

## Libyan Healthcare Professionals' Support for Stem Cell Biobanks - Survey Insights from Omar Al-Mukhtar University with a Veterinary Focus

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### Abstract:

Bio-banking is an advanced system designed to preserve biological materials alongside accurate data for use in medical research, clinical translational medicine, and veterinary applications. This study was conducted at the College of Veterinary Medicine, Omar Al-Mukhtar University in Al-Bayda, Libya, and aimed to evaluate the perspectives of the Libyan medical and veterinary community regarding the establishment of stem cell biobanks. A structured questionnaire was distributed to over 200 participants. Out of 200 participants, there were 52 men and 142 women, with 6 persons (3%) unspecified.—including veterinarians, physicians, pharmacists, students, and academic staff—during the university's first medical conference. The study explored the goals, quality standards, harmonization procedures, ethical considerations, and economic feasibility of establishing biobanks in Libya. Results revealed that 68% of respondents support the creation of stem cell biobanks under strict ethical guidelines, while 42% emphasized prioritizing veterinary applications to improve animal health and food security. Participants also identified orthopedic injuries (64%) and neurological disorders (51%) as primary veterinary conditions that could benefit from stem cell therapies. Despite positive attitudes, concerns were raised regarding the absence of legal frameworks and the need to increase public and professional awareness to ensure successful implementation.

**Keywords:** Stem Cells, Biobanking, Veterinary Medicine, Libya, Medical Community, Food Security, Ethics, Regenerative Therapies.

## دعم إقامة بنوك خلايا جذعية في ليبيا - استطلاع آراء المهنيين الطبيين والبيطريين مع التركيز على التطبيقات البيطرية

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### الملخص:

تُعد البنوك الحيوية أنظمة متقدمة تُستخدم لحفظ المواد البيولوجية وربطها ببيانات دقيقة لدعم الأبحاث الطبية، والطب الانتقالي، والتطبيقات البيطرية. أُجريت هذه الدراسة في كلية الطب البيطري جامعة عمر المختار بمدينة البيضاء، ليبيا، وهدفت هذه الدراسة إلى تقييم آراء المجتمع الطبي والبيطري الليبي بشأن إنشاء بنوك الخلايا الجذعية. تم توزيع استبيان منظم على أكثر من 200 مشارك 52 رجل و 142 نساء و 6 اشخاص لم يجيبوا عن خانة تحديد الجنس، شملوا الأطباء البيطريين، الأطباء، الصيادلة، الطلاب، وأعضاء الهيئة الأكاديمية، وذلك خلال المؤتمر الطبي الأول للجامعة. تناولت الدراسة أهداف إنشاء البنوك الحيوية، معايير الجودة، إجراءات التنسيق والتوحيد بين بنوك الخلايا الجذعية العالمية، الاعتبارات الأخلاقية، والجوانب الاقتصادية لإقامة بنوك حيوية في ليبيا. وأظهرت النتائج أن 68% من المشاركين يؤيدون إنشاء بنوك خلايا جذعية تحت إرشادات أخلاقية صارمة، بينما أكد 42% على ضرورة إعطاء الأولوية للتطبيقات البيطرية لتحسين صحة الحيوان والأمن الغذائي. كما حدد المشاركون الإصابات العظمية (64%) والاضطرابات العصبية (51%) كأهم الحالات البيطرية التي يمكن أن تستفيد من علاجات الخلايا الجذعية. ورغم المواقف الإيجابية، أثرت مخاوف بشأن غياب الأطر القانونية والحاجة إلى زيادة الوعي العام والمهني لضمان نجاح التطبيق.

**الكلمات المفتاحية:** الخلايا الجذعية، البنوك الحيوية، الطب البيطري، ليبيا، المجتمع الطبي، الأمن الغذائي، الأخلاقيات، العلاجات التجديدية.

## INTRODUCTION:

Stem cell technology has emerged as a revolutionary tool in veterinary medicine, offering new hope for treating a wide range of diseases and injuries in animals. Stem cells, characterized by their ability to differentiate into specialized cell types and promote tissue regeneration, present unique therapeutic opportunities. Veterinary applications of stem cell therapy have rapidly expanded, particularly in orthopedics, neurology, and internal medicine. This innovative approach not only enhances healing processes but also provides alternative treatments for conditions with limited conventional options. As research advances, stem cell technology continues to shape the future of animal healthcare, promoting improved outcomes and quality of life for veterinary patients (Vidal et al., 2020). Stem cell treatments represent a significant advancement in animal health, offering promising solutions for various diseases and injuries. Stem cells possess the unique ability to regenerate and differentiate into different cell types, aiding in tissue repair and promoting natural healing processes. Studies have demonstrated their effectiveness in treating musculoskeletal conditions such as osteoarthritis, neurological injuries, and chronic internal organ diseases. Additionally, stem cell therapies show great potential in reducing inflammation and enhancing immune responses, contributing to improved animal quality of life (Vidal et al., 2020). As research progresses, the critical role of this technology in providing innovative and effective veterinary care continues to expand (Harman et al., 2016). Stem cell technology has gained increasing attention in veterinary medicine due to its potential to revolutionize the treatment of various animal diseases and injuries. This research aims to evaluate the effectiveness of stem cell therapies in enhancing animal health and investigate their specific impact on conditions such as orthopedic and neurological disorders. The study also seeks to assess the safety, long-term outcomes, and underlying mechanisms of stem cell treatments. The rationale behind this research is to address existing knowledge gaps and contribute to the development of advanced, evidence-based therapeutic strategies that improve clinical outcomes and enhance the quality of life for animals (Vidal et al., 2020; Harman et al., 2016).

The Libyan medical community has faced several challenges in advancing healthcare services, with limited access to modern technologies and medical resources. In veterinary medicine, these challenges are even more pronounced, as the sector plays a critical role in maintaining animal health and supporting the agricultural industry. Despite this, there has been minimal integration of advanced therapies, such as stem cell treatments, in veterinary practices across the country. This study is highly relevant to the Libyan context as it aims to explore the potential of stem cell therapies in treating animal diseases and injuries, offering an innovative approach to addressing the healthcare needs of livestock and pets. By introducing these advanced treatment options, the research could play a pivotal role in improving animal welfare, supporting veterinary practitioners, and contributing to food security in Libya (Vidal et al., 2020; Harman et al., 2016).

Bio-banking refers to the systematic collection, processing, storage, and distribution of biological materials such as tissues, cells, blood, and serum, supporting medical and veterinary research (Watson & Kay, 2018). Historically, medical research relied on independently collected biomaterials, but the rapid advancement of biotechnology and data-driven medicine necessitated a more structured approach. Epidemiological studies and clinical trials have significantly improved our understanding of diseases, yet the complexity of modern biomedical research calls for large-scale, standardized biological repositories (Dove et al., 2020).

Stem cell biobanking, a critical component of this system, facilitates high-quality research by ensuring the availability of authenticated cell lines under standardized growth conditions (Holm et al., 2019). Stem cell banks minimize contamination risks, improve accessibility for researchers, and enable advancements in regenerative medicine. However, ethical concerns persist, particularly regarding embryonic stem cells, as debates continue on issues such as human personhood, donor consent, and oversight mechanisms (Lindsay & Berna, 2021). Induced pluripotent stem cells (iPSCs) offer an alternative that circumvents some ethical dilemmas, making them a promising avenue for therapeutic applications (Balint, 2022). In veterinary medicine, bio-banking presents substantial opportunities. Stem cell-based therapies have been developed for treating conditions such as equine arthritis and degenerative joint diseases (Erin & Robert, 2021). Additionally, the preservation of genetic materials from endangered species enhances conservation efforts, while tissue banks for livestock contribute to disease resistance and food security (Maria et al., 2022).

In the Arab world, bio-banking initiatives have been established in several countries, including Saudi Arabia and Qatar. Saudi Arabia's Stem Cell Therapy Program at King Faisal Specialist Hospital collaborates with global institutions like Harvard Medical School to advance stem cell research (Omar et al., 2023). However, challenges remain, particularly in Libya, where limited funding, regulatory gaps, and a lack of specialized expertise hinder the development of bio-banking infrastructure (Ahmed et al., 2024). Stem cell research in veterinary medicine has gained significant attention due to its potential in treating various animal diseases and improving livestock health. Applications include regenerative treatments for musculoskeletal injuries in horses and dogs, therapy for degenerative joint diseases, and wound healing in companion and farm animals. Additionally, stem cells contribute to genetic preservation programs, assisting in the conservation of endangered species. In Libya, such applications could enhance food security by improving livestock productivity and disease resistance (Smith & Brown, 2022).

The establishment of stem cell biobanks in Libya faces significant economic challenges, primarily due to high costs associated with infrastructure, maintenance, and operational sustainability. Ethically, concerns arise regarding donor informed consent, equitable access to biobanked materials, and preventing the misuse of biological resources. Additionally, the lack of a clear legislative framework poses a major obstacle to the successful implementation of stem cell biobanks in the country. This study explores the role of bio-banking in veterinary medicine, particularly in Libya, analyzing its applications, implementation challenges, and the perspectives of the medical community. Additionally, it discusses global best practices and proposes strategies for fostering bio-banking development in Libya. By evaluating the Libyan medical community's views on the implementation of stem cell banking systems, this research aims to provide practical recommendations for advancing stem cell therapies in the country.

## MATERIALS AND METHODS.

To get an acceptable outcome that accurately represents the community, a random sample of all community members is taken while conducting a community survey consists of creating culturally aware questions, getting ethical clearance from pertinent organizations, and enlisting a varied participant pool. To reach a broad audience, the questionnaire has to be translated into Arabic and

disseminated via social media, mosques, and community centers. To find patterns and trends in the answers, data analysis should also be done using the proper statistical techniques.

However, the concept of biobanking is unknown and misunderstood in a community such as Libyan society, where it is mistaken for an organ donation bank. The Libyan medical community is more aware and understanding of this kind of biotechnology, so the study group decided to approach them. This survey investigates the level of knowledge and acceptability of stem cell biobanking technology within this subset of the Libyan medical community, accounting for the moral and theological challenges that such a technology presents in a society such as ours. The intended audience for the straightforward English-language questions was made up of doctors, nurses, pharmacists, veterinarians, students, and faculty members who were present at Omar Al-Mukhtar University's inaugural medical conference. The **questions** were as follows:

### Survey on Stem Cell Banking.

1. Do you know the importance of Stem Cells in the body?
  - Yes
  - No
2. Do you have insights into what Stem Cell Banking is?
  - Yes
  - No
3. Would you recommend, or have you recommended, or enrolled yourself in Stem Cell Banking?
  - Yes
  - No
4. Do you feel Stem Cell Banking is important with the currently changing lifestyles?
  - Yes
  - No
  - Not Sure
  - No comments
5. Can you name Disease(s) Stem Cell Banking promises to bring a cure against?  
If Yes, please mention names or else write "No" in the Text Box.
  - Your answer: \_\_\_\_\_
6. Your Age:
  - 20-25 years

- 26-30 years
  - 31-35 years
  - 36-40 years
  - 41-45 years
  - 46-50 years
  - Above 50
7. You are:
- Male
  - Female
8. You are:
- Business Professional
  - Student
  - Working at a university
  - Medical/Para-Medical Professional

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### Research Objectives and Study Rationale.

9. Do you support the establishment of stem cell biobanks in Libya?
- Yes
  - No
  - Unsure
10. Do you believe that strict ethical regulations should govern stem cell biobanks in Libya?
- Yes
  - No
  - Unsure
11. What ethical concerns do you believe should be prioritized in the development of stem cell biobanks in Libya?

(Select all that apply)

- Informed consent
- Privacy and confidentiality of donors
- Ethical sourcing of stem cells
- Use of stem cells in research and treatment

- Other (Please specify): \_\_\_\_\_
12. Do you believe stem cell biobanks should primarily focus on veterinary medicine to enhance food security in Libya?
- Yes
  - No
  - Unsure
13. What specific veterinary conditions do you think could benefit the most from stem cell treatments?
- Orthopedic injuries
  - Neurological conditions
  - Chronic diseases (e.g., kidney or liver disease)
  - Other (Please specify): \_\_\_\_\_
14. Do you think there is a need for a specific legislative framework to regulate stem cell biobanks in Libya?
- Yes
  - No
  - Unsure
15. What type of regulations do you consider necessary for the successful establishment of stem cell biobanks in Libya?  
(Select all that apply)
- Safety and quality standards
  - Ethical guidelines
  - Monitoring and oversight
  - Other (Please specify): \_\_\_\_\_
16. How important is increasing public awareness about stem cell biobanks for their successful implementation in Libya?
- Very important
  - Somewhat important
  - Not important
17. What methods do you suggest to increase public awareness of stem cell biobanks in Libya?  
(Select all that apply)
- Media campaigns

- Educational programs in schools and universities
  - Public forums and discussions
  - Other (Please specify): \_\_\_\_\_
18. Do you believe stem cell biobanks would be economically feasible in Libya?
- Yes
  - No
  - Unsure
19. What factors do you think would affect the economic feasibility of stem cell biobanks in Libya?  
(Select all that apply)
- Initial investment costs
  - Government funding and support
  - Private sector involvement
  - Public willingness to pay for stem cell treatments
  - Other (Please specify): \_\_\_\_\_
20. What is your overall outlook on the future development of stem cell biobanks in Libya?
- Optimistic
  - Neutral
  - Pessimistic
21. What steps do you think are necessary to ensure the successful establishment of stem cell biobanks in Libya?  
(Select all that apply)
- Legislation and ethical frameworks
  - Public and professional education
  - Research and development support
  - Government and private sector collaboration
  - Other (Please specify): \_\_\_\_\_

The responses collected will provide valuable insights into the knowledge and attitudes towards stem cell biobanking within the Libyan medical community. This data can help inform future discussions and decisions regarding the integration of this technology in healthcare practices in our society. The feedback received will also aid in identifying potential barriers or concerns that may need to be addressed before implementing stem cell biobanking in medical institutions. Overall, the survey

aims to gauge the readiness and receptiveness of the Libyan medical community towards this innovative approach.

By understanding the perspectives of healthcare professionals in Libya, we can tailor educational programs and policies to ensure a smooth transition towards incorporating stem cell biobanking Libyan healthcare system. Additionally, this research can contribute to the global conversation on the ethical implications and practical considerations of utilizing stem cells for medical purposes.

### Result:

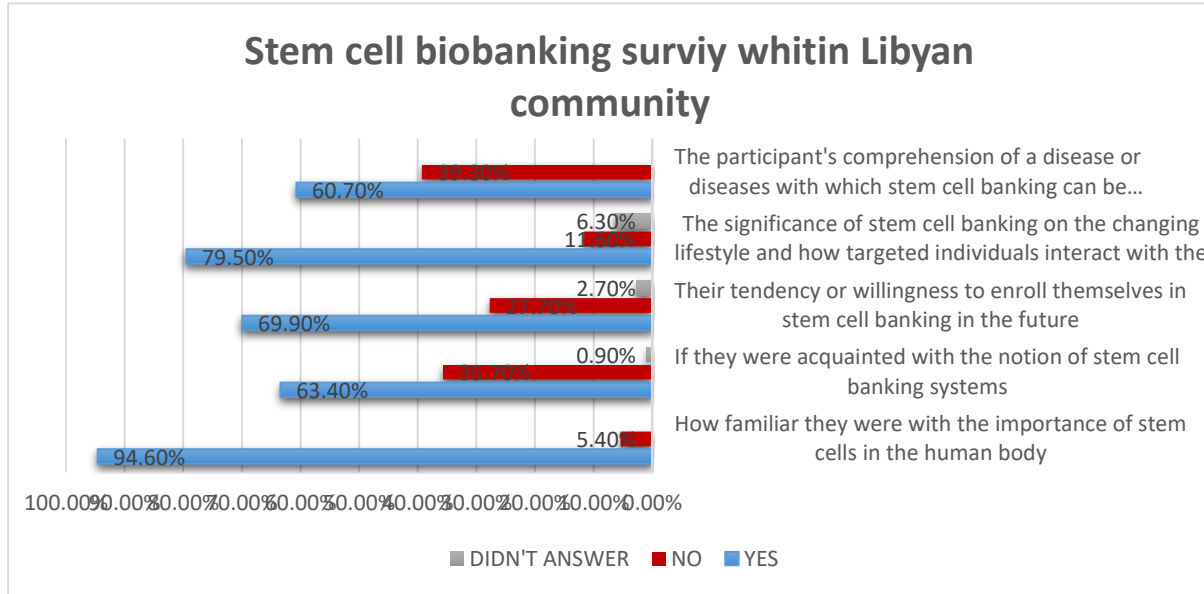
In a survey conducted at the College of Veterinary Medicine at Omar Almuktar University, Albida, the knowledge and the importance of stem cell banking among medically affiliated groups were assessed and analyzed. The targeted strata were medical students, medical business professionals, university workers, and medical/paramedical professionals. The questionnaire included questions regarding the support for stem cell biobanks, ethical regulations, and the economic feasibility of implementing such systems in Libya. According to the statistical analysis, targeted groups were firstly asked about general information as shown in table 1.

**Table 1. A Survey Results on Knowledge and Importance of Stem Cell Banking among Medically Affiliated Groups at Omar Almuktar University**

Question	Response Category	Percentage (%)
<b>Q1: Awareness of the importance of stem cells in the body</b>	Aware	94.6
	Not aware	5.4
<b>Q2: Familiarity with the concept of stem cell banking</b>	Familiar	63.4
	Not familiar	35.7
	No response	0.9
<b>Q3: Willingness to enroll in stem cell banking in the future</b>	Willing	69.9
	Not willing	27.7
	No response	2.7
<b>Q4: Positive attitude towards the importance of stem cell banking</b>	Favorable	79.5
	Unsure	11.6
	Not favorable	6.3
	No response	2.7
<b>Q5: Knowledge of diseases associated with stem cell banking</b>	Knowledgeable	60.7
	Not knowledgeable	39.3
<b>Q6: Age distribution of participants</b>	20–25 years	43.8
	26–30 years	10.7
	31–35 years	8.9
	36–40 years	9.8
	41–45 years	4.5
	46–50 years	8.0
	Above 50 years	10.7
	No response	3.6
<b>Q7: Gender distribution of participants</b>	Female	71.4

	Male	25.9
	No response	2.7

This table demonstrates a high level of awareness regarding the significance of stem cells among the surveyed medical community, with a notable willingness to participate in stem cell banking. The demographic data indicate a predominance of female participants and a majority within the younger age groups. As shown in the chart below:



**Figure 1.** Clustered bar chart showing participant responses to Questions 1 through 5 regarding awareness of stem cells, familiarity with stem cell banking, willingness to participate in banking, perceived importance of stem cell banking in changing lifestyles, and knowledge of treatable diseases. The data reflect strong awareness and positive attitudes among the Libyan medical community.

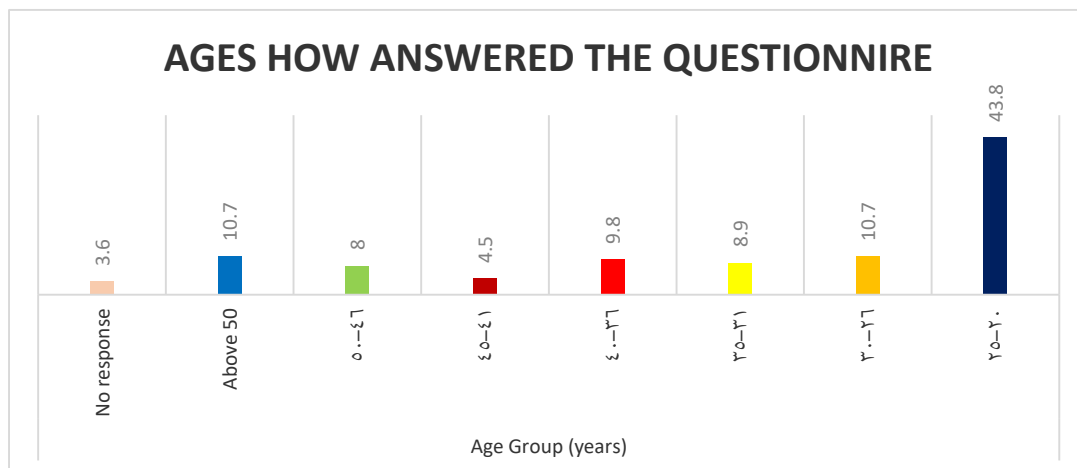
The sixth question was more about the distribution of participant age by using a five-year interval to separate participants into seven age groups as shown in table 1.

**Table 2. Distribution of Participants by Age Group and Gender**

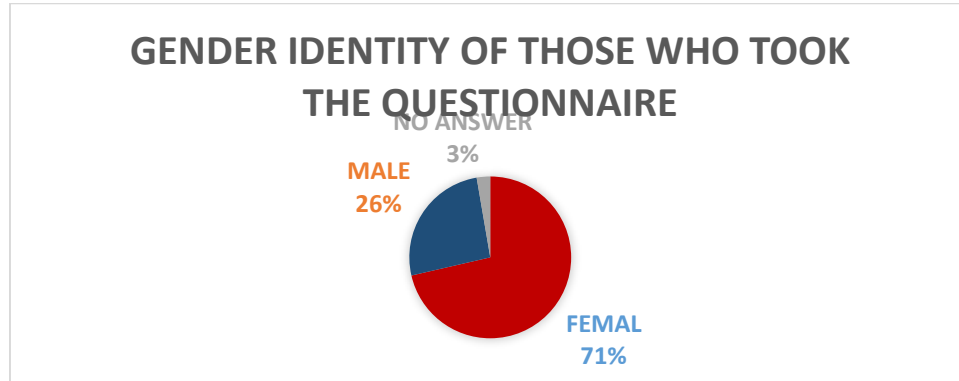
Demographic Variable	Category	Percentage (%)
Age Group (years)	20–25	43.8
	26–30	10.7
	31–35	8.9
	36–40	9.8

Demographic Variable	Category	Percentage (%)
	41–45	4.5
	46–50	8.0
	Above 50	10.7
	No response	3.6
<b>Gender</b>	Female	71.4
	Male	25.9
	No response	2.7

The majority of participants were in the 20–25 years age group, and female respondents constituted the largest proportion of the sample. This demographic profile should be considered when interpreting the survey results. As shown in the chart below:



**Figure 2.** Clustered column chart displaying age distribution of survey respondents. The majority of participants fall within the 20–25 age group, indicating a youthful demographic among the surveyed medical and veterinary professionals.



**Figure 3.** Pie chart showing gender distribution among survey participants. Female respondents constituted 71%, indicating higher engagement among women in the Libyan medical and veterinary community.

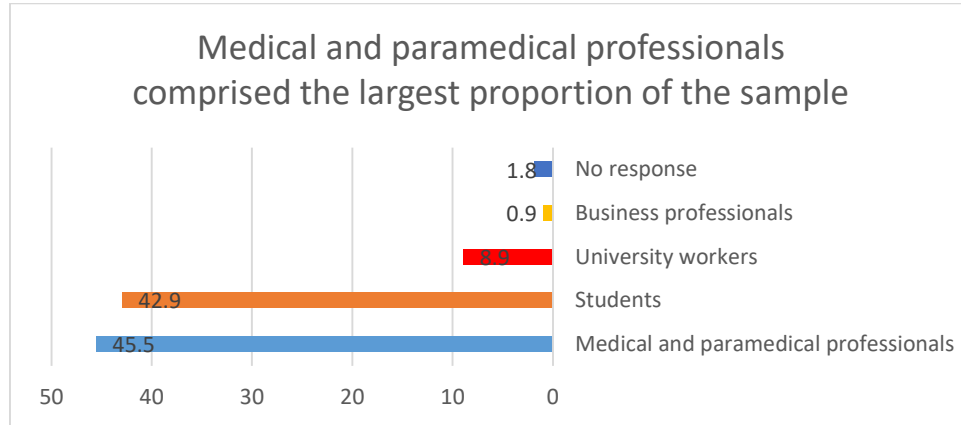
The final question was to clarify the occupational and educational differences among participants by dividing them into four categories as shown in table 3.

**Table 3. Distribution of Participants by Professional Group**

Professional Group	Percentage (%)
Medical and paramedical professionals	45.5
Students	42.9
University workers	8.9
Business professionals	0.9
No response	1.8

Medical and paramedical professionals comprised the largest proportion of the sample, followed closely by students. University

As shown in the chart below:



**Figure 4.** Clustered bar chart showing participant responses to Question 8 Distribution of Participants by Professional Group

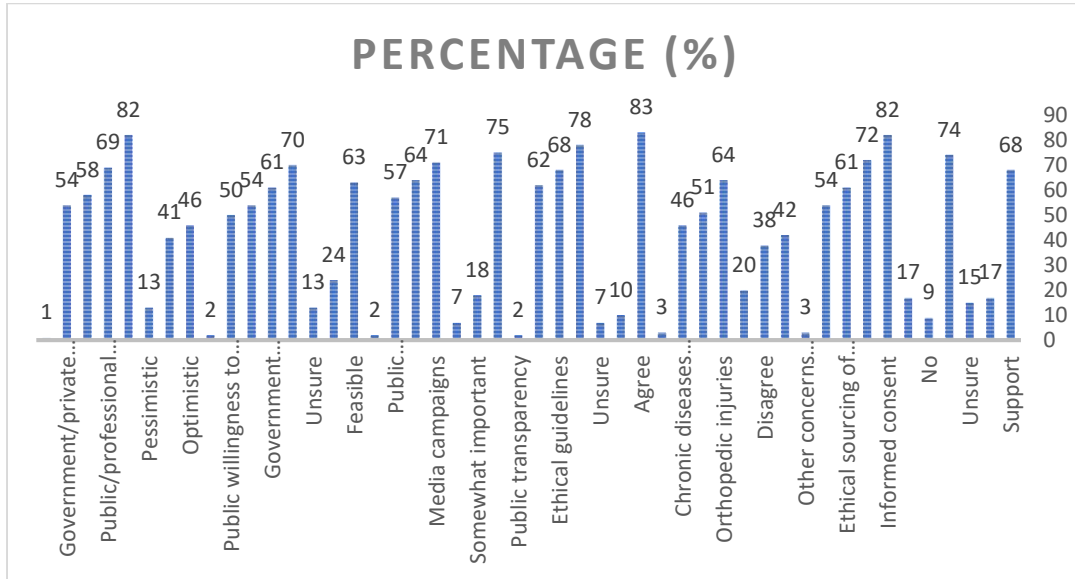
According to the statistical analysis for the Responses on Regulatory, Ethical, and Economic Aspects of Stem Cell Biobanks in Libya shown in table 4.

**Table 4. A Survey Responses on Regulatory, Ethical, and Economic Aspects of Stem Cell Biobanks in Libya**

Question	Response Category	Percentage (%)
<b>Q9: Support for establishing stem cell biobanks in Libya</b>	Support	68
	Opposed	17
	Unsure	15
<b>Q10: Need for strict ethical regulations for stem cell biobanks</b>	Yes	74
	No	9
	Unsure	17
<b>Q11: Priority ethical concerns for stem cell biobanks</b>	Informed consent	82
	Privacy/confidentiality of donors	72
	Ethical sourcing of stem cells	61
	Use in research and treatment	54
	Other concerns (e.g., veterinary use)	3
<b>Q12: Should biobanks focus on veterinary medicine in libya for food security?</b>	Agree	42
	Disagree	38
	Unsure	20
<b>Q13: Veterinary conditions benefiting from stem cell treatment</b>	Orthopedic injuries	64
	Neurological conditions	51
	Chronic diseases (kidney/liver)	46
	Other (e.g., cancer)	3
<b>Q14: Need for legislative framework for biobanks</b>	Agree	83
	Disagree	10

Question	Response Category	Percentage (%)
	Unsure	7
<b>Q15: Types of necessary regulations</b>	Safety and quality standards	78
	Ethical guidelines	68
	Monitoring and oversight	62
	Public transparency	2
<b>Q16: Importance of increasing public awareness for biobank success</b>	Very important	75
	Somewhat important	18
	Not important	7
<b>Q17: Suggested methods to increase public awareness</b>	Media campaigns	71
	Educational programs (schools/universities)	64
	Public forums/discussions	57
	Social media outreach	2
<b>Q18: Economic feasibility of stem cell biobanks in Libya</b>	Feasible	63
	Not feasible	24
	Unsure	13
<b>Q19: Factors affecting economic feasibility</b>	Initial investment costs	70
	Government funding/support	61
	Private sector involvement	54
	Public willingness to pay	50
	International collaborations	2
<b>Q20: Outlook on the future development of stem cell biobanks in Libya</b>	Optimistic	46
	Neutral	41
	Pessimistic	13
<b>Q21: Steps for successful establishment of stem cell biobanks</b>	Legislation and ethical frameworks	82
	Public/professional education	69
	Research and development support	58
	Government/private sector collaboration	54
	Healthcare infrastructure investment	1

This table presents a comprehensive overview of participant perspectives on regulatory, ethical, economic, and practical considerations for the establishment and success of stem cell biobanks in Libya, highlighting strong support for ethical governance, legislative frameworks, and public engagement.



**Fig4.** Clustered bar chart showing participant responses to Questions 9 through 21 illustrating participant responses regarding the regulatory, ethical, and economic dimensions of stem cell biobank implementation in Libya. The results highlight strong support for legal frameworks, ethical guidelines, veterinary applications, and public education as critical factors for successful integration.

### Discussion:

This study provides valuable insights into the awareness, acceptance, and perceptions of stem cell biobanking among members of the Libyan medical community, with a specific emphasis on veterinary applications. The findings indicate a relatively high level of awareness (94.6%) regarding the biological importance of stem cells, which reflects the increasing exposure of Libyan healthcare professionals to regenerative medicine. Despite this, familiarity with stem cell biobanking as a concept remains moderate (63.4%), suggesting a need for focused educational efforts.

Notably, 69.9% of respondents expressed willingness to enroll in stem cell banking programs, while 79.5% recognized the relevance of this technology to contemporary healthcare. These trends reflect growing acceptance, but they also reveal a knowledge gap that could hinder the practical adoption of stem cell infrastructure. This gap is especially relevant in Libya, where biotechnology remains underutilized in both human and veterinary sectors.

The support for establishing stem cell biobanks in Libya (68%)—particularly under strict ethical regulations (74%)—is a promising indicator of readiness within the professional community. Importantly, 42% of respondents emphasized the need for veterinary applications, highlighting a broader awareness of how stem cell therapies can contribute to food security. In countries like Libya,

where livestock productivity and animal health are essential to the economy, the application of regenerative treatments in veterinary medicine represents a strategic advancement.

Veterinary medicine stands to benefit significantly from stem cell technologies, particularly in areas such as orthopedic injuries, chronic organ diseases, and neurological conditions. Among respondents, orthopedic conditions (64%) and neurological disorders (51%) were identified as the primary veterinary targets for stem cell interventions. This aligns with global research trends demonstrating the efficacy of mesenchymal stem cells in treating joint injuries and inflammatory disorders in animals (Vidal et al., 2020; Harman et al., 2016).

However, the implementation of stem cell biobanks in Libya faces considerable challenges. While 63% believe the system could be economically feasible, cost-related concerns were common. High initial investments, limited government funding, and the absence of private sector involvement were cited as key barriers. These economic limitations must be addressed through national funding programs, international partnerships, and public-private initiatives.

Legislative and ethical challenges remain central concerns. A strong majority (83%) agreed on the need for a formal legal framework. Ethical priorities included informed consent (82%), donor privacy (72%), and the responsible sourcing and use of stem cells. Without clear regulation, Libya risks inconsistencies in stem cell governance that could erode public trust and hinder scientific development.

Public awareness also emerged as a critical factor. A total of 75% of respondents emphasized the importance of educational campaigns to improve societal understanding of stem cell biobanks. This is especially crucial in the veterinary field, where public misconceptions often delay acceptance of new technologies. Outreach through media, schools, and professional seminars will be essential in shaping public perception and encouraging community participation.

The study also highlighted the role of academic institutions and healthcare professionals in shaping Libya's biotechnology roadmap. Respondents called for greater collaboration between government entities, research institutions, and the private sector to support infrastructure development, training, and knowledge exchange. International examples—such as the Tunisian Society of Human Genomics—offer viable models for Libya to replicate in establishing a national genomic database and stem cell bank.

In summary, this study underscores the Libyan medical community's openness to the integration of stem cell technologies in veterinary and human medicine, provided that ethical, legislative, and financial frameworks are well established. There is significant potential to leverage stem cell research not only to advance clinical care but also to enhance animal health, livestock production, and national food security. Targeted policy action and sustained investment in education, regulation, and research are required to transform this potential into practical outcomes.

## Conclusion:

Stem cell technology offers a transformative approach to veterinary medicine, particularly in the treatment of musculoskeletal injuries, chronic diseases, and tissue regeneration. This study assessed the perceptions of the Libyan medical community toward the establishment of stem cell biobanks,

with specific attention to veterinary applications. Results revealed strong support for the integration of stem cell technologies into veterinary practice, with 42% of respondents identifying food security as a national priority that could benefit from improved animal health through regenerative therapies. The majority favored the implementation of strict ethical and legislative frameworks and highlighted the need for professional training, public awareness, and infrastructure development.

## **Research recommendations: Best Approach for Implementation in Veterinary Medicine**

### **1. Focus on Proven Clinical Applications**

- Use stem cells to treat orthopedic injuries and degenerative joint diseases in horses, dogs, and livestock.
- Support wound healing and inflammatory condition management.

### **2. Establish Pilot Programs at Veterinary Faculties**

- Launch dedicated stem cell units in veterinary colleges, beginning with clinical cases at teaching hospitals.
- Monitor outcomes to refine treatment protocols.

### **3. Develop a Veterinary Stem Cell Biobank**

- Collect, process, and preserve adipose- and bone marrow-derived stem cells from healthy animals.
- Create a centralized database of genetic and health records to support research and therapy.

### **4. Train Veterinary Professionals**

- Conduct workshops and certification programs on stem cell extraction, culture, and clinical use.
- Include stem cell science in veterinary curricula.

### **5. Create Standardized Treatment Protocols**

- Develop condition-specific protocols approved by veterinary authorities.
- Ensure consistency and safety in clinical applications.

### **6. Build Regional and International Research Collaborations**

- Partner with research centers in Tunisia, Turkey, and beyond to exchange expertise.
- Facilitate technology transfer and staff development.

### **7. Implement Legal and Ethical Regulations**

- Introduce legislation governing stem cell sourcing, consent, and use in animals.
- Ensure ethical oversight of all procedures.

## 8. Enhance Public and Stakeholder Awareness

- Launch targeted awareness campaigns for farmers, veterinarians, and policymakers.
- Use media and academic platforms to communicate the benefits and safety of veterinary stem cell therapies.

This structured approach provides a roadmap for integrating stem cell technology into veterinary medicine in Libya. It aims to improve animal health, increase livestock productivity, and contribute to long-term national food security.

### **ACKNOWLEDGEMENT.**

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### **ETHICS.**

In conducting a survey on a sample of humans, researchers obtained informed consent from participants and ensured the confidentiality of their data, while adhering to fairness and avoiding discrimination or harm. The study adhered to the ethical research guidelines as per the standards applied at Omar Al-Mukhtar University.

**Duality of interest:** The authors declare that they have no duality of interest associated with this manuscript.

### **Author contributions:**

Dr. Rahab Hamed conducted the survey and wrote the main body of the research, organizing the content and analyzing the preliminary results. Dr. Amraj performed the statistical analysis of the data and prepared the results and discussion section in detail. Both contributed to the overall structure and content of the research

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