

## AWARENESS AND ATTITUDES OF PRIMARY HEALTHCARE PHARMACISTS REGARDING THE EFFICACY AND SIGNIFICANCE OF STEM CELL APPLICATIONS FOR MEDICAL PURPOSES

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## SVEST I STAVOVI FARMACEUTA PRIMARNE ZDRAVSTVENE ZAŠTITE U VEZI SA EFIKASNOŠĆU I ZNAČAJEM PRIMENE MATIČNIH ČELIJA U MEDICINSKE SVRHE

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### ABSTRACT

**Objective.** In recent years, interest in the collection and preservation of umbilical cord blood stem cells has increased substantially, owing to their therapeutic potential in a range of medical conditions. As highly accessible healthcare professionals, primary care pharmacists are frequently consulted on diverse medical issues. Consequently, it is imperative that they possess comprehensive knowledge, including a thorough understanding of stem cell applications and engage in ongoing professional development. This study aimed to assess the awareness, attitudes, and opinions of licensed pharmacists working in primary healthcare regarding the medical use of stem cells.

**Methods.** A cross-sectional survey was conducted using anonymous questionnaires (Stem-KAAQ instrument) and was distributed to pharmacists (n=248) in primary healthcare settings across the Central part of Serbia. Data were collected from July 1 to August 1, 2022, and analyzed using IBM SPSS Statistics and MS Excel. Inclusion criteria encompassed current employment as a primary healthcare pharmacist in Serbia and voluntary informed consent to participate in the study.

**Results.** The study involved 248 participants employed at the primary healthcare level with the mean age of 29.61±2.23 and most of them were women (82.3%). The most of them, 154 (62.1%) had never heard of the stem cell donor registry, while 94 (37.9%) were informed about its existence, which indicates poor awareness of healthcare professionals in general about stem cell donor registries; 216 (87.1%) of the respondents claimed that embryonic stem cells are capable of differentiating into any type of cell in the body, including the placenta. 86.3% of the respondents considered that cord blood stem cells are the same as embryonic stem cells, while 13.7% of them considered this statement to be incorrect. Also, 89.1% of the respondents believed that the collection of cord blood stem cells could not cause pain and possible harmful risks for the newborn and the mother. Interestingly, the knowledge related to the stem cell donor registry was significantly higher in employees from private sector.

### SAŽETAK

**Cilj.** Tokom poslednjih godina znatno je porastao interes za prikupljanje i čuvanje matičnih ćelija iz krvi pupčanika zbog njihovog terapijskog potencijala u lečenju različitih medicinskih stanja. Kao lako dostupni zdravstveni profesionalci, farmaceuti primarne zdravstvene zaštite često se konsultuju o raznovrsnim medicinskim pitanjima. Stoga je suštinski značajno da poseduju sveobuhvatno znanje, uključujući temeljno razumevanje primene matičnih ćelija, kao i da se kontinuirano stručno usavršavaju. Ova studija imala je za cilj da proceni svest, stavove i mišljenja licenciranih farmaceuta zaposlenih u primarnoj zdravstvenoj zaštiti o medicinskoj upotrebi matičnih ćelija.

**Metode.** Sprovedena je studija preseka korišćenjem anonimnih upitnika (Stem-KAAQ instrument), koji su distribuirani farmaceutima (n = 248) u ustanovama primarne zdravstvene zaštite na području centralne Srbije. Podaci su prikupljeni od 1. jula do 1. avgusta 2022. godine i analizirani korišćenjem IBM SPSS Statistics i MS Excel programa. Kriterijumi za uključivanje obuhvatali su trenutno zaposlenje na mestu farmaceuta u primarnoj zdravstvenoj zaštiti u Srbiji i dobrovoljni informisani pristanak za učešće u studiji.

**Rezultati.** U studiji je učestvovalo 248 ispitanika zaposlenih na nivou primarne zdravstvene zaštite, prosečne starosti 29,61 ± 2,23 godine, pri čemu je većina bila ženskog pola (82,3%). Većina ispitanika, 154 (62,1%), nikada nije čula za registar donora matičnih ćelija, dok je 94 (37,9%) bilo informisano o njegovom postojanju, što ukazuje na nedovoljnu svest zdravstvenih profesionalaca o registrima donora matičnih ćelija. Dalje, 216 (87,1%) ispitanika tvrdilo je da embrionalne matične ćelije imaju sposobnost diferencijacije u bilo koji tip ćelija u organizmu, uključujući i placentu. 86,3% ispitanika smatralo je da su matične ćelije iz krvi pupčanika isto što i embrionalne matične ćelije, dok je 13,7% smatralo da je ova tvrdnja netačna. Takođe, 89,1% ispitanika verovalo je da prikupljanje matičnih ćelija iz krvi pupčanika ne može izazvati bol niti potencijalne štetne rizike za novorođenče i majku. Zanimljivo je da je znanje u vezi sa registrom donora matičnih ćelija bilo znatno veće kod zaposlenih u privatnom sektoru.

*Conclusion. The analysis revealed no statistically significant differences in awareness, attitudes, or opinions between pharmacists working in public and private sectors, except for a significant difference regarding knowledge of the existence of a stem cell donor registry ( $p < 0.05$ ). The findings indicate that pharmacists in both the public and private primary care sectors possess different levels of knowledge and share similar attitudes toward stem cell applications, with the prominent awareness of the pharmacists employed in the private sector. The study highlights the critical importance of continuous education and training for pharmacists in the evolving field of regenerative medicine.*

**Key words:** stem cells; regenerative medicine; pharmacists; attitude; primary health care.

## INTRODUCTION

In contemporary medicine, a growing number of diseases demand novel therapeutic strategies due to their resistance to existing treatments or the lack of comprehensive and effective therapies. One emerging approach is the use of stem cells and their derivatives in regenerative medicine. This method has garnered attention, particularly for patients with no alternative therapeutic options, positioning it as a potentially lifesaving intervention (1). However, widespread application is hindered by limited awareness among both healthcare professionals and patients. Therefore, education and informed consent are essential components prior to considering stem cell-based therapies (2).

Stem cells are classified in several ways, most notably by their tissue of origin or by their differentiation potential, also known as potency. Five major categories have been described to date: embryonic stem cells, very small embryonic-like stem cells, nuclear transfer stem cells, pluripotent stem cells, and adult stem cells. Among these, only nuclear transfer stem cells have demonstrated the ability to generate a complete organism, as demonstrated by the creation of non T cell-specific cells (NTSC) – derived from monkeys in China in 2018 (2).

The reprogramming of adult cells into a pluripotent state can be achieved through various methods, including nuclear transfer, cell fusion, and the introduction of pluripotency-associated transcription factors. The most well-known example of nuclear transfer is the cloning of Dolly the sheep, achieved using somatic follicular cells. Although the mechanism underlying cell fusion with embryonic stem cells remains poorly understood, it is well established that the introduction of genes such as OCT4, SOX2, KLF4, and C-MYC can induce a pluripotent state in differentiated cells (3, 4).

Assessment of pluripotency in vitro and in vivo typically involves animal models. The teratoma formation assay is employed to observe spontaneous differentiation into tissues of all three germ layers following transplantation into immunocompromised mice. The

*Zaključak. Analiza nije pokazala statistički značajne razlike u svesti, stavovima i mišljenjima između farmaceuta zaposlenih u javnom i privatnom sektoru, osim u pogledu znanja o postojanju registra donora matičnih ćelija ( $p < 0,05$ ). Nalazi ukazuju na to da farmaceuti u javnom i privatnom sektoru primarne zdravstvene zaštite poseduju različite nivoe znanja, ali dele slične stavove prema primeni matičnih ćelija, pri čemu je svest izražena kod farmaceuta zaposlenih u privatnom sektoru. Studija naglašava kritičnu važnost kontinuirane edukacije i obuke farmaceuta u oblasti regenerativne medicine koja se stalno razvija.*

**Ključne reči:** matične ćelije; regenerativna medicina; farmaceuti; stav; primarna zdravstvena zaštita.

chimera formation assay evaluates whether donor stem cells can integrate into early-stage embryos and contribute to germline development. The most stringent test, tetraploid complementation, determines the capacity of stem cells to support the development of a complete organism, thereby confirming their functional pluripotency (5).

Although induced pluripotent stem cells (iPSCs) are widely seen as therapeutic tools, their greatest value may be in disease modeling and drug testing. Due to the significant gap between animal models and human responses—evident in cases like amyotrophic lateral sclerosis drugs failing in clinical trials human cell-based systems are essential for reliable drug screening (4).

iPSCs have enabled the creation of disease-specific organoids and the modeling of pathological features in vitro. For example, Yamashita et al. showed that statins, commonly used for hyperlipidemia can reverse cartilage damage in iPSC-derived chondrocytes from patients with thanatophoric dysplasia type 5 and achondroplasia. This demonstrates the utility of iPSCs in disease modeling and drug repurpose, leading to the development of many patient-specific iPSC lines for studying rare and complex diseases (6).

Stem cell banking, a specialized form of biobanking, involves collecting and storing biological materials such as stem cells to support research and clinical use. Proper standardization and quality control are vital for advancing therapies and enabling cross-laboratory comparison of results. Umbilical cord blood banking has grown significantly, with over 600,000 units stored worldwide and more than 30,000 transplants performed. This trend reflects increasing parental interest in preserving newborn stem cells for future therapeutic use (7, 8).

Recent advances in regenerative medicine have highlighted the growing intersection between pharmacy and stem cell research, emphasizing the importance of interdisciplinary collaboration. Although pharmacy may initially appear unrelated to stem cell applications, pharmacists play a crucial role in research, particularly in

drug development and delivery systems. Stem cell-derived organoids serve as innovative platforms for drug testing, complementing traditional animal models and enhancing the predictive value of preclinical studies (9). Bioengineering utilizes scaffolds, specialized materials designed to support tissue growth to create transplantable organs and tissues, which also function as models for evaluating new drugs. Pharmacists, working alongside engineers and clinicians, contribute to optimizing these developments, especially in designing targeted drug delivery systems for challenging environments like the central nervous system and cardiac tissues. Combining advanced delivery systems with stem cells improves drug stability, survival, differentiation, and engraftment of transplanted cells (10, 11).

Pharmacists engage across all healthcare levels from primary care in community pharmacies to tertiary care in clinical centers where they contribute to medication management, patient counseling, and therapeutic decision-making. As accessible healthcare professionals, pharmacists often serve as the first point of contact, monitoring symptoms, guiding patients on treatment adherence, and advising on non-pharmacological interventions. Their involvement extends to developing treatment protocols and reporting adverse drug reactions. Given the novelty of regenerative therapies, pharmacists frequently encounter patients with unrealistic expectations or misinformation about stem cell treatments, including umbilical cord blood banking and supplements marketed to enhance stem cell function. Continuous education in regenerative medicine is essential for pharmacists to provide evidence-based guidance and clarify misconceptions (12, 13). Several antioxidants such as N-acetylcysteine (14), home cocktails with ascorbates, glutathione and tocopherol (15), hibiscus extract (16), lipocalin (17), ascorbic acid phosphate (18), edaravone (19), melatonin (20), tempol and resveratrol (21) have demonstrated protective effects on various stem cell types by reducing oxidative stress, promoting differentiation, and enhancing survival (22, 23). Additionally, platelet-rich plasma (PRP) therapy (24) and traditional Chinese medicine have shown potential in stimulating stem cell regeneration and overall cellular health (25).

Despite these advances, challenges persist. The pharmaceutical profession faces threats from healthcare policy changes, commercialization, and the rise of online consultations, which reduce direct pharmacist-patient interactions. Nonetheless, pharmacists' commitment to patient-centered care, disease prevention, and lifelong learning remains vital.

The aim of this research was to examine the general level of awareness of pharmacists regarding the basic concepts of regenerative medicine in the Republic of Serbia; to examine the level of awareness of pharmacists

at the primary health care level about the methods of isolating and using stem cells; and to analyse the attitudes of pharmacists regarding the use of stem cells in regenerative medicine.

## SUBJECTS AND METHODS

### *Design and ethical considerations*

This qualitative cross-sectional study was conducted as anonymous voluntary research using questionnaire. Written informed consent in form of question-choice was obtained from all participants. Approval for using the tool in our research (26) was obtained from the author of standardized questionnaire.

### *Study population and protocol*

This qualitative cross-sectional study was conducted between July 1 and August 1, 2022. The participants were licensed pharmacists employed in primary healthcare settings employed in the central part of Republic of Serbia (Sumadija Region). The questionnaire encompassed items related to sociodemographic characteristics, awareness, and attitudes regarding stem cell applications. The study included 248 licensed pharmacists employed in private and public primary healthcare settings. The main inclusion criteria were current employment as a pharmacist at the primary healthcare level in Serbia minimum 6 months before the study and voluntary participation in the study. Exclusion criteria comprised respondents without a valid pharmacy license, those residing outside Serbia, and incomplete questionnaire submissions.

Participants completed the questionnaire electronically via the Google Forms platform, which required all respondents to have internet access. The survey was distributed randomly, either individually or through social media channels, to individuals who confirmed their consent to participate by affirmatively answering the first question.

The questionnaire included questions about the pharmacist's knowledge, awareness, and attitudes regarding stem cell research and clinical applications

The used instrument (Stem-KAAQ) was an anonymous standardized questionnaire conducted by Al-Shammary et al (26) which consists of 32 questions (Supplement 1), designed to be completed in under 10 minutes. The questionnaire was designed to assess pharmacists' knowledge, awareness, and attitudes regarding stem cell research and clinical applications. The first question addressed consent for participation in the study. This instrument has 4 domains, as follows:

- I Demographic questions (7 questions),
- II General awareness of respondents about stem cell biology (Q1-Q7),

- III Knowledge of the participants related to the stem cell use and clinical applications (Q8-Q15),
- IV Awareness and concerns of the participants related to clinical application of stem cells (Q16-Q25).

The first group includes seven questions gathered sociodemographic information, including age, gender, marital status, years of work experience, current employment, and awareness of the stem cell donor registry.

The second domain is about the knowledge and understanding of fundamental concepts related to stem cell biology. Respondents were instructed to indicate whether each statement was "True" or "False." The items addressed key aspects of stem cell characteristics, sources, and medical applications. The third domain includes questions related to the participants' awareness of stem cell sources—such as umbilical cord blood, bone marrow, and somatic cells—as well as common misconceptions, for instance, whether sperm and egg cells are considered sources of adult stem cells or whether umbilical cord blood stem cells are embryonic in origin. The fourth domain has items examined participants' understanding of clinical and ethical dimensions of stem cell use, including potential risks associated with cord blood collection, the likelihood of graft-versus-host disease, and controversies surrounding embryonic stem cell transplantation. The inclusion of these questions aimed to capture both the factual and conceptual components of pharmacists' knowledge and to identify prevalent misconceptions relevant to their professional practice in the field of regenerative medicine. The attitudes section of the questionnaire consisted of 10 statements designed to assess participants' perceptions, ethical viewpoints, and professional attitudes regarding stem cell research and transplantation. Respondents were asked to indicate their level of agreement with each statement using a five-point Likert scale ranging from "Strongly disagree" to "Strongly agree."

All questions were closed-ended and mandatory, preventing submission of incomplete questionnaires. The items addressed ethical and moral considerations, including concerns about potential harm to human life, views on embryonic stem cell research, the moral status of the blastocyst, and the perceived legitimacy of using embryonic material for scientific purposes. Several statements explored participants' opinions on the broader implementation of stem cell transplantation and their willingness to advise patients on umbilical cord blood preservation for potential future therapeutic use (26).

Additional items focused on professional and educational attitudes, examining the perceived importance of competence in stem cell knowledge, awareness of potential benefits and risks associated with stem cell applications, and the need for further educational

resources and events to keep healthcare professionals informed about current developments in regenerative medicine. One statement also addressed optimism regarding the future of humanity considering ongoing stem cell research (26).

Collectively, these items aimed to capture both the ethical and professional dimensions of pharmacists' attitudes toward stem cell research and applications, providing insight into how their beliefs, awareness, and professional responsibilities intersect in the context of regenerative medicine.

### *Statistical analysis*

The sample size was calculated according to the sample-to-item ratio rule to ensure reliable results. Following data entry into the database, analysis was performed using the Chi-square test, with a significance level set at 0.05. If the p-value was less than 0.05, the difference between the data was considered statistically significant. Statistical analysis was conducted using IBM SPSS Statistics version 26.0.

## **RESULTS**

### *Baseline characteristics of study population*

The study involved 248 participants employed at the primary healthcare level with the mean age of  $29.61 \pm 2.23$  and most of them were women (82.3%). It is important to note that, according to data from the Pharmaceutical Chamber of Serbia, there are over 7,000 licensed pharmacists registered in Serbia, and in the Central Serbia (region Sumadija) about 1500 pharmacist are employed in the primary pharmaceutical sector. Therefore, the sample of 248 respondents represents approximately 16.5% of the total number of licensed pharmacists in the central region of country. The majority of respondents were female (82.3%) and employed in the public sector (76.2%). Most participants were non-smokers (83.9%) and unmarried (61.3%) (Table 1).

### *Assessment of the level of knowledge about the fundamental concepts related to stem cell biology among the study group*

The fact that out of the total number of respondents, as many as 154 (62.1%) had never heard of the stem cell donor registry, while 94 (37.9%) were informed about its existence indicates poor awareness of healthcare professionals in general about stem cell donor registries. In the part of the questionnaire that contained questions about the respondents' level of awareness, there is also the statement that stem cells are unspecialized, and the majority of 142 (57.3%) respondents marked "true", while 106 (42.7%) respondents marked a negative answer (Table 2). This shows that the majority of respondents are

Table 1. Socio-demographic characteristics of the study population.

| Variable                         | Frequency | Percentage | Statistical significance (p) |
|----------------------------------|-----------|------------|------------------------------|
| Age (years) 29.61±2.23           |           |            | /                            |
| Gender                           |           |            |                              |
| Male                             | 44/248    | 17.7%      | p<0.05*                      |
| Female                           | 204/248   | 82.3%      |                              |
| Work experience (years) 7.7±0.56 |           |            | /                            |
| Sector                           |           |            |                              |
| Public                           | 189/248   | 76.2%      | p<0.05*                      |
| State                            | 59/248    | 23.8%      |                              |
| Smoking status                   |           |            |                              |
| Yes                              | 208/248   | 16.1%      | p<0.05*                      |
| No                               | 40/248    | 83.9%      |                              |
| Marital status                   |           |            |                              |
| Married                          | 96/248    | 38.7%      | p<0.05*                      |
| Unmarried                        | 152/248   | 61.3%      |                              |

Table 2. Level of awareness among total study group.

| Item | Participants' level of awareness (n=248) |                         |                        |                         | Statistical significance (p) |
|------|------------------------------------------|-------------------------|------------------------|-------------------------|------------------------------|
|      | Informed                                 |                         | Un-informed            |                         |                              |
|      | Frequency (from total)                   | Percentage (from total) | Frequency (from total) | Percentage (from total) |                              |
| Q1   | 94                                       | 37.9%                   | 154                    | 62.1%                   | p<0.05*                      |
| Q2   | 142                                      | 57.3%                   | 106                    | 42.7%                   | p>0.05                       |
| Q3   | 218                                      | 87.9%                   | 30                     | 12.1%                   | p<0.05*                      |
| Q4   | 119                                      | 48%                     | 129                    | 52%                     | p>0.05                       |
| Q5   | 181                                      | 73%                     | 67                     | 27%                     | p<0.05*                      |
| Q6   | 216                                      | 87.1%                   | 32                     | 12.9%                   | p<0.05*                      |
| Q7   | 34                                       | 13.7%                   | 214                    | 86.3%                   | p<0.05*                      |
| Q8   | 221                                      | 89.1%                   | 27                     | 10.9%                   | p<0.05*                      |
| Q9   | 225                                      | 90.7%                   | 23                     | 9.3%                    | p<0.05*                      |
| Q10  | 147                                      | 59.3%                   | 101                    | 40.7%                   | p>0.05                       |
| Q11  | 207                                      | 83.5%                   | 41                     | 16.5%                   | p<0.05*                      |
| Q12  | 145                                      | 58.5%                   | 103                    | 41.5%                   | p>0.05                       |
| Q13  | 39                                       | 15.7%                   | 209                    | 84.3%                   | p<0.05*                      |
| Q14  | 208                                      | 83.9%                   | 40                     | 16.1%                   | p<0.05*                      |
| Q15  | 164                                      | 66.1%                   | 84                     | 33.9%                   | p<0.05*                      |

Table 3. General awareness of respondents about stem cell biology.

| Question                                                   |                                                                                                | Response | Private Sector Employees | Public Sector Employees | Statistical Significance |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------|--------------------------|-------------------------|--------------------------|
| I GENERAL AWARENESS OF RESPONDENTS ABOUT STEM CELL BIOLOGY |                                                                                                |          |                          |                         |                          |
| Q1                                                         | Are you familiar with the stem cell donor registry?                                            | Yes      | 64 (68.1%)               | 30 (31.9%)              | p<0.05*                  |
|                                                            |                                                                                                | No       | 125 (81.2%)              | 29 (18.8%)              |                          |
| Q2                                                         | Stem cells are unspecialized.                                                                  | True     | 111 (78.2%)              | 31 (21.8%)              | p<0.05*                  |
|                                                            |                                                                                                | False    | 78 (73.6%)               | 28 (26.4%)              |                          |
| Q3                                                         | Stem cells can divide and self-renew over long periods.                                        | True     | 164 (75.2%)              | 54 (24.8%)              | p<0.05*                  |
|                                                            |                                                                                                | False    | 25 (83.3%)               | 5 (16.7%)               |                          |
| Q4                                                         | Sperm and egg cells are sources of adult stem cells.                                           | True     | 95 (73.6%)               | 34 (26.4%)              | p<0.05*                  |
|                                                            |                                                                                                | False    | 94 (79.0%)               | 25 (21.0%)              |                          |
| Q5                                                         | Adult stem cells are also known as somatic stem cells.                                         | True     | 133 (75.6%)              | 43 (24.4%)              | p<0.05*                  |
|                                                            |                                                                                                | False    | 56 (77.8%)               | 16 (22.2%)              |                          |
| Q6                                                         | Embryonic stem cells can differentiate into any cell type in the body, including the placenta. | True     | 167 (77.3%)              | 49 (22.7%)              | p<0.05*                  |
|                                                            |                                                                                                | False    | 22 (68.8%)               | 10 (31.3%)              |                          |
| Q7                                                         | Stem cells from umbilical cord blood are embryonic stem cells.                                 | True     | 163 (76.1%)              | 51 (23.9%)              | p<0.05*                  |
|                                                            |                                                                                                | False    | 26 (76.5%)               | 8 (23.5%)               |                          |

Table 4. Knowledge of the participants related to the stem cell use and clinical applications.

| II KNOWLEDGE OF THE PARTICIPANTS RELATED TO THE STEM CELL USE AND CLINICAL APPLICATIONS |                                                                                                                                                   |          |                          |                         |                          |
|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------------|-------------------------|--------------------------|
| Question                                                                                |                                                                                                                                                   | Response | Private Sector Employees | Public Sector Employees | Statistical Significance |
| Q8                                                                                      | Collecting stem cells from umbilical cord blood may cause pain and potential risks for the newborn and the mother.                                | True     | 20 (71.4%)               | 8 (28.6%)               | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 169 (76.8%)              | 51 (23.2%)              |                          |
| Q9                                                                                      | Transplantation of umbilical cord blood stem cells carries a lower risk of graft-versus-host disease compared to other types of stem cells.       | True     | 169 (75.1%)              | 56 (24.9%)              | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 20 (87.0%)               | 3 (13.3%)               |                          |
| Q10                                                                                     | Autologous stem cell transplantation in adults is controversial, primarily due to immunogenic graft rejection.                                    | True     | 76 (76.0%)               | 24 (24.0%)              | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 113 (76.4%)              | 35 (23.6%)              |                          |
| Q11                                                                                     | Stem cells can be used for testing new drugs and their efficacy.                                                                                  | True     | 157 (75.8%)              | 50 (24.2%)              | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 32 (78.0%)               | 9 (22.0%)               |                          |
| Q12                                                                                     | Bone marrow stem cells are extracted from the spine.                                                                                              | True     | 109 (75.2%)              | 36 (24.8%)              | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 80 (77.7%)               | 23 (22.3%)              |                          |
| Q13                                                                                     | Embryonic stem cell transplantation carries a serious disadvantage as it may lead to tumor formation.                                             | True     | 34 (87.2%)               | 5 (12.8%)               | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 155 (74.2%)              | 54 (25.8%)              |                          |
| Q14                                                                                     | Umbilical cord blood stem cell transplantation is less effective compared to bone marrow stem cell transplantation.                               | True     | 33 (82.5%)               | 7 (17.5%)               | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 156 (75.0%)              | 52 (25.0%)              |                          |
| Q15                                                                                     | Induced pluripotent stem cells (iPSCs) can be obtained from normal skin cells by introducing genes that control pluripotency and differentiation. | True     | 122 (74.4%)              | 42 (25.6%)              | p<0.05*                  |
|                                                                                         |                                                                                                                                                   | False    | 67 (79.8%)               | 17 (20.2%)              |                          |

informed about the definition of stem cells, which is necessary for further understanding the use of stem cells. It is interesting that as many as 87.9% of respondents selected the label "true" that stem cells are capable of dividing and self-renewing over a long period, although a smaller percentage of respondents were familiar with the first statement. It was expected that pharmacists would be more informed about embryonic stem cells, due to the increasing number of foreign stem cell banks that provide leaflets to mothers informing them about umbilical stem cells. 216 (87.1%) of the respondents claimed that embryonic stem cells are capable of differentiating into any type of cell in the body, including the placenta. For the statement that cord blood stem cells are the same as embryonic stem cells, 86.3% of the respondents considered this to be the case, while 13.7% of them considered this statement to be incorrect. Also, 89.1% of the respondents believed that the collection of cord blood stem cells could not cause pain and possible harmful risks for the newborn and the mother (Table 2, Figures 1a and b).

#### *Assessment of the general awareness of respondents about stem cell biology in private/public sector employees*

In the form of the Table 3 answers regarding the stem cell use knowledge are presented. All answers are as True/False type and divided regarding to the type of working place (private/public). Statistical significance was observed in the all items in this section. Interestingly,

the knowledge related to the stem cell donor registry was significantly higher in employees from private sector in comparison with public sector employees (Table 3).

#### *Assessment of the knowledge related to the stem cell use and clinical applications in private/public sector employees*

The knowledge of the participants related to the stem cell use and clinical applications in different working places is presented in Table 4. Statistical significance was observed between the answers among all items in this domain, with significant higher distribution of true answers in private sector employees (Table 4).

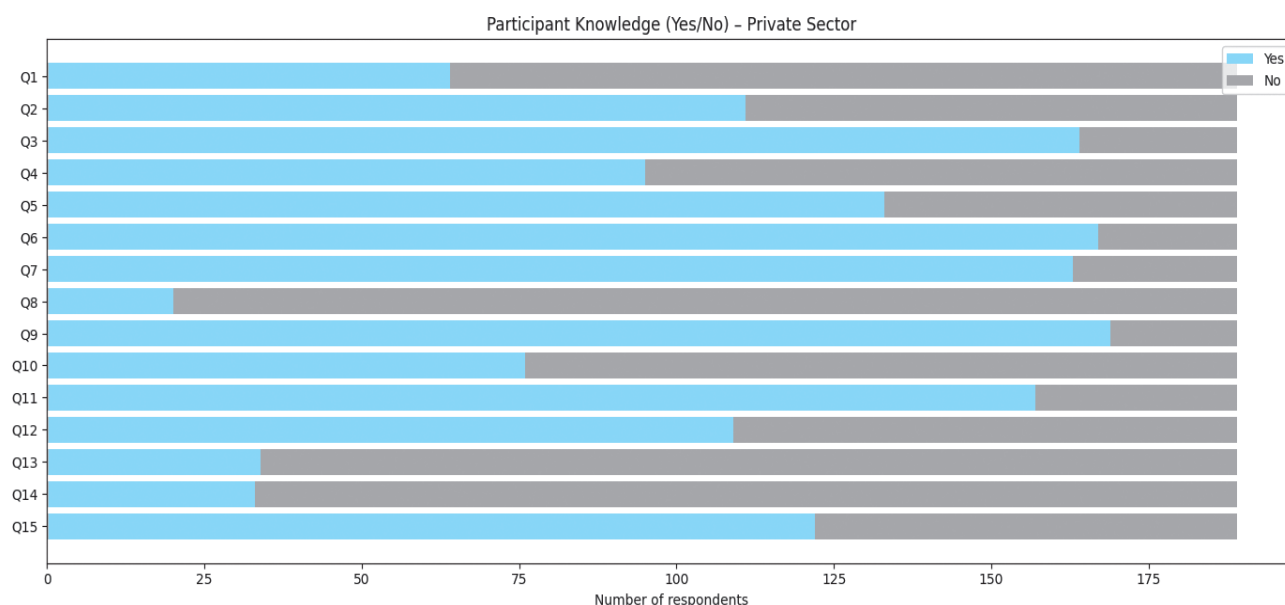
#### *Assessment of the awareness and concerns of the participants related to clinical application of stem cells in private/public sector employees*

The distribution the responses related to the awareness and concerns of the participants related to clinical application of stem cells is presented in Table 5. The responses were varied in type of the concerns, with predominately "disagree" and "not sure" at almost all items in both groups of participants. Similar distribution of responses were in Q20-Q22 and Q24, items which are related to future implementation and education in stem cell transplantations and other clinical applications. Interestingly, the concerns about the future stem cell research and use were very heterogenous in both employees, which means that the future of stem cells is questionable in general (Table 5).

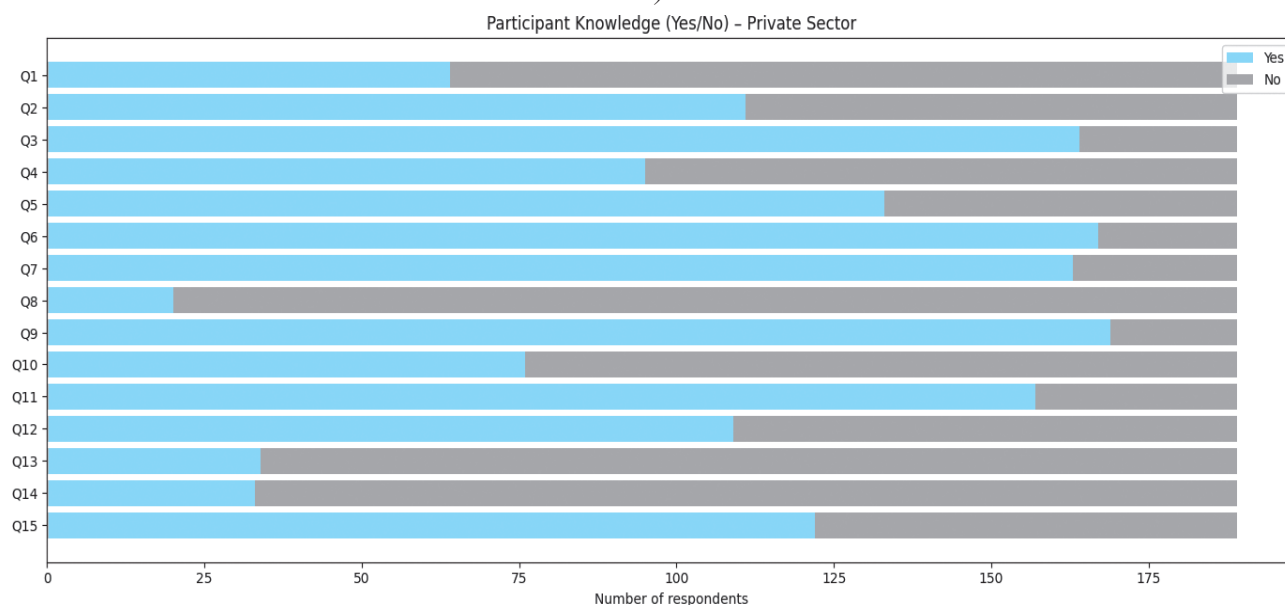
Table 5. Awareness and concerns of the participants related to clinical application of stem cells.

| III AWARENESS AND CONCERNS OF THE PARTICIPANTS RELATED TO CLINICAL APPLICATION OF STEM CELLS |                                                                                                                                         |                          |                         |                          |         |
|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------------|--------------------------|---------|
| Question                                                                                     | Response                                                                                                                                | Private Sector Employees | Public Sector Employees | Statistical Significance | p       |
| Q16                                                                                          | I am concerned that stem cell transplantation could potentially open the door to taking human lives for the benefit of others.          | Strongly disagree        | 38 (80.9%)              | 9 (19.1%)                | p<0.05* |
|                                                                                              |                                                                                                                                         | Disagree                 | 61 (77.2%)              | 18 (22.8%)               |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 67 (72.2%)              | 26 (28.0%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 17 (81.0%)              | 4 (19.0%)                |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 6 (75.0%)               | 2 (25.0%)                |         |
| Q17                                                                                          | Do you think the state should prohibit all research involving embryonic stem cells (including material obtained after abortion)?        | Strongly disagree        | 44 (75.9%)              | 14 (24.1%)               | p<0.05* |
|                                                                                              |                                                                                                                                         | Disagree                 | 84 (78.9%)              | 27 (24.3%)               |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 45 (78.9%)              | 12 (21.1%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 13 (81.3%)              | 3 (18.8%)                |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 3 (50.0%)               | 3 (50.0%)                |         |
| Q18                                                                                          | Life begins with conception; therefore, embryonic stem cell research involving embryo destruction is immoral, illegal, and unnecessary. | Strongly disagree        | 22 (73.3%)              | 8 (26.7%)                | p<0.05* |
|                                                                                              |                                                                                                                                         | Disagree                 | 39 (70.9%)              | 16 (29.1%)               |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 66 (74.2%)              | 23 (25.8%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 43 (89.6%)              | 5 (10.4%)                |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 19 (73.1%)              | 7 (26.9%)                |         |
| Q19                                                                                          | A blastocyst should be treated the same as a living adult human being.                                                                  | Strongly disagree        | 15 (62.5%)              | 9 (37.5%)                | p<0.05* |
|                                                                                              |                                                                                                                                         | Disagree                 | 46(86.8%)               | 7 (13.2%)                |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 70(73.7 %)              | 25 (26.3%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 35 (74.5%)              | 12 (25.5%)               |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 23 (79.3%)              | 6 (20.7%)                |         |
| Q20                                                                                          | Stem cell transplantation should be implemented more broadly.                                                                           | Strongly disagree        | 0 (0%)                  | 0 (0%)                   | p>0.05  |
|                                                                                              |                                                                                                                                         | Disagree                 | 8 (88.9%)               | 1 (11.1%)                |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 44 (72.1%)              | 17 (27.9%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 84 (75.7%)              | 27 (24.3%)               |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 53 (79.1%)              | 14 (20.9%)               |         |
| Q21                                                                                          | I would advise pregnant women to preserve umbilical cord blood stem cells of their child for potential future therapeutic use.          | Strongly disagree        | 1 (50.0%)               | 1 (50.0%)                | p>0.05  |
|                                                                                              |                                                                                                                                         | Disagree                 | 1 (100.0%)              | 0 (0.0%)                 |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 26 (72.2%)              | 10 (27.8%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 71 (75.5%)              | 23 (24.5%)               |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 90 (78.3%)              | 25 (21.7%)               |         |
| Q22                                                                                          | Competence in stem cell knowledge is important to me as a healthcare professional.                                                      | Strongly disagree        | 1 (100.0%)              | 0 (0.0%)                 | p>0.05  |
|                                                                                              |                                                                                                                                         | Disagree                 | 4 (57.1%)               | 3 (42.9%)                |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 27 (71.7%)              | 11 (28.3%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 96 (78.7%)              | 26 (21.3%)               |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 61 (76.3%)              | 19 (23.8%)               |         |
| Q23                                                                                          | I am aware of the potential benefits, applications, and risks associated with stem cell research.                                       | Strongly disagree        | 3 (100.0%)              | 0 (0.0%)                 | p<0.05* |
|                                                                                              |                                                                                                                                         | Disagree                 | 17 (81.0%)              | 4 (19.0%)                |         |
|                                                                                              |                                                                                                                                         | Not sure                 | 72 (79.1%)              | 19 (20.9%)               |         |
|                                                                                              |                                                                                                                                         | Agree                    | 64 (71.9%)              | 25 (28.1%)               |         |
|                                                                                              |                                                                                                                                         | Strongly agree           | 33 (75.0%)              | 11 (25.0%)               |         |

|     |                                                                                                                                                             |                   |             |            |         |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------|------------|---------|
| Q24 | There should be more educational events and materials to raise awareness about current developments in stem cell research and its therapeutic applications. | Strongly disagree | 0 (0.0%)    | 0 (0.0%)   | p>0.05  |
|     |                                                                                                                                                             | Disagree          | 1 (100.0%)  | 0 (0.0%)   |         |
|     |                                                                                                                                                             | Not sure          | 10 (83.3%)  | 2 (16.7%)  |         |
|     |                                                                                                                                                             | Agree             | 75 (71.4%)  | 30 (28.6%) |         |
|     |                                                                                                                                                             | Strongly agree    | 103 (79.2%) | 27 (20.8%) |         |
| Q25 | It is believed that with future stem cell research, humanity will have a bright future.                                                                     | Strongly disagree | 1 (100.0%)  | 0 (0.0%)   | p<0.05* |
|     |                                                                                                                                                             | Disagree          | 0 (0.0%)    | 1 (100.0%) |         |
|     |                                                                                                                                                             | Not sure          | 21 (61.8%)  | 13 (38.2%) |         |
|     |                                                                                                                                                             | Agree             | 86 (78.2%)  | 24 (21.8%) |         |
|     |                                                                                                                                                             | Strongly agree    | 81 (79.4%)  | 21 (20.6%) |         |



a)



b)

Figure 1. Distribution of the responses at Q1-Q15 in private (a) and public sector employees (b). Results are presented as distribution in percent (%) from total number of participants.

## DISCUSSION

This qualitative cross-sectional study was conducted through anonymous collection of responses to questions taken from a standardized questionnaire (2) which examined the knowledge and attitudes of licensed pharmacists working in primary healthcare across the territory of the Republic of Serbia regarding the application of stem cells for medical purposes. The main objective of the research was to assess the awareness and attitudes of primary healthcare pharmacists in order to gain a better understanding of the current level of knowledge, availability of information, willingness to acquire new knowledge, and openness to new treatment methods. The focus on primary healthcare was deliberate, as these healthcare professionals represent the “first line” in disease treatment and are the initial point of contact within any primary healthcare sector, preceding secondary and tertiary levels. Pharmacists were included in this research because, as part of public pharmacies operating within primary healthcare and in partnership with patients, they are always accessible for advice and support throughout any stage of the patient’s illness. Moreover, patients often place complete trust in them.

Given that pharmacists in public pharmacies at the primary healthcare level typically have a substantial workload including ordering, receiving, and storing goods, dispensing prescription and over-the-counter medications, as well as patient counseling, the study examined how they cope with daily changes and innovations in medicine. It also assessed whether they are up to date, have time for professional development and additional education, and whether they are sufficiently informed about stem cells. Furthermore, considering the increasing popularization of the topic and the continuous highlighting of stem cell therapy as a novel and highly promising treatment, the study explored pharmacists’ personal opinions regarding the application of stem cells, which may depend on various factors.

In a study by Cambray Smith et al. (27), which investigated the opinions, attitudes, and different approaches of specialist physicians in cardiology, ophthalmology, orthopedics, pulmonology, and neurology regarding experimental stem cell interventions, it was demonstrated that physicians tend to rely more on providing standard information about stem cell use to patients rather than adopting an individualized approach. Notably, the study emphasized the tools and resources available to physicians for obtaining information about the unconfirmed use of stem cells for medical purposes and for presenting patients with evidence-based information. Although the respondents in this study were physicians, similar results can confidently be expected when interviewing pharmacists, given the general lack of timely and accurate information. This underscores the necessity

for all healthcare professionals to stay informed about innovations in pharmacy and medicine, and to be able to distinguish confirmed therapeutic activity from assumptions.

The study included 248 graduate pharmacists employed at the primary healthcare level in the territory of the Republic of Serbia. The main inclusion criterion was that the participant was employed as a graduate pharmacist at the primary healthcare level and gave affirmative consent to participate in the study by answering the first question. Both pharmacists without prior experience and those with many years of work experience were included. The questionnaire was designed so that all questions were mandatory, and completion required answering every question. All participants were informed about the purpose of the study and were asked to respond honestly.

Approximately 60% of the total population of pharmacists identify as female. The pharmacy profession is considered one of the most desirable for employed mothers, and considering the statistically higher number of female pharmacists, it is concluded that this profession attracts more women than men (28). This explains why 82.3% of participants in this study were women, compared to 17.7% men.

Given the state of the labor market in the Republic of Serbia and the number of available positions, currently more pharmacists are employed in the private sector compared to the public sector. In this study, 189 participants (76.2%) were from the private healthcare sector, and only 23.8% were employed in the public sector. Differences in opinions and attitudes were also expected in relation to years of work experience; however, due to the broad scope of healthcare activities learned at the faculty and the rapid availability of information, younger pharmacists with minimal work experience can easily access desired information and are more likely to engage with new guidelines and innovations in pharmacy and medicine.

Another notable sociodemographic characteristic in this study was the low percentage of smokers among participants only 16.1%. This is explained partly by the higher number of female participants, as statistical data show women are less likely to smoke, and partly by the awareness and impact of knowledge about the harmful effects of tobacco smoke and the importance of leading a healthy lifestyle. Marital status was included as a parameter to show the percentage of participants in marital unions, with only 38.7% married, which reflects a trend of healthcare workers in the pharmaceutical profession postponing marriage at younger ages.

A striking fact is that 154 (62.1%) of the participants had never heard of a stem cell donor registry, while 94 (37.9%) were informed about its existence, indicating

generally low awareness among healthcare workers about stem cell donor registries. Such registries have been established in some countries to include healthy young donors willing to donate tissue, who have specific HLA typing, into a special database that enables faster and easier matching with recipients who are available and have signed consent for stem cell donation. The Stem Cell Club is a special NGO in Canada that gathers stem cell donors, maintaining a database to facilitate the need for stem cell donors in urgent transplantation cases (29).

Regarding the knowledge section of the questionnaire, 142 (57.3%) participants correctly identified that stem cells are unspecialized, while 106 (42.7%) gave a negative answer. This shows that most participants were aware of the definition of stem cells necessary for further understanding their use. Interestingly, 87.9% of respondents correctly identified that stem cells can divide and self-renew over long periods, although fewer were familiar with the first statement. It is assumed that the term "unspecialized" was not sufficiently clear for participants to give an adequate answer. From the table, the distribution of answers to the statement that sperm and egg cells are sources of adult stem cells shows some uncertainty, likely due to limited information in the native language and lower familiarity. Most participants (73%) know that adult stem cells are also known as somatic stem cells, while 27% consider this statement false.

Furthermore, 90.7% recognized that transplantation of stem cells from umbilical cord blood carries a lower risk of graft-versus-host disease (GVHD) than other types of stem cells, reflecting awareness based on available online materials. It is known that umbilical cord blood transplantation (UCBT) has several advantages over other methods, including safety for mother and donor, availability for urgent use, less strict HLA matching requirements, lower incidence and severity of chronic GVHD, and possibly stronger graft-versus-leukemia effects, especially in patients with minimal residual disease prior to transplantation. Recent studies have shown that UCBT outcomes are improved and comparable to other types of allogeneic hematopoietic stem cell transplantation (allo-HSCT). Currently, UCBT is widely used in malignant, non-malignant, hematologic, congenital, and metabolic diseases (30).

Beside general awareness, it was shown that the majority were familiar with the terminology related to transplantation, as 59.3% of respondents acknowledged that autologous stem cell transplantation in adults is controversial, primarily due to immunogenic graft rejection.

Most of the pharmacists (83.5%) were aware that clinical trials were being conducted on stem cells. Just over half of the respondents knew that bone marrow stem cells could be harvested from the spine. Regarding

questions on respondents' awareness, only 15.7% knew that the use of stem cells can cause tumor formation as an adverse effect. This issue raises many concerns regarding the application and justification of stem cell therapy, and highlights the need for more detailed education and consideration of therapeutic possibilities. It has been confirmed that stem cells, when applied in in vivo conditions, can lead to leukocyte reprogramming, resulting in pro-tumor immune cells that may cause metastasis, chemoresistance, tumorigenicity, and even increased tumor cell counts (31).

In accordance with table, the respondents showed that most believe the statement "umbilical cord blood stem cell transplantation is less effective compared to bone marrow stem cell transplantation" is not true, while 66.1% affirmed that induced pluripotent stem cells can be obtained from normal skin cells by introducing genes that regulate pluripotency and stem cell differentiation.

All previously mentioned questions concerned either demographic characteristics or respondents' knowledge about the use, terminology, and understanding of stem cells. Following this section, respondents expressed their attitudes toward the use of stem cells using a five-point Likert scale, ranging from "strongly disagree" to "strongly agree," based on their awareness and general knowledge about stem cells.

Despite all the information they possess, most respondents are not concerned that stem cells could be prone to misuse. Opinions were particularly divided regarding legal regulation of embryonic stem cell use and whether the state should ban all research involving embryonic stem cells (including material obtained after abortion). Most respondents disagreed, to a greater or lesser extent, with the statement advocating a ban. The highest percentage of them were uncertain when responding to questions related to ethical principles on the application and use of embryonic stem cells. The statement, "Life begins at conception; therefore, embryonic stem cell research involving embryo destruction is immoral, illegal, and unnecessary," elicited varied opinions, with 39.5% unsure how to respond and 34.3% somewhat disagreeing. Additionally, 38.3% were uncertain whether a blastocyst should be regarded as a living individual.

Respondents generally agreed, to varying degrees, that stem cell transplantation should be conducted more extensively. Most showed a positive attitude towards the preservation of umbilical cord blood stem cells, although 36.3% were uncertain about the potential benefits and risks associated with stem cell application. More than 80% considered competence in stem cell knowledge important for health professionals, and there was a confirmed belief that more educational events and materials raising awareness about current developments in stem cell

research and therapeutic applications are needed. Over 80% of respondents agreed, to some extent, that humanity will have a bright future with ongoing stem cell research.

A study by Aaron D. Levine et al. (32) highlights the problem where, due to the popularity of stem cell research, numerous clinics worldwide offer "stem cell therapies" for various medical conditions despite concerns about the safety and efficacy of these interventions. This phenomenon has raised alarm among regulatory institutions in the USA, prompting efforts to mitigate risks through the development of guidelines for patients and physicians. Professional guidelines from the American Medical Association and the International Society for Stem Cell Research were examined, assessing the professional and legal obligations of physicians towards patients considering unproven stem cell therapies. The study also underscores the importance of the roles of physicians and pharmacists in patient decision-making and compares these real-world roles with their professional and legal duties.

The study conducted by Smith, C. and colleagues (27) aimed to examine healthcare professionals' attitudes and opinions regarding the application of stem cells and interventions in regenerative medicine. The research included 25 physicians of various specialties who completed semi-structured questionnaires, later analyzed using statistical methods. The findings revealed that physicians relied more on providing information to patients about regenerative medicine interventions than on using relational counseling approaches. It is believed that efforts should be directed toward supporting physicians in meeting patients' informational and relational needs, including the provision of tools and resources to inform physicians about unproven interventions from the regenerative medicine industry, building empathetic communication skills, and developing and disseminating evidence-based resources for patients.

The study by Jennifer R. Arthurs and colleagues (33), which investigated the role of primary healthcare professionals in patient monitoring and counseling, highlighted certain shortcomings in information delivery. The authors emphasized that healthcare providers should recognize the type of information patients seeking and understand their level of knowledge regarding stem cells and regenerative medicine. Based on this, providers should communicate evidence-based information aligned with patients' levels of understanding, enabling them to be aware of the risks, benefits, and descriptions of potential procedures. During consultations, patients should be referred to reliable sources for further information. Ultimately, providers must make efforts to address misinformation in a non-judgmental, patient-centered manner, ensuring that patients feel safe and comfortable.

The cross-sectional study conducted by Abdulrahman Almaeen and colleagues (2) involved 217 medical and dental students from Jouf University and formed the basis for the current research. After obtaining informed written consent, the students were given a questionnaire comprising three sections: the first collected socio-demographic data, the second contained 15 questions on awareness, and the third consisted of 10 questions regarding attitudes towards stem cells. Considering the sociological context of the country, most participants were male (54.4%) aged 21–22 years. Awareness of the Saudi Stem Cell Donor Registry was reported by 50.7% of students. In total, 72.4% of students demonstrated moderate knowledge, while 70% held a positive attitude toward stem cell research and its medical significance. A significant correlation was observed between awareness and knowledge scores of the Saudi registry ( $p = 0.04$ ). The relationship between knowledge and attitude scores was also significant ( $p = 0.001$ ), with a Pearson correlation coefficient of  $r = 0.334$ . Most participants demonstrated a moderate to high level of knowledge, and a positive attitude towards stem cells and their relevance. A significant positive correlation was found between knowledge scores and attitudes. The study recommends the inclusion of various educational interventions for medical and dental students about the importance of stem cells in medicine. The results of this study are comparable to our findings, even though this study focused on students. We believe that common conclusions can be drawn, namely that improving understanding requires better education, more educational programs on stem cells, and, in our context, continuous education and greater involvement of healthcare professionals in patient counseling on this topic.

Stem cell research has been widely explored globally to improve human health within medical settings. However, there remains a lack of complete understanding regarding the level of knowledge and attitudes among nursing students in Malaysia. The study conducted by Jee Leng Lye and colleagues (34) aimed to assess the level of knowledge about stem cells, attitudes toward their application in medicine, and the correlation between knowledge and years of education among nursing students at Universiti Sains Malaysia (USM). In this cross-sectional study involving 88 participants enrolled in nursing programs, a questionnaire was used that included demographic information, knowledge of stem cells, and attitude statements. The data were statistically analyzed. Most participants (92%) had moderate knowledge of stem cells. Many students (33%) expressed concern that stem cell application could harm humanity, yet they held a positive attitude (76.1%) towards the therapeutic potential of stem cells (45.5%). A weak correlation between knowledge and attitude ( $r = 0.08$ ) indicates that acceptance of stem cells is not solely based on knowledge levels but

is also influenced by other factors including religion and culture. The study highlights the need to implement diverse educational programs on stem cells that account for religious, cultural, social, and behavioral determinants within the population in order to improve knowledge and promote a more positive attitude among healthcare professionals.

In our study, a comparison was made between responses to statements/questions across sectors namely, private versus public healthcare sectors. Data analysis did not reveal any statistically significant differences between the two groups across most questions, except in the case of awareness regarding the stem cell donor registry. A significant value of  $p < 0.05$  was recorded, indicating a difference in responses between pharmacists employed in the private versus the public sector. Overall, the study shows that there is no major difference in response distribution between pharmacists working in the private and public sectors. In accordance with the Health Care Act and the principles of equality in healthcare delivery, services in both sectors should be of standardized quality, ensuring equal levels of knowledge, awareness, and competence among healthcare professionals. This study demonstrates that pharmacists' level of awareness is uniform regardless of sector and employment type.

The limitations of this study include: a relatively small sample size, the fact that the survey was conducted online (which may have excluded individuals without internet access), the use of a pre-validated questionnaire adapted from a clinical trial rather than the creation of a custom-made instrument, and geographical limitations of the research.

We consider this study significant as it is the first in our country to compare opinions, awareness, and attitudes of primary healthcare pharmacists on the topic of stem cells. It highlights the need for conducting similar studies on larger samples in the future.

In conclusion, pharmaceutical healthcare at the primary level is organized in such a way that there is no significant difference in the responses of graduate pharmacists employed in public and private institutions. The level of awareness among graduate pharmacists was high, with most participants demonstrating considerable knowledge about stem cells. However, this knowledge should be further supported and framed through reliable sources available for ongoing education. Pharmacists' attitudes were not dependent on the sector in which they were employed. Their opinions generally leaned toward advocating for broader use of stem cells for medical purposes. A moderate to high level of knowledge was recorded among the majority of respondents employed in private sector, along with a clearly positive attitude toward the relevance and potential of stem cells. A significant positive correlation was observed between knowledge scores and attitudes. It is therefore recommended to

include various targeted educational programs for healthcare professionals working in primary care — as the most essential link in the healthcare system and the first point of contact — to improve understanding of the importance of stem cells in medical practice.

## NOTES

**Contributions.** Conceptualization, methodology, software, J.K.T. validation, formal analysis, investigation P.S; M.I; resources, data curation, writing original draft preparation, Dj.F., T.N.T.; writing review and editing, visualization, T.N.T.; P.S. supervision, S.M. project administration and funding acquisition. All authors have read and agreed to the published version of the manuscript.

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