

# Identifying Barriers to Umbilical Cord Blood Banking in Jordan: A Cross-Sectional Survey of Obstetricians

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## ABSTRACT

**Background:** The expansion of umbilical cord blood (UCB) banking necessitates a greater understanding among obstetricians in order to responsibly inform parents about UCB collection and storage. Gaps in knowledge can compromise public UCB banking efforts and result in missed opportunities and public misguidance about UCB banking.

**Materials and Methods:** A cross-sectional survey was disseminated among obstetricians in Amman, Jordan. The questionnaire aimed to evaluate obstetricians' knowledge of and attitude toward UCB storage and applications, as well as current practice patterns.

**Results:** Ninety-six obstetricians responded (55% response rate), most of whom were Jordanian (71%), female (83%), resident physicians (59%), and working in either private (43%) or public (42%) hospitals, with an average of 6.5 years in practice. Only 26% had personal experience in UCB collection, and 20% had received education on UCB collection. Nearly 75% said their hospitals lacked standard operating procedures, guidelines, or infectious disease screening for UCB units. Overall knowledge about UCB was moderate, and the internet was the most common information source (54%). Overall attitudes were positive, especially in desire to expand personal knowledge about UCB, integrate information into medical residency curricula, and establish a public UCB bank in Jordan. However, many believed that ethical (61%) and religious (56%) controversies surround UCB donation.

**Conclusion:** This study identifies deficiencies in quality control and experience in UCB collection in Jordan, as well as areas of inadequate knowledge and ethical controversies among obstetricians. These issues contribute to public misinformation and limit public UCB donation programs, and requires improved medical education on this topic

**Keywords:** Umbilical cord blood banking; Obstetricians; Jordan; Knowledge; Attitudes

## INTRODUCTION

Since the first successful umbilical cord blood (UCB) transplantation for treatment of Fanconi anemia<sup>1</sup>, the umbilical cord has been transformed from a

disposable byproduct to a valuable source of therapeutic stem cells (SCs)<sup>2</sup>. Over the last 30 years, clinical applications and research on UCB SCs have advanced tremendously, and numerous facilities for

UCB storage have been established worldwide<sup>3,4</sup>. Related and unrelated allogeneic UCB transplantation can be a potentially life-saving therapy for both children and adults with a variety of malignant and nonmalignant diseases such as: leukemias and lymphoproliferative disorders, hemoglobinopathies, metabolic diseases and immunodeficiencies, bone marrow (BM) failures syndromes, and autoimmune diseases<sup>5-7</sup>.

Multipotent hematopoietic SCs and mesenchymal SCs can be isolated from both UCB and cord tissue<sup>8</sup>. Unlike adult SCs, UCB SCs can grow extensively *in vitro*, allowing expansion of human therapy applications, such as creation of tissues or disease models<sup>9</sup>. Hematopoietic SCs from UCB have emerged as an alternate to allogeneic hematopoietic SC transplantation using BM, especially for patients without a fully-matched human leukocyte antigen (HLA) donor and for ethnic minorities<sup>10, 11</sup>. In the Eastern Mediterranean region, nearly 8,000 hematopoietic SC transplants were reported between 1984 and 2007, of which over 4% were in Jordan, and over three-fourths were allogeneic<sup>12</sup>. Mesenchymal SCs have the potential to differentiate into various cell types, including myoblasts, neural cells, pancreatic islets, and keratinocytes, which are potential sources for tissue engineering and regenerative medicine<sup>13</sup>. Endothelial progenitor cells are another unique cell type that can be isolated from UCB and have been investigated as a potential therapy for vascular reconstruction and wound healing<sup>14</sup>. UCB is also considered a possible source for induced pluripotent stem cells for cellular therapies<sup>15</sup>.

UCB transplantation has several advantages over BM transplantation, such as faster availability of the cells, avoidance of invasive procedures for donors, increased proliferative capacity, lower risk of acute graft-versus-host disease, and lower viral transmission rate<sup>16</sup>. UCB collection is relatively safe for mother and child, and it can be performed in a variety of delivery scenarios, including caesarean section and preterm labor<sup>17</sup>. Major obstacles to UCB transplantation include reduced volume of hematopoietic SCs, low total nucleated cell counts, and increased risk of graft failure due to limited engraftment potential. Double-unit cord

transplantation and *ex vivo* cell expansion have been utilized to overcome these barriers<sup>18, 19</sup>.

To facilitate UCB usage, private, public, and private-public hybrid banks have been established to cryopreserve the UCB units. In Jordan, several private companies offer UCB collection and storage services<sup>20</sup>. Furthermore, the department of cell therapy and applied genomics at King Hussein Cancer Center (KHCC) is establishing the first public/hybrid UCB bank in the country<sup>21</sup>. Public banks rely on government and/or non-profit funds to preserve units for general public use, while private banks are financed by the families who opt to store the units for personal use. While private UCB storage can provide a sense of insurance for parents in treating certain pediatric disorders, portrayal of therapeutic uses of UCB SCs by private banks may not be realistic<sup>22</sup>. Furthermore, parents may not be adequately informed about other public or hybrid banking options.

Prior research has investigated the knowledge of and attitudes toward UCB banking among parents<sup>23</sup> and healthcare professionals<sup>24</sup>. While knowledge of UCB banking among parents is generally low, many have positive attitudes toward UCB donation and are aware of the value of the UCB and its therapeutic uses<sup>23</sup>. In comparison, limited high-quality studies have investigated healthcare professionals' knowledge regarding UCB banking, and only two have been done in an Arabic-speaking country<sup>25, 26</sup>, both among nurses in Egypt, not obstetricians. Two studies were conducted in Jordan by Matsumoto *et al.* to assess women's knowledge and attitudes toward UCB banking with a sample size of 899 women<sup>27,28</sup>. More than three quarters of respondents indicated they know nothing about UCB banking in Jordan, and more than half had never heard of UCB banking before. However, overall public opinion about UCB banking was positive, and most women wanted more information on UCB banking, especially from their obstetricians<sup>27</sup>. Level of knowledge and opinions about UCB banking differed significantly between women at private versus public hospitals; women at private hospitals had higher levels of awareness about UCB banking and indicated a higher likelihood of participating in UCB banking in the future<sup>28</sup>.

Further research is needed to better assess knowledge deficits, attitudes, and practices of healthcare professionals concerning UCB, including their communication with expectant parents<sup>24</sup>. Therefore, this study was conducted to understand current practices and understandings among obstetricians in Jordan about UCB usage and collection, so that potential gaps in education and opinions can be addressed.

## MATERIALS AND METHODS

### Study design, participants, and settings

This study was a cross-sectional survey conducted among 96 obstetricians recruited from 9 hospitals (1 university hospital, 2 public hospitals, 6 private hospitals), and 17 private clinics within Amman, Jordan. It was conducted as phase III of “Stem Cells: Hope or Hype?” project (see Appendix). Nine of a total 20 hospitals with obstetrics and gynecology departments or clinics were selected in Amman, from each of the 9 sub-governorates. One-hundred twenty-five self-administered questionnaires were distributed in-person to obstetricians at the selected hospitals, and additional questionnaires were distributed to obstetricians in 50 outpatient clinics in Amman, with two follow-ups. The study protocol was approved by the Ethics Committee of the University of Science and Technology Yemen (USTY)-Jordan branch. Participation in the study was voluntary. The purpose of the study was explained clearly to the study participants, and verbal agreements were obtained.

### Study tool

A questionnaire designed as a scoring system was developed based on updated medical applications, research advances, and guidelines on UCB SCs. A pilot study included 15 obstetricians (5 specialists, 10 resident physicians) in order to identify ambiguous terms and time required. A list of operational definitions on the cover page explained terminology. The questionnaire was designed not only to measure knowledge and attitudes, but also to inform the development of an educational tool. The questionnaire was reviewed for content and face validity by three experts in the fields of oncology, SC research, and UCB banking. It consisted of four major

sections, and the internal consistency for the last two sections (knowledge and attitude scales) was calculated by using Cronbach’s alpha reliability coefficient ( $\alpha$ ).

Section 1 collected information about demographic characteristics of participants (age, gender, nationality, marital status, level of residency/years in practice, number of deliveries, workplace). Section 2 assessed obstetricians’ experience and participation in UCB collection and banking, including evaluation of quality control, financial compensation, and training. Section 3 assessed obstetricians’ knowledge and information sources, and consisted of 44 statements ( $\alpha = 0.72$ ) sub-classified into four domains: (1) 12 statements on UCB SCs ( $\alpha = 0.29$ ), (2) 14 statements on UCB collection and banking ( $\alpha = 0.57$ ), (3) 13 statements on UCB therapeutic uses and transplantation ( $\alpha = 0.51$ ), and (4) 5 statements on UCB research applications ( $\alpha = 0.82$ ). Section 4 was designed to assess obstetricians’ attitudes and consisted of 14 statements ( $\alpha = 0.67$ ). Internal consistency of all total and subtotal scales was found to be satisfactory, except for section 2, which is considered acceptable for a newly-developed scale. *Scoring*: Both knowledge and attitude statements were presented in a 5-point Likert-type format. Responses ranged from “strongly agree” to “strongly disagree”, and scored from 0 to 4 as follows: “strongly agree” (4), “agree” (3), “neutral” (2), “disagree” (1) and “strongly disagree” (0), based on accuracy of knowledge statements and positivity of attitude statements. Reverse coding was performed for select statements. In section 3, knowledge scores ranged from: (0 to 176) for total knowledge score, (0 to 48) for domain 1, (0 to 56) for domain 2, (0 to 52) for domain 3, and (0 to 20) for domain 4. Total attitude scores in section 4 ranged from 0 to 56. Higher scores indicated more positive attitudes and higher levels of knowledge. In order to facilitate interpretation of the results, all knowledge and attitude scales were converted to a range of 0 to 4 by dividing each score within the scale by the total number of statements comprising the scale.

### Data analysis

Data were entered and analyzed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp.,

Armonk, NY, USA). Categorical variables were presented as frequencies and proportions, while continuous variables were presented as means, standard deviations, and percentages, with 95% confidence intervals.

## RESULTS

The overall response rate was 55% (n = 96/175). As summarized in **Table 1**, this study was conducted among 96 obstetricians, of whom 57 (59.4%) were

residents, 20 (20.8%) were specialists, and 19 (19.8%) were consultants. Mean age of participants was 35.7 ( $\pm 11.1$ ) years, and the majority were female (n = 80, 83.3%), Jordanian (n = 68, 70.8%) and married (n = 63, 65.6%). More than 80% of participants were working in the private and public sectors, with 6.5 ( $\pm 8.6$ ) mean years in practice for specialists and consultants. The mean number of monthly deliveries was 78 ( $\pm 114$ ).

**Table 1:** Demographic characteristics of questionnaire respondents (n = 96).

Variables	Value
Age, M (SD)	35.7 (11.1)
<b>Gender, N (%)</b>	
Female	80 (83.3)
Male	16 (16.7)
<b>Marital status, N (%)</b>	
Married	63 (65.6)
Single	29 (30.2)
Divorced	4 (4.2)
Number with children, N (%)	60 (62.5)
<b>Nationality, N (%)</b>	
Jordanian	68 (70.8)
Palestinian	8 (8.3)
Iraqi	5 (5.2)
Syrian	4 (4.2)
Yemeni	3 (3.1)
Other	8 (8.3)
<b>Current position, N (%)</b>	
Resident physician	57 (59.4)
Specialist physician	20 (20.8)
Consultant physician	19 (19.8)
<b>*Working place, N (%)</b>	
Private hospital	41 (42.7)
Public hospital	40 (41.7)
Private clinic	11 (11.5)
University hospital	10 (10.4)
Military hospital	1 (1.0)
‡ Years in practice, M (SD)	6.5 (8.6)
Deliveries per month, M (SD)	78 (114)

N = Frequency, M = Mean and SD = Standard Deviation

\* Participants were given the option to choose more than one working place

‡ For specialists and consultants post OB/GYN Board Certification

### UCB Collection and Banking

More than half of participants were familiar with the existence of private banks in Jordan to store UCB (Table 2). However, only 25 (26.0%) had experience in UCB collection, with 3.4 ( $\pm$  4.9) mean years of experience, and only 15 (15.6%) were actually participating in UCB collection at their hospitals. Mean number of collected UCB units among the 15 obstetricians participating in UCB collection was 1.4 ( $\pm$ 3.9). Seven (46.7%) obstetricians confirmed that UCB collection was done under sterile conditions. However, around three quarters noted that no standard operating procedures or general guidelines

existed for UCB collection, and screening for possible infections pre-and-post UCB collection was not routinely performed. An even higher percentage had not attended an educative forum ( $n=12$ , 80.0%), or received a training course prior to UCB collection ( $n=13$ , 86.7%). All but one ( $n=14$ , 93.3%) agreed that UCB collection did not put any burden on their regular work as an obstetrician, and 12 (80.0%) stated that they had not received any financial compensation to collect UCB.

**Table 2:** Obstetricians' experience with umbilical cord blood (UCB) collection and banking.

Questions	Yes, N (%)	No, N (%)
Experience and participation in UCB collection and banking ( $n=96$ )		
1- Do you know that there are private banks in Jordan to preserve UCB?	54 (56.3)	42 (43.8)
2- Do you have experience in UCB collection?	25 (26.0)	71 (74.0)
If yes, how many years? <i>M (SD)</i>	3.4 (4.9)	
3- Do you participate in UCB collection at your hospital?	15 (15.6)	81 (84.3)
If yes, how many UCB units do you collect per month? <i>M (SD)</i>	1.4 (3.9)	
*Quality control of UCB units ( $n=15$ )		
4- Is there a standard operating procedure at your hospital to collect UCB?	4 (26.7)	11 (73.3)
5- Are there general guidelines for UCB collection at your hospital?	4 (26.7)	11 (73.3)
6- Is UCB collection done under sterile conditions?	7 (46.7)	8 (53.3)
7- Do you perform routine screening for possible infectious diseases before or after UCB collection?	4 (26.7)	11 (73.3)
*Extra work and financial compensation ( $n=15$ )		
8- Does the collection of UCB put any burden on your regular clinical work as an obstetrician?	1 (6.7)	14 (93.3)
9- Do you receive any financial compensation to collect UCB?	3 (20.0)	12 (80.0)
*History of previous educative forum or training on UCB collection ( $n=15$ )		
10- Have you attended any educative forum on UCB collection or banking in the past?	3 (20.0)	12 (80.0)
11- Have you attended a training course prior to UCB collection?	2 (13.3)	13 (86.7)

*N* = Frequency, *M* = Mean and *SD* = Standard Deviation

Note: data presented as frequencies unless otherwise stated.

\*Questions only pertained to obstetricians who participated in UCB collection

### Obstetricians' Knowledge

The three most common sources of knowledge regarding UCB collection and banking were internet, books, and brochures from the private banks, while panel discussions and websites of the public banks were the least two common sources (Figure 1). As demonstrated in Table 3, participants achieved an average total knowledge score of 58.8% ( $2.35 \pm 0.27$ ). The highest score (68.5%,  $2.74 \pm 0.65$ ) was

reported for the fourth domain (UCB-potential research applications), while the lowest score (55.0%,  $2.20 \pm 0.31$ ) was reported for the first domain (UCB SCs).

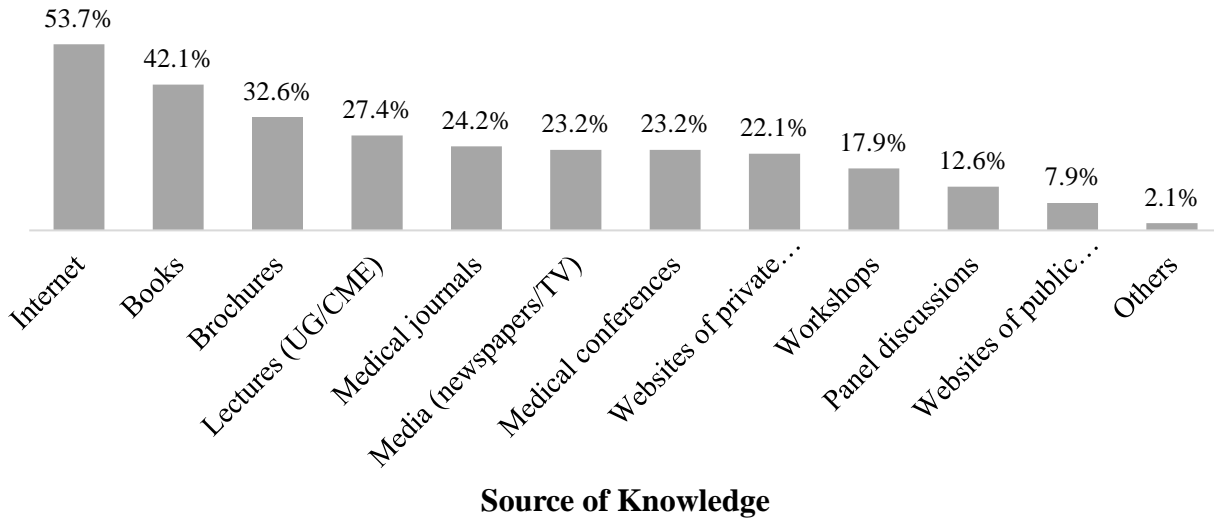


Figure 1: Sources of knowledge regarding umbilical cord blood collection and banking among study participants (n = 96).  
CME, continuing medical education; UG, undergraduate  
Note: Participants were given the option to choose more than one source

**Table 3:** Obstetricians' knowledge regarding umbilical cord blood (UCB), including stem cells, collection, banking, therapeutic uses, and research applications (n = 96). Each statement is designated "true" or "false" here for reporting purposes. Knowledge scores > 2 indicate good knowledge, while < 2 indicate poor knowledge.

Statements	M (SD)	95% CI		M%
		Lower	Upper	
<b>First Domain: UCB Stem Cells</b>				
1- I have basic knowledge about UCB stem cells.	2.52 (0.89)	2.34	2.70	63.0%
2- I am familiar with different types of UCB stem cells such as hematopoietic and mesenchymal stem cells.	2.19 (1.01)	1.96	2.39	54.8%
3- Stem cells are only found in UCB, not cord tissue. (False)	2.03 (1.04)	1.81	2.24	50.8%
4- UCB stem cells are embryonic stem cells. (False)	1.63 (1.19)	1.41	1.85	40.8%
5- UCB stem cells are pluripotent cells that have the potential to make all cell types of the body. (False)	1.44 (1.01)	1.24	1.65	36.0%
6- Hematopoietic stem cells in UCB have the potential to differentiate into blood cells. (True)	2.75 (0.91)	2.56	2.94	68.8%
7- Mesenchymal stem cells in UCB and cord tissue have the potential to differentiate into other cell types such as cardiac myoblasts and keratinocytes. (True)	2.65 (0.88)	2.48	2.81	66.3%
8- Endothelial cells in UCB have the potential to differentiate into blood vessels. (True)	2.47 (0.95)	2.28	2.65	61.8%
9- UCB is considered a potential source of induced pluripotent stem cells. (True)	2.51 (0.93)	2.33	2.69	62.8%
10- I am familiar with Wharton's Jelly as a source for stromal cells.	2.23 (0.96)	2.04	2.43	55.8%
11- UCB stem cells have decreased immune reactivity when compared to other sources of stem cells such as bone marrow and peripheral blood. (True)	2.32 (0.88)	2.15	2.50	58.0%
12- UCB contains a high number of hematopoietic stem cells in comparison with other sources such as bone marrow and peripheral blood. (False)	1.76 (0.90)	1.58	1.94	44.0%
Total knowledge score of first domain (UCB stem cells).	2.20 (0.31)	2.14	2.27	55.0%
<b>Second Domain: UCB Collection and Banking</b>				
13- I am familiar with techniques of UCB collection.	2.42 (1.01)	2.23	2.62	60.5%
14- The procedure of UCB collection poses serious risks for both mother and child. (False)	2.40 (1.15)	2.17	2.61	60.0%
15- UCB collection is only done ex utero (i.e. after delivery of placenta). (False)	2.22 (1.08)	2.00	2.43	55.5%
16- UCB collection cannot be performed following caesarean section. (False)	2.61 (1.08)	2.41	2.82	65.3%
17- UCB collection cannot be performed following preterm labor. (False)	2.46 (0.97)	2.27	2.66	61.5%
18- UCB collection is a simple procedure that requires no special training. (False)	2.22 (1.09)	1.99	2.45	55.5%
19- After collection, cord blood units should be submitted to quality control. (True)	2.55 (0.84)	2.39	2.72	63.8%
20- There is a probability for a collected UCB unit not to be stored and subsequently to be discarded. (True)	2.30 (0.95)	2.11	2.49	57.5%
21- Maternal blood should be tested for possible infectious diseases prior to UCB banking. (True)	2.46 (1.07)	2.25	2.69	61.5%
22- Fetal blood should be tested for possible infectious diseases prior to UCB banking. (True)	2.53 (0.97)	2.33	2.74	63.3%
23- I know the difference between private, public, and hybrid UCB banks.	2.10 (0.93)	1.92	2.29	52.5%
24- Quality management systems in private banks are always better than those in public banks. (False)	1.77 (0.91)	1.59	1.97	44.3%
25- Decision for UCB donation is made mainly by the mother after being informed before the delivery, and it is followed by her written consent. (True)	2.67 (0.96)	2.48	2.85	66.8%
26- Parents who choose to donate UCB to public banks have to pay fees. (False)	2.11 (1.04)	1.91	2.31	52.8%
Total knowledge score of second domain (UCB collection and banking)	2.34 (0.40)	2.26	2.42	58.5%
<b>Third Domain: UCB Therapeutic Uses and Transplantation</b>				

27- Stem cells derived from UCB can be used to cure a number of malignant diseases such as acute leukemia and lymphoproliferative conditions. (True)	2.81 (0.85)	2.65	2.99	70.3%
28- Stem cells derived from UCB can be used to treat hemoglobinopathies such as thalassemia major and sickle cell disease. (True)	2.72 (0.88)	2.55	2.90	68.0%
29- Stem cells derived from UCB can be used to treat metabolic diseases and immunodeficiency syndromes. (True)	2.36 (0.90)	2.19	2.57	59.0%
30- Allogeneic UCB transplantation is a suitable alternative to bone marrow transplantation especially in patients who lack a human leukocyte antigen (HLA)-matched donor. (True)	2.50 (0.77)	2.34	2.66	62.5%
31- UCB transplantation is done only for pediatric patients, not for adult patients. (False)	2.26 (1.01)	2.05	2.45	56.5%
32- UCB units can be used for transplantation even many years after initial storage. (True)	2.65 (0.95)	2.46	2.84	66.3%
33- Clinical protocols support the use of two CB units instead of one unit for UCB transplantation. (True)	2.23 (0.79)	2.07	2.38	55.8%
34- I would be comfortable counseling women on whether or not to store UCB.	2.39 (0.96)	2.20	2.57	59.8%
35- The storage of UCB in private banks for autologous transplantation has limited value based on current evidence. (True)	2.09 (0.95)	1.91	2.29	52.3%
36- Total nucleated cell dose, HLA matching, and CD34+ are the most important factors for survival after hematopoietic stem cell transplantation. (True)	2.39 (0.74)	2.23	2.53	59.8%
37- UCB transplantation reports a lot of advantages in comparison with bone marrow transplantation. (True)	2.58 (0.79)	2.43	2.74	64.5%
38- UCB transplantation is associated with increased risk of transmitting viruses such as cytomegalovirus and Epstein Barr virus. (False)	1.93 (0.97)	1.73	2.11	48.3%
39- UCB transplantation is associated with increased risk of acute graft-versus-host disease in comparison with bone marrow transplantation. (False)	1.97 (1.09)	1.74	2.18	49.3%
Total knowledge score of third domain (UCB therapeutic uses and transplantation).	2.36 (0.34)	2.30	2.44	59.0%
<b>Fourth Domain: UCB Potential Research Applications</b>				
40- Stem cells derived from UCB can be used to replace or restore tissues that have been damaged by disease or injury. (True)	2.83 (0.77)	2.68	2.99	70.8%
41- Stem cells derived from UCB have the potential to treat autoimmune diseases such as systemic lupus erythematosus. (True)	2.74 (0.87)	2.57	2.93	68.5%
42- Stem cells derived from UCB can be used to understand pathophysiology and analyze disease mechanisms by modeling disease in a culture dish outside the human body. (True)	2.73 (0.92)	2.55	2.93	68.3%
43- Stem cells derived from UCB can be used to test and screen new drug candidates and toxins to figure out their potential side effects. (True)	2.78 (0.90)	2.60	2.96	69.5%
44- Stem cells derived from UCB can be used in combination with genome editing techniques to deliver missing genes. (True)	2.59 (0.84)	2.45	2.77	64.8%
Total knowledge score of fourth domain (UCB potential research applications)	2.74 (0.65)	2.61	2.88	68.5%
Overall total knowledge score	2.35 (0.27)	2.31	2.41	58.8%

Note: *M* = Mean, *SD* = Standard Deviation, *CI* = Confidence Interval and *M%* = Percentage of mean

Note: total knowledge score is the sum of total scores of 4 major domains (UCB stem cells, collection and banking, transplantation and therapeutic uses, and potential research applications).

Note: *M%* was calculated by using the following equation (mean score/4 x100).

In the first domain, obstetricians self-rated their basic knowledge regarding UCB SCs as 63.0% ( $2.52 \pm 0.89$ ), but their actual knowledge as measured by our scale was 55.0% ( $2.20 \pm 0.31$ ). Obstetricians were more familiar with the differentiation potential of hematopoietic SCs (68.8%,  $2.75 \pm 0.91$ ), mesenchymal SCs (66.3%,  $2.65 \pm 0.88$ ) and endothelial cells (61.8%,  $2.47 \pm 0.95$ ). They were less familiar with cord tissue as a source for SCs (50.8%,  $2.03 \pm 1.04$ ) and Wharton's Jelly as a source for stromal cells (55.8%,  $2.23 \pm 0.96$ ). Moreover, they were more knowledgeable about decreased immune reactivity of UCB SCs in comparison with BM SCs (58.0%,  $2.32 \pm 0.88$ ), but were less knowledgeable about the low SC count in UCB in comparison with

BM (44.0%,  $1.76 \pm 0.90$ ). Only a minority were aware that UCB SCs are neither embryonic (40.8%,  $1.63 \pm 1.19$ ) nor pluripotent (36.0%,  $1.44 \pm 1.01$ ).

In the second domain, 60.5% ( $2.42 \pm 1.01$ ) of participants were familiar with techniques of UCB collection, and 60.0% ( $2.40 \pm 1.15$ ) were aware that the procedure is safe for both mother and child. Most participants were aware that UCB collection can be performed following cesarean section (65.3%,  $2.61 \pm 1.08$ ) and preterm labor (61.5%,  $2.46 \pm 0.97$ ). Fewer were aware that UCB collection can occur before placental delivery (55.5%,  $2.22 \pm 1.08$ ), and that it requires special training (55.5%,  $2.22 \pm 1.09$ ). A majority (63.8%,  $2.55 \pm 0.84$ ) knew that collected UCB units should be submitted to quality control,



and that maternal (61.5%,  $2.46 \pm 1.07$ ) and fetal (63.3%,  $2.53 \pm 0.97$ ) blood should be screened for possible infections, and that there is a probability that an UCB unit may be discarded before storage (57.5%,  $2.30 \pm 0.95$ ). Most believed that the decision for UCB donation should be made mainly by the mother (66.8%,  $2.67 \pm 0.96$ ). Approximately half knew that UCB donation to public banks is completely free for the parents (52.8%,  $2.11 \pm 1.04$ ) and were familiar with differences between private, public, and hybrid UCB banks (52.5%,  $2.10 \pm 0.93$ ). Only 44.3% ( $1.77 \pm 0.91$ ) recognized that quality management systems in private banks is not always better than those in public banks.

In the third domain, obstetricians were familiar with therapeutic uses of UCB SCs for malignant diseases (70.3%,  $2.81 \pm 0.85$ ), hemoglobinopathies (68.0%,  $2.72 \pm 0.88$ ), and metabolic diseases and immunodeficiency syndromes (59.0%,  $2.36 \pm 0.90$ ). Furthermore, 66.3% ( $2.65 \pm 0.95$ ) knew that UCB units can be used for transplantation several years after initial storage, but fewer (55.8%,  $2.23 \pm 0.79$ ) were familiar with recent guidelines that support the use of two UCB units instead of one. A similar number (59.8%,  $2.39 \pm 0.95$ ) were confident in their ability to counsel pregnant women about UCB banking. About two-thirds (62.5%,  $2.50 \pm 0.77$ ) were aware that allogeneic UCB transplantation is considered a suitable alternative to BM transplantation in patients who lack an HLA-matched donor, and that UCB transplantation has many advantages in comparison with BM transplantation (64.5%,  $2.58 \pm 0.79$ ). However, less than half were actually aware of these advantages such as: decreased risk of acute graft-versus-host disease (49.3%,  $1.97 \pm 1.09$ ), and low transmission rate of cytomegalovirus and Epstein Barr virus (48.3%,  $1.93 \pm 0.97$ ). They were less aware that UCB transplants can be done for both pediatric and adult patients (56.5%,  $2.26 \pm 1.01$ ), and about half (52.3%,  $2.09 \pm 1.01$ ) agreed that private UCB banking for autologous transplantation is of limited value based on current evidence. Finally, 59.8% ( $2.39 \pm 0.79$ ) were aware about survival factors after hematopoietic SC transplantation such as: total nucleated cell dose, HLA matching, and CD34+.

In the last domain, participants overall demonstrated sufficient knowledge regarding potential research application of UCB, such as regenerative medicine (70.8%,  $2.83 \pm 0.77$ ), treatment of autoimmune diseases (68.5%,  $2.74 \pm 0.87$ ), modeling diseases *in vitro* (68.3%,  $2.73 \pm 0.92$ ), screening new drug candidates (69.5%,  $2.78 \pm 0.90$ ), and genome editing (64.8%,  $2.59 \pm 0.84$ ).

#### Obstetricians' Attitudes

The total attitude score was 66.8% ( $2.67 \pm 0.40$ ) (**Table 4**), which was higher than the total knowledge score. In general, participants showed positive attitudes regarding: expanding their knowledge about UCB SCs and their therapeutic uses (77.8%,  $3.11 \pm 0.82$ ), integration of UCB SC science and medicine in residency program graduate curricula (71.3%,  $2.85 \pm 0.83$ ), and attending conferences about research applications of UCB SCs (70.0%,  $2.80 \pm 0.92$ ). In addition, about three-fourths encouraged the establishment of a public UCB bank in Jordan (75.3%,  $3.01 \pm 0.76$ ) and said they would collect UCB for free (75.0%,  $3.00 \pm 0.66$ ). They encouraged the utilization of UCB SCs for experimental research and clinical trials (74.0%,  $2.96 \pm 0.72$ ) with governmental financial support (72.0%,  $2.88 \pm 0.87$ ). Most also agreed that every hospital should have a standard operating procedure for UCB collection (74.0%,  $2.96 \pm 0.74$ ). Over two-thirds of obstetricians (68.0%,  $2.72 \pm 0.85$ ) said that, if parents asked, they would discuss UCB banking by presenting all the options and leaving the final decision for them. Furthermore, 61.5% ( $2.46 \pm 1.07$ ) believed it unethical to convince parents to privately bank their baby's UCB without significant need or family history. Finally, a substantial proportion of participants thought that UCB donation is surrounded by ethical (61.0%,  $1.56 \pm 1.01$ ) and religious (56.2%,  $1.75 \pm 1.14$ ) controversies.

**Table 4:** Obstetricians' attitudes about umbilical cord blood (UCB) stem cells, collection, and banking (n = 96). Each statement is designated "positive" or "negative" here for reporting purposes. Attitude scores > 2 indicate positive attitudes, while < 2 indicate negative attitudes.

Statements	M (SD)	95% CI		M%
		Lower	Upper	
1- I am interested to expand my knowledge about UCB stem cells and their therapeutic uses. (Positive)	3.11 (0.82)	2.95	3.28	77.8%
2- UCB stem cell science should be integrated in graduate curricula of residency programs. (Positive)	2.85 (0.83)	2.69	3.02	71.3%
3- I will consider a well-structured training focusing on techniques of UCB collection. (Positive)	2.74 (0.99)	2.53	2.96	68.5%
4- I may attend a conference about potential research applications of UCB stem cells. (Positive)	2.80 (0.92)	2.60	2.99	70.0%
5- I encourage the use of UCB stem cells for experimental research and clinical trials. (Positive)	2.96 (0.72)	2.81	3.10	74.0%
6- Every hospital should have a standard operation procedure for UCB collection. (Positive)	2.96 (0.74)	2.81	3.10	74.0%
7- I encourage establishing a public cord blood bank in my country. (Positive)	3.01 (0.76)	2.86	3.16	75.3%
8- I may collect UCB for free for a public CB bank. (Positive)	3.00 (0.66)	2.86	3.14	75.0%
9- If there was a public bank, I would discuss with parents about donating their UCB. (Positive)	2.92 (0.77)	2.76	3.06	73.0%
10- The government should spend money to support CB stem cell research. (Positive)	2.88 (0.87)	2.71	3.04	72.0%
11- I think there are ethical controversies surrounding CB donation. (Negative)	1.56 (1.01)	1.36	1.77	39.0%
12- I think there are religious controversies surrounding CB donation. (Negative)	1.75 (1.14)	1.53	1.98	43.8%
13- If the parents ask for my opinion about CB banking, I will discuss all the options and leave the decision for them. (Positive)	2.72 (0.85)	2.54	2.89	68.0%
14- It is unethical to convince parents to preserve UCB of their babies for a private bank when there is no significant need or family history. (Positive)	2.46 (1.07)	2.24	2.67	61.5%
Overall total attitude score	2.67 (0.40)	2.59	2.75	66.8%

Note: M = Mean, SD = Standard Deviation, CI = Confidence Interval and M% = Percentage of mean

Note: Total attitude score is the sum of total scores of 14 statements which were designed to assess attitudes.

Note: M% was calculated by using the following equation (mean score/4 x100).

## DISCUSSION

This study is a cross-sectional survey that aims to assess the attitudes and knowledge regarding UCB collection, banking, therapeutic uses and research applications among obstetricians in Jordan. Obstetricians demonstrated a moderate level of overall knowledge about UCB, although a substantial proportion lacked confidence in their ability to provide counseling for pregnant women about UCB banking. These results may explain the low level of knowledge among the general public that by Matsumoto *et al.* found<sup>27</sup>. Most of the obstetricians surveyed were working in private hospitals and had no prior experience in UCB collection. Every obstetrician who was collecting UCB was working in a private hospital (data not shown), which corresponds with the higher level of awareness among women at private hospitals versus public ones<sup>28</sup>.

Quality control, including lack of sterile conditions, standard operating procedures, and infectious

disease screening, is a major concern. These results suggest a lack of oversight and regulation in Jordan that can negatively impact patients and their families, especially when compared to quality standards in other self-reported studies<sup>33</sup>. Notably, most respondents agreed that having guidelines and standard operating procedures was important. Furthermore, nearly all participants agreed that UCB collection did not place excess burden on their regular work as obstetricians, which is promising and suggestive of a positive environment in Jordan<sup>33</sup>. Quality control should be a priority for the Ministry of Health in regulating UCB banking in Jordan, especially with the opening of the new KHCC bank. Regardless of the low level of experience in UCB collection in Jordan, the level of knowledge needs to increase for public UCB to be feasible, so that obstetricians can better inform parents about UCB storage options. The Internet was the main source of knowledge among study participants about UCB collection and banking. Healthcare providers and the general public should rely on evidence-based

information and be aware about false claims and misleading information on websites, such as those of private banks, that often promote UCB-based therapies for conditions without scientific evidence<sup>22</sup>. Emphasis should be placed on information from peer-review medical journals and other qualified sources, such as lectures, medical conferences, and workshops. Furthermore, several gaps in knowledge were identified regarding the characteristics and potency of UCB SCs, UCB-versus-BM transplantation, and public UCB banks. In order to bridge these gaps, the curricula of obstetrics/gynecology residency programs should include information on clinical and research evidence for using UCB SCs.

Obstetricians have professional and ethical obligations to provide accurate and unbiased information to prospective parents about UCB banking<sup>29</sup>. For example, they should be able to facilitate an objective discussion of the pros and cons of each type of banking, while leaving the final decision for the family<sup>30,31</sup>. However, this expectation stipulates that obstetricians have a basic understanding of guidelines and evidence about UCB storage, research, and therapeutic uses, which is lacking<sup>32</sup>. Compared with other studies, a larger proportion of obstetricians in this study believed that UCB collection poses serious risk to mother or child<sup>33,34</sup>. This fundamental misconception suggests an underlying lack of familiarity with the UCB collection procedure, which, although requiring specialized training, is considered a safe process. Furthermore, some respondents reported receiving financial compensation for collecting UCB, which is a major conflict of interest and is likely associated with private UCB storage. This practice can bias healthcare providers to prioritize personal benefit, rather than that of their patients.

A more nuanced understanding among healthcare providers about UCB collection, donation, and storage options is needed in Jordan. A large proportion of participants said they were not familiar with differences between private, public, and hybrid UCB banks. Many thought parents have to pay fees for UCB donation and that quality management systems are better in private than public banks. In reality, the quality management systems in public

banks are often stricter than those in private banks, and many private banks store UCB units regardless of quality factors, such as cell count, which not only is expensive for families but also can compromise the usability of the unit<sup>36</sup>. Furthermore, respondents possessed low knowledge regarding private storage of UCB for autologous use. For example, UCB cannot be used to treat a genetic disease or malignancy in that same individual because stored UCB contains the same genetic variant or premalignant cells that led to the condition being treated<sup>37</sup>. Private UCB banking is not a 'biological insurance' and should be discouraged unless an existing family member (sibling or biological parent) is suffering from diseases approved to be cured by allogeneic SC transplantation<sup>31</sup>. These beliefs represent barriers to UCB donation in Jordan, since obstetricians are not currently equipped to provide accurate information to pregnant women about UCB banking options.

The primary limitation of this study is generalizability, due to the relatively small sample size drawn from a restricted, albeit cross-sectional, population of obstetricians in Amman, Jordan. Nevertheless, this population was chosen specifically due to the relevance to current developments in UCB banking in the region. Furthermore, the relatively low response rate may introduce bias in the data. However, it would be expected that those more knowledgeable or interested in the subject would be more likely to respond, especially due to the length of the survey, so these results may overestimate the current level of knowledge about UCB among obstetricians in Jordan. In addition, the response rate is consistent with cross-sectional survey-based studies. A large part of the survey relied on self-reports of practices and self-assessments of knowledge, which could not be validated. However, the anonymity of the survey and the true/false questions support the accuracy of the data.

This study identified several barriers to UCB collection and banking in Jordan from the perspective of healthcare providers. Deficiencies in quality control and protocols for UCB collection were identified, as well as ethical issues in conflict of interest. Several areas of inadequate knowledge and false beliefs regarding UCB banking and usage were found among obstetricians. For example, they lacked

familiarity with UCB collection procedures and had a poor understanding about important clinical and research applications. Despite these shortcomings, obstetricians expressed relatively positive attitudes toward public UCB banking, as well as interest in expanding their own knowledge about UCB collection options. Information generated from this study can be utilized by policymakers to not only improve curricula of medical residency programs but also support opportunities for obstetricians to learn about UCB banking. These initiatives will better support the establishment of a public UCB bank in Jordan so that patients and providers alike are informed about UCB donation. . Future research and activity should focus on effective ways to educate healthcare providers about UCB banking and evaluate the role of obstetricians in the UCB collection and storage process.

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