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Pregnancy Outcomes on Chronically Hemodialyzed Women in Arab World: A Systematic Review

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Abstract

Pregnancy carries a major risk of difficulties, as highlighted by the present systemic study on pregnancy outcomes in persistently hemodialyzed women in the Arab world. The objective of this systematic review was to describe the pregnancy outcomes among chronically hemodialyzed pregnant women in Arab countries in terms of the incidence of pregnancy among women on maintenance hemodialysis and the incidence of maternal and fetal complications of pregnant women on hemodialysis. A systematic review was performed based on PRISMA guidelines. Data searches were conducted through databases such as MEDLINE, and Scopus, and manual search of multiple databases. 11 studies met the inclusion criteria after applying a filtering approach, which was ready for analysis. Results indicated that the included studies reported 302 pregnancies with a success rate of 43.4%. The mean yearly incidence rate of pregnancy among women was 1.12%. The most common complications reported were abortion for mothers and IUFR for fetuses (7.7%). The main recommendation was to increase the duration and the frequency of HD, as it is reported in four articles to be associated with a higher success rate with statistical significance (p-value<0.05).

Keywords: End-stage renal disease, chronic kidney disease, pregnancy outcome, fetal outcome, hemodialysis

INTRODUCTION

One of the most significant times in a woman's life is the pregnancy period, where the body undergoes many physiological changes as a result of hormonal influence to ensure optimal pregnancy and birth circumstances. Numerous structural and functional alterations occur, and the kidneys are one of the many organs and systems that are greatly impacted by the hormonal state. The impact of physiological changes during pregnancy on the kidney itself would be more serious when the pregnant woman is diagnosed with end-stage renal disease (ESRD). Although dialysis does not completely restore many normal physiological processes that are abnormal in severe chronic kidney disease (CKD), it has changed the treatment of patients with ESRD. Pregnancy and childbirth are two such processes that are significant to women. Pregnancy in a dialysis patient is still uncommon and carries a considerable degree of risk, despite significant advancements over the past 50 years [1]. ESRD is linked to reduce the fertility and conception rates among dialysis patients which are estimated to be 1/100th of the general population. On the other hand, live birth rates are steadily rising for women receiving hemodialysis while being stagnant for

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those receiving peritoneal dialysis. Improved live birth rates and longer gestational ages are linked to intensifying hemodialysis, with the goal of a serum BUN<35 mg/dl or 36 h of dialysis per week in women with no residual renal function [2].

In the past, it was quite rare for women receiving dialysis with ESRD to become pregnant. Although it is not common, pregnancy among women receiving dialysis is increasing and becoming more relevant. The high rates of pregnancy failure, including stillbirth and fetal and neonatal fatalities, as well as reproductive issues are the main causes of this event's rarity [3]. As a result, these women constitute a high-risk patient population with greater rates of unfavorable pregnancy outcomes, such as abortion, preeclampsia, preterm birth, low birth weight, and more frequent admissions to the critical care units [4]. Following pregnancy, kidney function in women with severe stages of CKD may continue to deteriorate. Because of the various challenges in managing this group of high-risk patients, when pregnancy did occur, it was usually accompanied by severe risk for both mother and child. Hence doctors frequently counseled women on dialysis who were of reproductive age not to get pregnant, and patients who did not receive a transplant promptly were unlikely to become parents.

Surveys, case series, and anecdotal tales provide experience with pregnancy and dialysis. Herwig *et al.;* [5] and Orme *et al*. (1968) [6] documented the first examples of pregnant women receiving hemodialysis (HD). An Italian group reported the first occurrence of a pregnant woman using HD internationally. Several case reports from the US and Europe that detailed dialysis patients' successful births came after this [7].

Pregnant women may face critical situations when undergoing chronic hemodialysis because of the physical and physiological demands of both procedures. Pregnancy is typically regarded as high-risk in patients on chronic hemodialysis, necessitating intensive monitoring and collaboration between nephrologists and obstetricians. Both ESRD and CKD have elevated rates of morbidity, mortality, and socioeconomic costs, making it a significant public health issue [8]. Patients with ESRD have a low chance of becoming pregnant, and women receiving dialysis have lower fertility rates. Even while recent developments have raised the number of live births among pregnant dialysis patients, there is still a higher risk of various adverse outcomes for pregnant women using this modality [9].

Comparing dialysis patients' conception rates to those of the general population, they are still extremely low. Nonetheless, the success rates of these pregnancies have increased recently. Precautions for pregnant women receiving dialysis include maintaining low pre-dialysis urea levels, ensuring an adequate tension profile, managing anemia, taking care to prevent infections, monitoring for nutritional deficiencies, observing changes in phosphorus-calcium metabolism, and monitoring electrolytic fluctuations. Additionally, close observation of the growth and development of the fetus is required. Maternal and fetal problems are more likely to occur in pregnant women receiving dialysis, which highlights the significance of a multidisciplinary approach involving nephrologists, obstetricians, and pediatricians [10].

The underlying cause of renal illness, the length of dialysis, the general health of the woman, and the quality of dialysis are some of the variables that can affect the pregnancy outcomes in women receiving prolonged hemodialysis. Furthermore, the quality of medical care provided and one's ability to access healthcare resources can influence the results.

Since the 1970s, when a chronic hemodialysis patient had a successful pregnancy and childbirth, there has likely been a rise in pregnancies, in part because of the improved prognosis. Thus, it is more acceptable to become pregnant, which results in fewer instances of treatment stoppage. But in addition to all the advancements in dialysis conditions, including longer dialysis sessions and urea levels kept low to prevent hypertension in mothers, other improvements like anemia correction, sufficient fetal monitoring, and improvements in obstetric and neonatal care are also accountable for this notable rise [11].

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However, due to advancements in technology and decades of experience, pregnant women receiving dialysis can now benefit from improved nutritional and pharmacological approaches, as well as adequate dialysis techniques, which can significantly improve their quality of life and increase their chances of a successful pregnancy. Even with all the advancements in this profession, the majority of babies are born prematurely, and there is often a high rate of maternal-fetal problems, including infections, polyhydramnios, anemia, and fetal growth limits. The topic of discussion in the joint meetings of pediatricians, obstetricians, and nephrologists is contentious and lacks agreement. It is apparent that findings on the overall maternal and fetal outcomes for a pregnant woman on dialysis are inconsistent. In light of the ambiguous evidence presented in previous literature reviews, this investigation set out to systematically review the literature for scientific evidence to support or refute the assumptions that pregnant women on dialysis experience compromised pregnancy outcomes.

REVIEW AIMS

This systematic review aimed to estimate the incidence of pregnancy among women on maintenance hemodialysis and to assess how pregnant women on hemodialysis reported incidences of maternal and fetal complications.

MATERIAL AND METHODS

The current systematic review adheres to the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines.

Search Strategy

The search strategy included the use of keywords such as pregnancy, pregnant, "prenatal, antenatal, maternal, hemodialysis, renal treatment, ESRD, and renal dialysis. Synonyms of relevant keywords, truncations (*, #), and wildcards (?) were considered in the search strategy. Initially, one main keyword was used in the search strategy, and then Boolean operators (AND/OR/NOT) were added to combine the initial keyword. Three major electronic databases (MEDLINE, Scopus, and manual search in different databases) were considered in the search strategy for all published papers up to October 2023. Papers included in the review were in English language, peer-reviewed journals, reported the outcomes of pregnancy for women on chronic hemodialysis and presented cases from the Arab countries (Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the United Arab Emirates, and Yemen). The review excluded papers that reported pregnancy outcomes for women with other kidney pathologies like acute kidney injury, and those demonstrated cases outside the Arab world. Geographical filters were applied to include peer-reviewed articles from Arab countries only mentioned in the inclusion and exclusion criteria.

Study Selection

Three reviewers participated in reviewing the filtered articles; the first two reviewers independently reviewed the titles and abstracts to evaluate the eligibility of the potential articles according to the previously mentioned inclusion and exclusion criteria. Second, the reviewers reviewed the full texts of the potentially eligible articles to confirm their eligibility. The third reviewer compared the lists of selected papers and confirmed the final status of each publication, whether to be included or not.

Data Extraction

Two reviewers extracted data independently on study characteristics that include demographics and the pregnancy outcomes (maternal death, neonatal death, miscarriage, stillbirth, preterm birth, low birth weight, and congenital anomalies) for each study. The third reviewer confirmed the collected data. The risk of bias in selected articles was assessed independently by two reviewers and confirmed by the third reviewer.

Data Analysis

Data was transformed into a data sheet that included all studies to be prepared for statistical analysis; only publications that report pregnancy outcomes were retained for analysis. Descriptive statistics were

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used to present the review findings, mainly the pregnancy outcomes, including frequencies, percentages, fractions, and/or relative frequencies. Interferential statistical tests assessed the relationship between variables and compared different groups. The statistical significance level was set throughout the statistical tests at p P-value of 0.05 or less.

RESULTS

Study Selection

Database search results in 723160 studies were automatically filtered to include only articles published in peer-reviewed journals, which yielded 355279. An automatic geographic filter was used to identify articles from the Arab countries mentioned above. Moreover, regions with Arab states were added to the filter, including the Middle East, Africa, and Asia. Applying the geographic filter resulted in 178, which were included in one datasheet to exclude the duplicates. 11 articles were used for data extraction after assessing the eligibility and seeking the reports (PRISMA flow chart) (Figure 1) [12].

Characteristics of Included Studies

The studies included were published between 1992 and 2022; five studies relied on a retrospective review of the medical charts, either at a single center or multiple centers, where the study team identified the occurrence of pregnancy and followed the patient till the delivery.

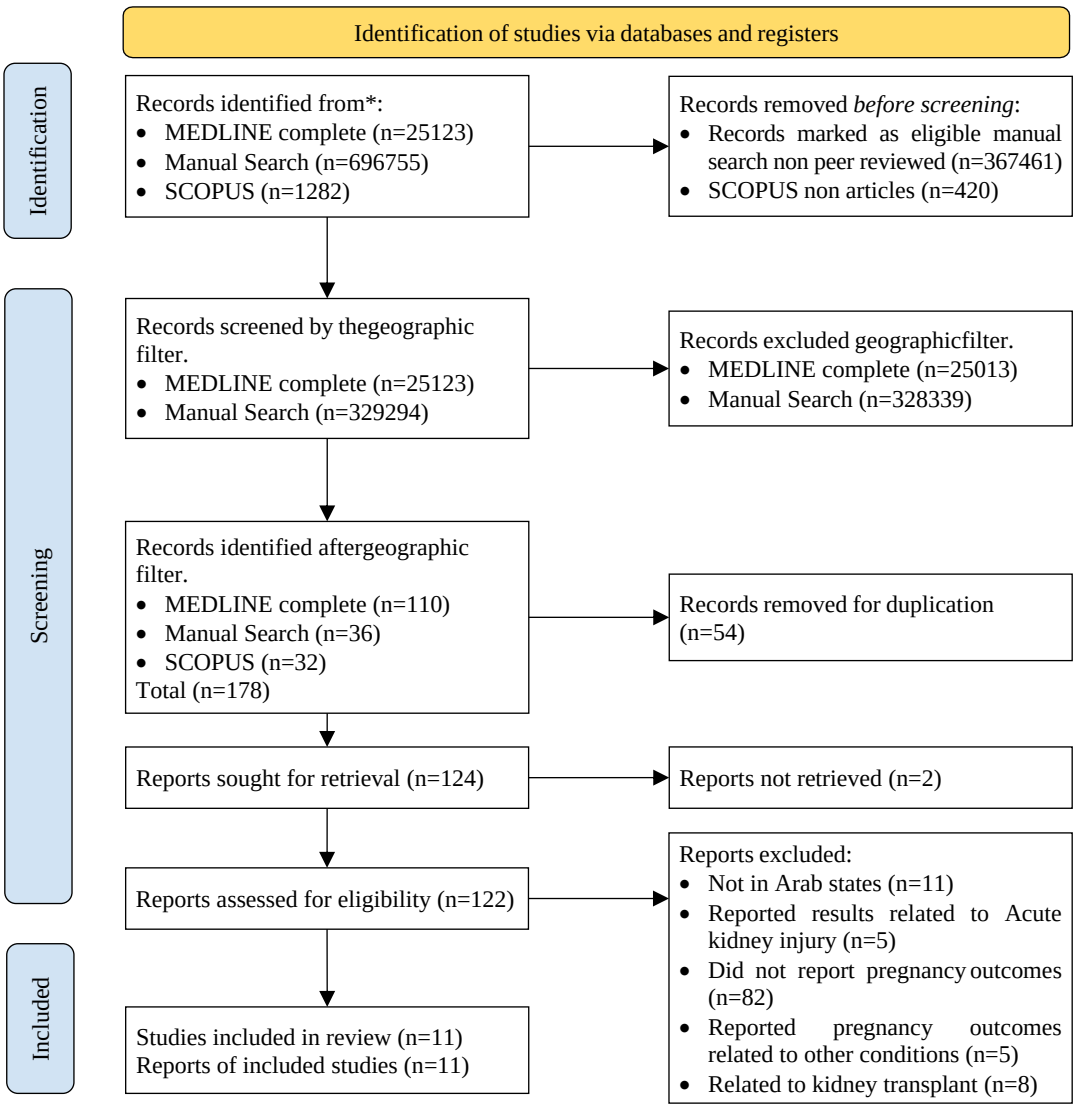

Figure 1. Prisma flow chart.

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Table 1. Characteristics of the included studies.

Study	Country	Study design	Subjects	Pregnancies	Vaginal rout Delivery	Outcomes
Doukkali et al., 2015 [13]	Morocco	Case series	n=12 mean age 34 (22–44)	N=12 Average term =35 Average gestational age = 16 years	10/12	Successful pregnancy (born with a live newborn) =8 preterm birth =1 birth weight = 1800 (350–2900 gm)
Bahadi et al., 2010 [14]	Morocco	Case series	N=9 Mean age 34 (22–40)	N=9 Average term =33 Average gestational age =14	7/9	Successful pregnancy =5 miscarriage =2 birth weight =2380 gm (1800–2900) gm
Souqiyyeh et al., 1992 [1]	Saudi Arabia	Cross-sectional survey-multicenter	N= 22 Mean age 26 (21–40)	N=27	NR	Successful pregnancy with live babies =8 unsuccessful pregnancy =17 stillbirth =2
Hadj Sadek et al., 2011 [15]	Morocco	Retrospective Medical chart review-single center	N=8 Mean age 34 (24–45)	N=11 Mean term 33.6 weeks	4/11	Successful pregnancy with live babies =5 miscarriage =4 intrauterine fetal death =2 mean birth weight =2070 gm
(Sulaiman, 1997) [16]	Saudi Arabia	Retrospective Medical chart review-single center	N= 5 Mean age 32.6 (17–40)	N= 6 mean gustational age 26.3 (12-36)	4/6	Successful with live baby=4 Abortion=2 Fetal weight 1265 gm (760–1600)
Chaker et al., 2020 [17]	Tunesia	Case series	19 Mean age 35.6 (23–44)	25 Mdn gestational age 34 (28-38)	12/25	Successful with live baby=16 Neonatal wt=1970 (1500–2300) gm Miscarriages=5/25 Unknown 4
Malik et al., 2005 [18]	Saudi Arabia	Retrospective medical chart review	9 Mean age 29.4 (20–41) 5 on HD	12 31.6 (28-36)	3/9	Successful with live baby=7 Abortion=3 Neonatal wt=1700 (1115–2300) gm
Megahed et al., 2020 [19]	Egypt	Multi-center multicenter observational study	NR, phase I 33, phase II (24–50 year old)	193, phase I 57, phase II 32.6 (24-36)	6/21	Successful with live baby=72 Successful with live baby=19 Abortion=110 36 Still pregnant 11, Neonatal wt 2.1 kg (0.9–3.5 kg)
Abd and Al-Shamma, 2007 [20]	Iraq	Case report	1 18 age	1 32 gestational age	1/1	Successful with live baby Neonatal wt=2100 gm
Imtiaz et al., 2008 [21]	Saudi Arabia	Case report	1 Age 36	1 36 weeks gestational age	0/1	Successful with live baby Neonatal wt=3500 gm
Iqbal et al., 2022 [22]	Saudi Arabia	Case series	5 Age 32.2 (27–40)	5 Gestational age 35.4 weeks	3/5	Live baby 4 Intrauterine death 1 Neonatal wt=2342 (1670–2700) gm
	Total			302		Successful with live baby 131

**No maternal death was reported.*
**No congenital anomaly was reported.*
**Total number of pregnancies 279 with a successful rate of delivering a live baby of 45.5% (n=127).*

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Two studies relied on a multi-central survey where the study team sent a survey to multiple hemodialysis centers requiring information on the incidence of pregnancy and outcomes in their centers. The included studies reported 302 pregnancies with a successful rate of delivering live babies of 43.4% (n=131), and no maternal death nor congenital anomaly was reported (study characteristics table). Table 1 presents the characteristics of the included studies.

Prevalence

To calculate the incidence of pregnancy among women on maintenance HD, researchers relied only on retrospective medical chart reviews that reported the total number of women on MHD. The yearly incident rate was calculated by dividing the total number of pregnancies by the number of women and the number of years as illustrated in Table 2.

The mean yearly incidence rate of pregnancy among women with CBA and active sexual partners under MHD is 1.12%. This rate was calculated by excluding the total number of females in CBA with active sexual partners, as the author did not report this data.

The most reported maternal complications included abortion, hypertension, and polyhydramnios, as demonstrated in Table 3. Less common complications included one case of oligohydramnios along with a ruptured uterus reported by Malik *et al*. [18], and two cases of delivery hemorrhage reported by Chaker *et al*. [17].

Table 2. The yearly incident rate was calculated by dividing the total number of pregnancies.

Study variables	(Souqiyyeh *et al*., 1992) [1]	(Hadj Sadek *et al*., 2011) [15]	(Sulaiman, 1997) [16]	(Malik *et al*., 2005) [18]	(Megahed *et al*., 2020) [19]
Study duration (years)	5	10.5	6	12	5
General	1018	NR	NR	NR	25381
Female	380	NR	80	289	9890
Female with CBA age	NR	23	NR	192	4472
Female with CBA with an active sexual partner	300	14	NR	82	3714
Pregnant women	22	8	5	9	NR
Pregnancies	27	11	6	12	193
Yearly incidence females	1.4	NA	1.3	0.3	0.4
Yearly incidence of female CBA with an active sexual partner	1.8	7.5	NA	1.2	1.0

NR: Not Reported, NA: not applicable, CBA: Childbearing Age

Table 3. Report of maternal complications included abortion, hypertension, and polyhydramnios.

Studies	Abortion n (%)	HTN n (%)	Polyhydramnios n (%)
(Doukkali *et al*., 2015) [13] (n=12)	4 (33.3)	5 (41.7)	6 (50)
(Bahadi *et al*., 2010) [14] (n=9)	2 (22.2)	4 (44.4)	4 (44.4)
(Souqiyyeh *et al*., 1992) [1] (n=27)	17 (63)	1 (3.7)	NA
(Hadj Sadek *et al*., 2011) [15] (n=11)	6 (54.5)	5 (45.5)	NA
(Sulaiman, 1997) [16] (n=6)	2 (33.3)	2 (33.3)	NA
(Chaker *et al*., 2020) [17] (n=25)	5 (20)	7 (28)	3 (12)
(Malik *et al*., 2005) [18] (n=12)	3 (25)	8 (66.7)	5 (41.7)
(Megahed *et al*., 2020) [19], phase I (n=193)	110 (57)	90 (46.6)	NA
(Megahed *et al*., 2020) [19], phase II (n=57)	36 (63.2)	NR (NA)	NA
(Iqbal *et al*., 2022) [22] (n=5)	1 (20)	3 (60)	0 (0)
Total (n=300)	186 (62.0)	125 (41.7)	NA

NR: Not Reported, NA: not applicable

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The total number reported for polyhydramnios was 18 [13, 14, 17, 18, 22]. Doukkali *et al*. [13] reported the use of amniocentesis in 2 cases (67%), and Bahadi *et al*. [14] also reported the use of amniocentesis in 2 cases (50%), they suggested that optimizing the dialysis may limit the severity of polyhydramnios, a suggestion was also made by Chaker *et al*. [17].

HTN during pregnancy was treated by Calcium Channel Blockers, alpha methyldopa [13, 14, 22], and one case reported the use of beta-blockers [22]. Souqiyyeh *et al*. did not report the use of any antihypertensive; the rest of the publications did not mention a specific antihypertensive therapy [1].

Fetal Complications

Table 4 demonstrates that the most common fetal complications reported for women with MHD are Intrauterine Fetal Retardation (IUFR), and Prematurity (n=23, 7.7%). Other Complications included one case of ventricular septal defect [16], and one case of molar pregnancy reported by Malik *et al*. [18].

Recommendations in Treatment Modalities

Increasing the frequency and/or duration of hemodialysis sessions for pregnant women receiving MHD was recommended by all included articles [13–22]. Moreover, Doukkali *et al*. [13] and Iqbal *et al*. [22], have recommended the management of the cases by a multidisciplinary team in addition to modifying the frequency and/or duration of HD.

Statistical significance association between longer duration of hemodialysis and birth with live babies was reported; and moreover Megahed *et al*. have reported a statistical significance association with younger age, lower phosphorus level, better nutrition, and C-section with better neonatal outcomes [19]. Specifically, in cases with polyhydramnios, Chaker *et al*. reported a statistically significant association between the duration of dialysis and success of pregnancy [17].

Table 4. Fetal complications reported for women.

	IUFR	**IUFD**	**Prematurity**	**Neonatal death**
	n (%)	***n (%)***	***n (%)***	***n (%)***
(Doukkali *et al*., 2015) [13] (n=12)	1 (8.3)	NR	1 (8.3)	NR
(Bahadi *et al*., 2010) [14] (n=9)	1 (11.1)	2 (22.2)	0 (0.0)	0 (0.0)
(Souqiyyeh *et al*., 1992) [1] (n=27)	NR	2 (7.4)	3 (11.1)	2 (7.4)
(Hadj Sadek *et al*., 2011) [15] (n=11)	1 (9.1)	2 (18.2)	1 (9.1)	NR
(Sulaiman, 1997) [16] (n=6)	NR	NR	3 (50.0)	2 (33.3)
(Chaker *et al*., 2020) [17] (n=25)	13 (52)	4 (16.0)	15 (60.0)	2 (8.0)
(Malik *et al*., 2005) [18] (n=12)	7 (58.3)	2 (16.7)	NR	1 (8.3)
(Megahed *et al*., 2020) [19], phase I (n=193)	NR	NR	NR	NR
(Megahed *et al*., 2020) [19], phase II (n=57)	NR	2 (3.5)	NR	3 (5.3)
(Iqbal *et al*., 2022) [22] (n=5)	0 (0.0)	1 (20.0)	0 (0.0)	0 (0.0)
Total (n=300)	23 (7.7)	15 (5.0)	23 (7.7)	10 (3.3)

NR: Not Reported, NA: not applicable, IUFD: Intrauterine fetal death, IUFR: Intrauterine fetal retardation

Table 5. The number of pregnant women who received each method of anemia treatment.

	EPO n (%)	**IV iron n (%)**	**blood transfusion n (%)**
(Doukkali *et al*., 2015) [13] (n=12)	4 (33.3)	4 (33.3)	7 (58.3)
(Bahadi *et al*., 2010) [14] (n=9)	3 (33.3)	4 (44.4)	5 (55.6)
(Hadj Sadek *et al*., 2011) [15] (n=11)	7 (63.6)	11 (100)	4 (36.4)
(Chaker *et al*., 2020) [17] (n=25)	12 (48)	11 (44)	6 (24)
(Malik *et al*., 2005) [18] (n=12)	8 (66.7)	0 (0)	0 (0)
(Iqbal *et al*., 2022) [22] (n=5)	4 (80)	4 (80)	4 (80)
(Abd and Al-Shamma, 2007) [20] (n=1)	1 (100)	1 (100)	0 (0)
(Imtiaz *et al*., 2008) [21] (n=1)	1 (100)	0 (0)	0 (0)
Total (n=76)	40 (52.6)	35 (46.1)	26 (34.2)

EPO: Erythropoietin

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Anemia is a predominant complication of renal failure, as it was reported in all publications included in this review. The researchers reported three methods to treat anemia: (1) administer or modify the dose of Erythropoietin; (2) administer Iron supplement; and (3) blood transfusion, whereas relatively old articles preferred blood transfusion over EPO treatment, and more recent studies recommended EPO.

Table 5 includes the articles that reported the number of pregnant women who received each method of anemia treatment. The total number of cases was 76; of those, 52% (n=40), received EPO dose modification in their anemia treatment regime.

In addition to the previous recommendation, researchers recommended the usage of regional heparinization during the dialysis sessions; and Chaker *et al*. encouraged the discussion with the patient regarding the risks before planning the pregnancy [17].

DISCUSSION

Pregnancy in women undergoing hemodialysis presents a unique and complex medical challenge [23]. This systemic review aimed to synthesize the available evidence on pregnancy outcomes in women undergoing hemodialysis, specifically within the Arab world. The analysis of the results provided valuable insights into the unique condition and shed light on the risks and complications associated with pregnancy among this specific population. Hence, the gap in knowledge and areas for further research can be identified to enhance clinical practice and improve the care provided to these women.

The review identified a limited number of studies conducted in the Arab world that focused on pregnancy outcomes in women undergoing hemodialysis. Despite the scarcity of data, the extensive literature search revealed 11 relevant studies that demonstrated pregnancy outcomes and the associated risks and complications in this population. The result of the present study illustrated a low incidence of pregnancy among women undergoing MHD [2, 24].

These results could be related to hormonal factors, sexual dysfunction, and menstrual changes. The low level of estradiol and reduced clearance of prolactin among women with End-Stage Kidney Disease (ESKD) may interfere with the normal functioning of the hypothalamic-pituitary-gonadal axis responsible for regulating ovulation [4]. As a result, women with ESKD may experience a disruption in the production of gonadotropin-releasing hormone and the midcycle surge of luteinizing hormone that subsequently affects normal ovulation [23].

Moreover, women with ESKD often experience thinning of the lining of the uterus, which is known as endometrial atrophy. This can further impact their ability to conceive, even if ovulation does take place. It is estimated that around 70% of women on hemodialysis are oligo- or amenorrheic or have irregular menstrual cycles [25]. This, coupled with sexual dysfunction and low sexual activity, worsens the condition and complicates the conception process [4]. In their literature review study, Oliverio and Hladunewich confirmed that the incidence of pregnancy and delivery among women on hemodialysis showed a significant rise from 1970 to 2023 [2]. It is noticed that the incidence of pregnancy among women undergoing hemodialysis (1.12%) is comparable to the incidence in other regions. The literature showed that the incidence of pregnancy was 25 pregnancies (1.26%/5 years) were reported for 20 women receiving hemodialysis in Japan [26].

Pregnancy in women undergoing MHD is associated with a higher risk of maternal complications compared to the general population [24]. These complications arise due to the complex interaction between the physiological changes of pregnancy, the challenges posed by renal dysfunction, and the need for ongoing dialysis. This systematic review revealed that the main maternal complications associated with pregnancy in Arabian women undergoing hemodialysis include abortion (62%), hypertension (41.7%), polyhydramnios (28.57), and preterm birth (7.7%). These complications arise from maternal renal dysfunction, the challenges of maintaining dialysis adequacy, and the impact of maternal comorbidities. These findings are in alignment with several studies conducted in other regions [27, 28].

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For instance, Baouche *et al*. conducted a similar systematic review in France and reported that HTN remains the main maternal complication, where the incidence of preeclampsia and hypertension among pregnant women undergoing MHD was 11.9 and 7.7%, respectively [24]. In parallel, Hirano *et al.* found that the main complications of women with MHD were anemia (3.9%), hypertension (7.7%), and preeclampsia (11.9%) [26]. This could be justified because women with ESRD may already have pre-existing HTN that can be exacerbated during pregnancy. Fluid and electrolyte imbalance and hormonal changes can also contribute to the occurrence of HTN. In Ribeiro and Silva's study, it was highlighted that pregnancy is normally associated with a 30% increase in renal volume, an enlargement of the renal bipolar diameter by approximately 1.0 to 1.5 cm, and a significant increase in renal blood flow by 50–80%, particularly in the first trimester [23]. Besides, they confirmed that proteinuria is predominant during pregnancy due to the heightened glomerular filtration rate and increased permeability of the glomerular basement membrane up to 300 mg of protein excretion in 24 h is considered normal for pregnant women. With the existing ESKD, the condition becomes worse, where preeclampsia is a common condition among women undergoing MHD [23]. This is confirmed in a systematic review done by Yang *et al.*, where the rate of pre-eclampsia was 30.2% [29]. Hence, Baouche *et al*. recommended that intensified dialysis during pregnancy is essential during pregnancy as it results in a significant reduction in the rate of preeclampsia [24].

These findings of the reviewed studies reported 186 (62.0%) cases of abortion among 300 pregnancies. In a study conducted by Hirano *et al*., it was reported 5 cases of abortion (1 elective and four spontaneous) among 19 women on MHD [26]. These results are comparable to the findings of Baouche *et al*., who reported that spontaneous represents miscarriages in 68 out of 402 (16.9%) while 21 women (5.2%) opted for therapeutic abortions [24]. Likewise, the systematic review by Hirano *et al*. revealed 68 (16.9%) spontaneous miscarriages, 21 (5.2%) therapeutic abortions, and 26 (8.3%) stillbirths [26]. Women on dialysis often have complex medical conditions; these health concerns may influence the decision-making process regarding pregnancy continuation or termination. Moreover, they may experience increased anxiety, stress, and emotional strain due to the physical demands of dialysis, concerns about their health and the health of the fetus, and the overall uncertainty surrounding their pregnancy. In some cases, those women may decide to have a planned abortion to protect their health and well-being [30]. In the Arab world, Al-Matary and Ali mentioned that the generally accepted belief in Islam is that planned abortion at any stage of pregnancy is forbidden unless the pregnancy continuation poses a risk to the mother's life, and therefore, abortion shall be permissible [31].

Women with ESKD have impaired renal function may lead to fluid overload. This can also result in the accumulation of excess amniotic fluid or polyhydramnios [32]. Polyhydramnios can pose several risks and complications such as preterm labor and premature birth, placental abruption, fetal malpresentation, and umbilical cord prolapse. A recent study conducted by Bas Lando *et al*. confirmed that women with polyhydramnios are at a higher risk of labor complications and postpartum hemorrhage due to uterine atony [33].

Regarding the pregnancy outcomes, the present review revealed that some women with ESKD delivered high-risk neonates. These risks included Intra-Uterine Growth Restriction (IUGR) (7.7%), Intrauterine Fetal Demise (IUFD) (5.0%), Prematurity (7.7%), and neonatal death (3.3%). Many studies reported similar findings and systematic reviews conducted in different areas around the globe.

For instance, in the systematic review conducted by Hirano *et al*. on 14 studies included 2364 cases and 2754 pregnancies, found that preterm birth was the most common complication (50 to 100% of cases across the studies) as well as the neonates' birth weight ranged from 590 to 3500 gm. The IUGR constitutes 5.9% of neonates, and 18.9% were small for gestational age [26].

The physiological stress of pregnancy, combined with the underlying kidney disease and the challenges of managing dialysis, can contribute to an increased risk of preterm birth and IUGR. The

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uterus of a woman on dialysis may be more prone to uterine irritability, frequent contractions, and subsequent preterm birth [23]. Polyhydramnios can also increase the risk of preterm birth due to stretching and irritation of the uterus. The placenta plays a crucial role in providing essential nutrients and oxygen to support fetal growth. Luders *et al*. studied the risk factors for adverse fetal outcomes in pregnant women on MHD [34]. They clarified that kidney disease and dialysis can lead to impaired placental function. Women with ESKD often have vascular complications and fluctuating blood pressure during dialysis sessions. These alterations in blood flow dynamics can impact maternal blood flow and the delivery of Oxygen and nutrients to the fetus. Insufficient blood flow to the uterus can also impact fetal growth and development, leading to IUGR [34]. Further, protein-energy malnutrition is more common in women on dialysis due to dietary restrictions and the loss of protein during dialysis sessions. Inadequate protein and calorie intake can hinder optimal fetal growth and contribute to IUGR. Other factors that can contribute to IUGR in women on dialysis include maternal anemia, certain medications, and infections [32].

This systematic review highlighted the need for specialized prenatal care and comprehensive preconception counseling for women with end-stage renal disease who are considering pregnancy. The findings emphasize the importance of assessing the overall health status of the mother, optimizing dialysis, and managing the associated conditions. Furthermore, the review showed the critical role of a multidisciplinary team consisting of nephrologists, obstetricians, neonatologists, and specialized nurses to provide comprehensive care throughout pregnancy [11, 35, 36].

Recommendations

While the review presents the challenges faced by chronically hemodialyzed women during pregnancy in the Arab world, it also reveals a knowledge gap in the topic of pregnancy among hemodialyzed women. The limited number of available studies signifies the need for future research in this area, including larger sample sizes, standardized data collection, and long-term follow-up to provide more robust evidence on pregnancy outcomes and identify factors associated with improved maternal and fetal outcomes. Experts in maternal-fetal medicine, such as nephrologists, neonatologists, nurses, midwives, and dieticians, are required to provide appropriate pre-pregnancy counseling and management.

Additionally, research should explore interventions and strategies to optimize pregnancy outcomes in this population. This may include examining the impact of dialysis modalities, timing and frequency of dialysis, nutritional support, and the role of medications. Understanding the effects of these interventions on maternal and fetal outcomes can guide clinical practice and improve the care provided to chronically hemodialyzed pregnant women in the Arab world.

CONCLUSION

The pregnancy rate in women receiving dialysis has increased in the last decades. However, it is still a difficult and dangerous clinical situation that puts women at high risk which calls for meticulous care from an interdisciplinary team. For all women with ESKD who are of reproductive age, family planning should aim for shared, informed decision-making. It takes a team effort from nephrologists, obstetricians, neonatologists, dieticians, nurses, and social workers to provide this extremely specialized care. Long-term studies on the outcomes of mothers receiving dialysis and their offspring would contribute to the expanding corpus of research that we may use to guide our patients. Research in the literature indicates a clear correlation between prolonged dialysis treatments and previous pregnancies that were more successful, even though there are no specific guidelines or protocols for this topic. So, it is possible to become pregnant while receiving dialysis, but it can be challenging to manage and potentially critical.

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