworks often lag in defining the methods for obtaining, applying, and overseeing stem cells. Contemporary societies differ in their stance on the status of the embryo, the right to life, and the commercial use of stem cells, leading to inconsistencies in regulation. The aim of this paper is to analyze the existing legal regulations concerning the therapeutic use of stem cells and to explore the influence of ethical and cultural factors on their formulation. A systematization of scientific and professional evidence from available literature on legal regulations in the application of stem cells in regenerative medicine has been conducted. Various sources were used, including publications from medical journals, scientific and professional papers, as well as textbooks and expert monographs. The literature review was conducted using electronic databases (PubMed interface of MEDLINE from the National Library of Medicine, Google Scholar, Kobson, and SCIndex). The results indicate that legal systems worldwide are strongly influenced by religious and cultural factors. Significant differences were observed: from restrictive models in Italy to more liberal approaches in the United Kingdom, where the use of embryos from in vitro fertilization for research purposes is permitted. Iran stands out as a specific example, where Islamic ethical principles have been successfully integrated into the legal framework, allowing for stable development in this field. In the United States, the distinction between federal and state levels creates legal fragmentation. Clear legal regulation promotes clinical application and builds public trust, while legal ambiguity slows scientific progress. The conclusion emphasizes that global harmonization of ethical and legal standards is a prerequisite for the sustainable and safe development of stem cell therapies, and that public education and well-defined legal frameworks are essential to overcoming ethical uncertainties.*

Key words: *stem cells, legal regulation, ethical principles, embryonic stem cells, regenerative medicine*

Introduction

Stem cells represent the foundation of modern regenerative medicine due to their ability for self-renewal and differentiation into various cell types [1]. The first discoveries on the existence of stem cells date back to the mid-20th century, when experiments on animals confirmed the presence of cells capable of regenerating the hematopoietic system [2]. This laid the groundwork for the first clinical applications, among which bone marrow transplantation, used in the treatment of hematological disorders, remains the most successful stem cell-based therapy to this day [3,4].

The development of human embryonic stem cells (hESCs) during the 1990s opened new research opportunities, but also raised numerous ethical and legal debates due to their origin [5,6]. Adult stem cells, found in bone marrow, blood, adipose tissue, and other organs, have a more limited differentiation potential, but their use in transplantation medicine has demonstrated great clinical importance for decades [7,8]. Induced pluripotent stem cells (iPSCs), created by reprogramming differentiated cells into a state similar to embryonic ones, represent a revolutionary discovery, offering great potential without the ethical controversies surrounding embryonic cells [9,10,11].

Although stem cells bring enormous therapeutic possibilities, their clinical application requires careful and clear legal regulation, since the speed of scientific progress often surpasses the pace of legal framework adaptation [12]. The aim of this paper is to analyze existing legal regulations in the application of stem cells for therapeutic purposes and to highlight the influence of cultural and religious factors on their formation. At the same time, these scientific breakthroughs raise the question of how to reconcile scientific advancement with ethical and legal norms, which remains one of the key challenges today.

Methodology

The method applied in this paper was the systematization of scientific and professional data from available literature. The review included publications in medical journals, original research papers, systematic reviews, and monographs. Databases used were PubMed, Google Scholar, Kobson, and SCIndex. The analyzed documents referred to legal regulations in the application of stem cells, including national laws, ethical codes, and international recommendations. In this way, systematic analysis and comparability of data from different sources were ensured. The literature search was carried out using the following keywords: stem cells, embryonic stem cells, induced pluripotent stem cells, mesenchymal stem cells, legal regulations and stem cells, ethical principles, regenerative medicine.

Results and Discussion

There is no unified concept according to which ethical principles are defined and transformed into legal regulations. The concept depends on the socio-political or religious position of a given country or society.

Legal Regulations Worldwide, United States of America. The legal framework in the USA is complex due to differences between the federal and state levels. At the federal level, research on human embryonic stem cells has been limited to cell lines created before August 9, 2001 [13,14]. The federal government prohibited funding for new lines, which significantly slowed progress in this field. Certain states, such as California, adopted a more liberal approach and financed research with their own funds, leading to legal fragmentation and different working conditions within the same country [15]. This situation prompted the need for a more detailed analysis of the consequences on research development and the availability of therapies.

Europe. In Europe, legislation varies widely. The United Kingdom was one of the first countries to allow research and use of surplus embryos from IVF programs for scientific purposes, including the creation of new hESC lines, but always under strict supervision and clear restrictions [16]. Italy, on the contrary, applies a restrictive model where the use of embryos for research purposes is strictly prohibited. Other European countries, such as Denmark, France, and Spain, take moderate positions, while Belgium and Sweden go a step further, permitting even the creation of embryos for research, under strict regulation and control [15]. The European Union strives to harmonize these issues, but due to cultural and religious differences, a unified regulation has not yet been achieved. Germany adopts a more restrictive stance, allowing work only with imported embryonic stem cell lines, while prohibiting the creation of new ones. France also maintained a moderately restrictive position, with a long-standing ban on embryonic research, which was later partially lifted, allowing limited studies under strict state supervision [15]. Differences in legal models stem from diverse cultural and religious traditions, preventing quick harmonization.

Iran. Iran is a specific example in which Islamic ethical principles have been integrated into the national legal framework. In 2014, a national ethical code was adopted, consisting of 19 articles regulating research and application of stem cells [17]. Without presenting all articles in detail, it is important to emphasize that the code defines permissible sources of cells, prohibits commercialization of human material, and requires mandatory informed consent. This approach enabled stable research development and positioned Iran as a regional leader [18,19]. The example of Iran shows that it is possible to build a stable legislative framework that integrates local cultural and religious values with contemporary scientific demands.

Serbia. In Serbia, the application of stem cells is regulated by the Law on Human Cells and Tissues. Article 25 stipulates the collection of umbilical cord blood from live-born children and the storage of hematopoietic stem cells [20]. These stem cells may be used for the treatment of both related and unrelated persons, with written parental or guardian consent. Although a legal framework exists, it is still under development and requires further specification and improvement. The Agency for Biomedicine plays a special role in regulation, being responsible for issuing permits, controlling, and supervising the work with human cells and tissues. The future development of legislation in Serbia will need to follow European standards, particularly in the context of the EU accession process.

The comparative analysis shows that legislative models differ significantly depending on cultural and religious factors. Restrictive systems, as in Italy, practically prevent the development of research, while liberal models, such as in the United Kingdom, encourage scientific progress under strict supervision [14–16]. The United States illustrates the problem of legal fragmentation, where different states have opposing approaches, leading to uneven conditions and slowing progress [14,15]. Iran demonstrates that the integration of religious principles into the law can provide a stable system, while Serbia is still laying the groundwork for further development [17,18–20]. Clear and transparent regulation not only encourages research but also builds public trust, which is crucial for the acceptance of new therapies. The lack of clear regulations in some countries has led to a 'brain drain' of scientists and the relocation of research to countries with more liberal legislation. On the other hand, overly liberal approaches pose the risk of ethical disputes and potential misuse, requiring continuous adaptation of regulations to scientific progress and social needs. The consequences of such legal fragmentation are reflected in uneven development of research and clinical applications. While states with more liberal regulations, such as California, lead in the development of therapeutic methods and clinical trials, other states practically prohibit work on embryonic stem cell lines. This creates situations where patients within the same country do not have equal access to new therapies. Researchers are also forced to relocate their projects to states with more favorable legislation, generating additional financial and organizational difficulties [14,15].

Table 1. Overview of comparative legal regulations on the application of stem cells in different countries and regions. The table presents regulatory approaches, key characteristics, and their consequences for the development of research and clinical practice.

Country / Region	Regulatory approach	Characteristics	Consequences
USA [13,14,15]	Fragmented (federal and state levels)	Restriction to old hESC lines; California funds independent research	Uneven development, researcher relocation
Europe [15,16]	Variable (from restrictive to liberal)	UK liberal, Italy restrictive, others moderate	Lack of harmonization, different pace of development
Iran [17-19]	National ethical code (2014)	Integration of religious principles and modern science	Stable development, strengthened public trust
Serbia [20]	Law on Human Cells and Tissues	Collection and storage of umbilical cord stem cells	Foundations established, but further refinement required

Conclusion

Legal regulations in the field of stem cell application show significant differences among countries, shaped by cultural, religious, and political factors. While liberal systems enable faster development under supervision and control, restrictive approaches lead to stagnation in application. Global harmonization of standards and the development of clear national regulations are prerequisites for the safe and

effective use of stem cells in therapeutic purposes. For Serbia, it is particularly important to align with European legal frameworks, which will provide not only legal security but also better integration into international research projects. Future development in this area will depend on the ability of states to establish a balance between scientific freedom and legal certainty.

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ZAKONSKE REGULATIVE U PRIMENI MATIČNIH ĆELIJA

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Sazetak. *Ubrzani razvoj regenerativne medicine i upotrebe matičnih ćelija praćen je značajnim etičkim, društvenim i pravnim izazovima. Dok naučna istraživanja napreduju, pravni okviri često kasne u definisanju načina dobijanja, primene i kontrole matičnih ćelija. Savremena društva se različito odnose prema statusu embriona, pravu na život, kao i komercijalnoj upotrebi matičnih ćelija, što dovodi do neujednačenosti u regulativama. Cilj ovog rada je da se analiziraju postojeće zakonske regulative u vezi sa primenom matičnih ćelija u terapeutske svrhe, i da se sagleda uticaj etičkih i kulturoloških faktora na njihovo formiranje. Izvršena je sistematizacija naučnih i stručnih dokaza iz dostupne literature u oblasti pravnih regulativa primene matičnih ćelija u regenerativnoj medicini. U izradi su korišćene različite publikacije medicinskih časopisa, naučnih i stručnih radova, kao i dostupne literature iz udžbenika i stručnih knjiga. Pregled literature je izvršen korišćenjem elektronske baze podataka (PubMed interface MEDLINE -a iz National Library of Medicine, Google Scholar, Kobson i SCIndex). Rezultati ukazuju da su pravni sistemi u svetu snažno uslovljeni religijskim i kulturnim faktorima. Uočene su značajne razlike: od restriktivnih modela u Italiji, do liberalnih pristupa u Velikoj Britaniji, gde je dozvoljeno korišćenje embriona iz vantelesne oplodnje za istraživanja. Poseban primer predstavlja Iran, gde su islamski etički principi uspešno integrisani u pravnu regulativu, što je omogućilo stabilan razvoj u ovoj oblasti. U SAD postoji razlika između federalnog i državnog nivoa, što stvara pravnu fragmentaciju. Jasna zakonska regulativa podstiče kliničku primenu i poverenje javnosti, dok pravna neuređenost usporava naučni napredak. Zaključak pokazuje da je globalna harmonizacija etičkih i pravnih standarda preduslov za održiv i bezbedan razvoj terapije matičnim ćelijama, a da edukacija javnosti i jasni zakonski okviri predstavljaju ključ u prevazilaženju etičkih nedoumica.*

Ključne reči: *matične ćelije, zakonska regulativa, etički principi, embrionalne matične ćelije, regenerativna medicina*