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The Relationship between Iodine Nutrition, Thyroid Function and Obstetrical Outcomes for Jordanian Pregnant Women

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Abstract

Iodine deficiency causes many health problems to pregnant women and their newborns. Knowledge about the impact of Iodine deficiency can improve health-related practices, such as seeking dietary and exogenous supplements to improve iodine levels. This study evaluates the knowledge level of pregnant women concerning the significance of the intake of iodine-supported salt and iodine-rich diets during pregnancy. It also investigates the impact of this knowledge on certain dietary habits and the effects of iodine deficiency on several maternal and child complications. It explores the impact of iodine deficiency on the health condition of mothers and their newborns. Among the 500 women surveyed in this study, the majority were young (aged<45) and had previous pregnancies and at least one abortion. This study found that women had limited knowledge and poor dietary supplements of iodine relevant to a relatively high prevalence of abortion and anemia. Iodine deficiency is associated with several health conditions, such as infertility, fetal deaths, post-partum hemorrhage, and learning difficulties in the children to be born. This study suggests developing national policies and programs to improve people's awareness regarding iodine-related health conditions.

Keywords: Iodine, Nutrition, Women, pregnancy, Jordan

1. Introduction

Iodine has a structural role forming the thyroid hormones, which influence many functions in the body (Rohner *et al*., 2014). It has been reported in the literature that even mild forms of iodine deficiency can be responsible for changes in the neurological and cognitive developments of the fetus and the young child (Bath *et al*., 2013). This impact can also extend to the school age developing cognitive and learning difficulties in the children as they grow up (Zimmerman and Boelaert, 2015). Furthermore, hypothyroidism and goiter, which are adaptive responses secondary to the low dietary intake of iodine (WHO, 2013), have been reported to increase the likelihood of iodine-related conditions later in the life, such as neurological deficits (Zimmerman and Andersson, 2012).

Iodine is an essential nutritional component during pregnancy for the health of women and their newborns (Pires *et al*., 2017). It is estimated that iodine requirements are increased to approximately 220 and 270 µg/day during pregnancy and lactation, respectively (Simpson *et al*., 2011). This change is related to the increased production of thyroxine by the mother to maintain the euthyroid state, transfers thyroid hormone to the fetus along with iodine, due to the increased renal iodine clearance by the mother (Glenoer, 2007). It has also been reported that the thyroid gland increases in size by 10 % in iodine replete-countries, and that this increase reaches 20 % to 40 % in areas of reported iodine deficiency during pregnancy in healthy women (Alexander *et al*., 2017). Consequently, thyroid hormones increase by nearly 50 % putting further demands on women to increase their uptake by a comparable percentage (Stagnaro-Green *et al*., 2011).

Among the most challenging issues concerning iodine deficiency, is the knowledge of the women about the key role of iodine for their health and the fetus development. Charlton *et al*. (2012) argued that poor knowledge about iodine is a main contributor to hypothyroidism among pregnant women. Unlike most other essential nutrients, iodine status is linked mainly to geography, but not to the socioeconomic status of the individual. Iodine is obtained from external supplementary sources through the consumption of food. Therefore, countries, like Jordan, could have issues concerning iodine deficiency in substantial proportions of its population, as iodine natural sources are not widely dispersed or easy to obtain. Steps

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toward providing adequate exogenous iodine supplements to decrease the prevalence of hypothyroidism, such as encouraging the use of iodide household salt, have to be followed for many decades in many countries, including Jordan (Abebe *et al*., 2017). Unfortunately, it was estimated that approximately two billion people in 2013 were either having or facing the risk of developing iodine deficiency around the world (WHO, 2014).

Since iodine is an exogenous substance, many factors influence its serum levels, including the use of non-iodide table salts, the use of unpacked salts, storing salts for lengthy periods, salt exposure to humidity and heat or sunlight, consuming foods containing goitrogens, and the presence of other nutritional deficiencies, such as iron and vitamin A deficiency can all cause low-serum concentration of iodine (Jaruratanasirikul *et al*., 2009; Kazungu *et al*., 2015; Vanderpas, 2006). These factors would precipitate low-serum levels of iodine especially affecting pregnant women and their children (Kedir *et al*., 2014). In addition, low maternal and paternal knowledge, poor economic status, history of poor maternal iodine consumption, place of residence, and large-size families are significantly associated with iodine deficiency-related conditions (Alvarez-Pedrerol *et al*., 2010).

Women, who have an iodine deficiency-related condition, may transfer this condition to their babies causing serious developmental health conditions for them. In Jordan, there is a scarcity of studies investigating this topic, leaving a gap of knowledge. Such needed studies might inform decision-makers in the country about the iodine status among this vulnerable group of the population. One relevant study was conducted by Alkafajei *et al*. (2012) in Jordan. It investigated the prevalence and risk factors of hypothyroidism among women, not specifically pregnant women, concluding that iodine deficiency is observed among a large proportion of the women in the country. Alkafajei *et al*. (2012) concluded that young aged and first-trimester women are at a higher risk for hypothyroidism as a result of iodine deficiency.

Because Jordan has limited seaside land, the iodine content of food depends mainly on the soil iodine coming from the volatile form carried into the atmosphere and returning to earth via rain, and on the dairy products (Brent, 2010). However, this source is highly variable, very slow, and does not usually deposit a significant amount of soil-based iodine (Zimmermann, 2010). Therefore, low iodine concentrations in the soil and water may result in deficiency despite the supplementation via fortified milks and iodide table salts. The International Council for the Control of Iodine Deficiency Disorders (ICCIDD) under the United Nations Children's Fund (UNICEF) recommend that the daily intake for adults must be 150 μg/day, and that this amount has to be increased to 250 μg/day for pregnant women. The European Food Safety Authority (2014) suggested a 200 μg/day daily intake as a new reference value of the adequate intake for pregnant women to avoid hypothyroidism in the mother and her fetus, and to increase the maternal renal clearance during pregnancy. Bearing in mind the need for more iodine, pregnant women in Jordan, who usually have a limited consumption of iodine, might be particularly exposed to the development of iodine deficiency which makes it necessary to have a close follow-up to diagnose and manage this health issue.

Therefore, this study was conducted to measure the level of knowledge of pregnant women concerning iodine-supported salt and iodine-rich diet during pregnancy. It also investigated the impact of this knowledge on certain dietary habits and the effect of iodine deficiency on several maternal and child complications.

2. Material and Methods

This descriptive cross-section study addressed a convenience sample of 500 Jordanian pregnant women from the north and the middle regions of the country. Participants were recruited from six governmental hospitals and two specialized maternal health clinics in six different cities in Jordan, namely Amman, Salt, Zarqa, Irbid, and Madaba, and the Northern Jordan Valley. There were efforts to recruit participants from the southern regions of the country, such as Karak, Tafileh, and Aqaba, but there were limitations.

Data were collected between November of 2014 and December of 2015. These data included demographic and previous obstetric and gynecological history-related complications of iodine deficiency, blood samples for serum TSH, FT4, and hemoglobin levels, and biophysical measurements (i.e. height and weight). These data were collected using focused interviews.

The knowledge part of the questionnaire addressed iodine dietary habits, including using iodide salts (amounts and timing), consumption of fish meals per week and knowledge concerning the impact of dietary habits on iodine serum levels and thyroid function. In addition, the questionnaire asked the participants whether they are familiar with sources of iodine, Ca interactions and iodine-deficiency-related health conditions.

According to ROCHE (Heil and Ehrhardt, 2008) reference range for free tetra-iodothyronin (FT4) in pregnancy, the first trimester FT4 range is 12.1-19.6 pmol/L, the second trimester is 9.6-17 pmol/L, and the third trimester FT4 8.4 pmol/L. Any value falling above or below these ranges is considered abnormal. All biochemical tests were completed using the ECL technique with commercially available kits (ROCHE Diagnostics, Germany).

Thyroid dysfunctions related to iodine deficiency have been defined according to the American Thyroid Association (Alexander *et al*., 2017) as follows:

Isolated hypothyroxinemia: normal maternal thyroid stimulating hormone (TSH) concentration with low FT4 in the lower 5^{th} or 10^{th} percentile of the pregnancy reference range.

*Overt hypothyroidism (OH)***:** elevated TSH (>2.5mIU) with decreased FT4 according to pregnancy reference range. Women with TSH of 10.0 mlU/L or more, irrespective of their FT4 has been considered OH.

Sub-clinical hypothyroidism (SCH): elevated TSH are based on the trimester. They are 2.51^{st} trimester, 3 in 2^{nd}, 3^{rd} trimester up to 10 mIU/L with normal FT4.

Additionally, based on the Cobland model for pregnancy risk factor assessment at Jordanian MCH centers, anemia in pregnancy is defined as the hemoglobin value being less than 11.0 g/dL (PRAMs, 1987). It is

worthwhile mentioning that there are no Jordanian, or Middle Eastern references for the FT4 and the TSH serum levels.

2.1. Statistical Analysis

For statistics, all data were computed and analyzed using SPSS version 21.0 (SPSS@ IBM). Descriptive statistics were used to describe the characteristics of the study sample and findings from the study questionnaire in terms of the numbers of health conditions related to knowledge about sources of iodine, iodine-deficiency related health conditions, and dietary habits related to the weekly intake of iodine. Normality tests were conducted on the study findings and confirmed their suitability for parametric statistical tests. Inferential statistics (i.e. t-test and ANOVA) were then used to measure the impact of dietary habits on selected maternal and child health conditions, the relationship between thyroid function on serum hemoglobin levels, and the effect of dietary habits on thyroid function.

2.2. Ethical Considerations

Permission for data collection was obtained from the Jordanian Research Ethics Committee at the Ministry of Health in Jordan, and from each center separately. The researchers explained to the candidate participants that participation in the study was voluntary. They were assured that their names would not appear anywhere in this study, and that the collected data were confidential, and would be used only by the researchers for scientific purposes. A cover letter explaining the purpose, significance of the study, and the instructions of responding to the questionnaire was attached to the study questionnaire. The researchers explained all the questions asked to the participants, who were also ensured that they can withdraw from the study anytime they feel necessary. Blood samples were collected by the researchers, who are trained and licensed registered nurses. Participants were ensured that they could get a copy of the results once prepared by the laboratory. All participants consented to participate and accepted to have a blood sample withdrawn. All participants received the results of their blood samples and the cases that required treatment were referred for further medical follow-up and management.

3. Results

3.1. Participants' Characteristics

Of the 500 participant women, the majority were less than forty years of age (Table 1). Nearly half of them were in their third trimester, and all of them had at least one previous birth. Interestingly, the proportion of women, who had previous abortions, were significantly high (45.2 %, n=226). Obese women also represented approximately half of the participants with a morbid obesity percentage of 7.4 % (n=37). It should be noted that 45 % (n=225) of the women participating in this study were in their third trimester. BMI was measured based on their actual weight after it has been calculated before pregnancy. Overweight women represented almost half the sample.

Table 1. Characteristics of the participants (n=500).

Factor	N (%)
Age	
<21	48 (9.6%)
21-30	255 (51%)
31-40	176 (35.2%)
41-47	11 (2.2%)
Trimester	
First	178 (35.6%)
Second	97 (19.4%)
Third	225 (45.0%)
Number of previous pregnancies	
1-3	224 (44.8%)
4-6	192 (38.4%)
More than 6	84 (16.8%)
Number of abortions	
0	274 (54.8%)
1-4	215 (43%)
5-8	11(2.2%)
Number of deliveries	
0	113 (22.6%)
1-4	339 (67.8%)
More than 4	48 (9.6%)
Body Mass Index	
Less than 18.9	9 (1.8%)
19-24.9	239 (47.8%)
25-29.9	150 (30%)
30-34.9	65 (13%)
More than 35	37 (7.4%)

3.2. Conditions Related to Iodine Deficiency

As illustrated in table 2, the prevalence of health conditions that are related to iodine and thyroid hypofunction during pregnancy is relatively high. Fetal deaths, for instance, have been reported to occur among 22 % (n=110) of the participants, and the number of low birth weight in babies represented 12.4 % (n=62). To ensure that these conditions are correctly reported in this study, these data were obtained from the medical records of each woman present at the hospitals after obtaining permission from the Ethics Committee at the Ministry of Health.

Table 2. Complications related to iodine deficiency.

The condition	N (%)
Number of fetal death in previous pregnancies	110 (22%)
Pre-eclampsia	45 (9%)
Placenta previa	50 (10%)
Fertility conditions	53 (10.6%)
Abruptio placenta	30 (6%)
Low weight birth	62 (12.4%)
History of fetal distress	54 (10.8%)
History of early deliveries	56 (11.2%)
Post-partum hemorrhage	39 (7.8%)
Number of children with cerebral palsy	22 (4.4%)
Number of children with learning difficulty	27 (5.4%)

3.3. Serum Thyroid and Hemoglobin Function

The majority of the participants had normal FT4 serum levels for the first and second trimesters (n=139, 78.1 % and n= 86, 88.7 %, respectively), and only 20.2 % (n=36)

of women at their first trimester had lower than normal levels (Table 3). Women in the third trimester had significantly higher than normal serum levels of FT4, but with no clinically significant symptoms appearing on them. The TSH serum levels for most of the women in their first trimester were lower or higher than the normal values. Opposite to this finding, women in their second and third trimesters had normal values, but with significantly increased ratio of high serum levels of TSH (26.8 % (n=26) and 19.6 % (n=44), respectively). Surprisingly, more than 40 % (n=206) of the women in this study were anemic (Hg < 11 gm/dl).

Table 3. Findings of the thyroid function and hemoglobin tests.

	Trimester	Level	N (%)
FT4	First	Low	36 (20.2 %)
		Normal	139 (78.1 %)
		High	3 (1.7 %)
	Second	Low	9 (9.3 %)
		Normal	86 (88.7 %)
		High	2 (2.1 %)
	Third	Lower than 8.4	18 (8.0 %)
		Higher than 8.4	207 (92.0 %)
TSH	First	Low	171 (98.3 %)
		High	3 (1.7 %)
	Second	Normal	71 (73.2 %)
		High	26 (26.8 %)
	Third	Low	7 (3.1 %)
		Normal	174 (77.3)
		High	44 (19.6 %)
Hemoglobin	Less than 11gm/dl (anemic)		206 (41.2 %)
	More than 11 gm/dl		294 (48.8 %)

3.4. Effect of Knowledge and Dietary Habits and Complications of Mother and Child

3.4.1. Fish meal per Week and Maternal or Child Conditions

Consuming weekly fish-containing meals had a statistically-significant impact on decreasing the number of fetal deaths from previous pregnancies, decreasing infertility conditions, decreasing the numbers of early deliveries, and the numbers of children with learning difficulties (Table 4).

Table 4. The Impact of weekly fish-containing meals on maternal and child health conditions.

	Mean Square	F	Sig.
Number of fetal death in previous pregnancies	1.786	10.589	**.001**
Pre-eclampsia	.003	.041	.840
Placenta previa	.177	1.962	.162
(In)Fertility conditions	.928	9.946	**.002**
Abruptio placenta	.183	3.259	.072
Low birth weight	.274	3.452	.064
History of early delivery	.417	4.213	**.041**
Post-partum hemorrhage	.050	.694	.405
Number of children with cerebral palsy	.043	1.020	.313
Number of children with learning difficulty	.298	5.869	**.016**

3.4.2. Iodide Salts and Maternal or Child Conditions

Post-partum hemorrhage and the number of children with learning difficulties decreased significantly among the women reported using iodide salts (Table 5). However, the use of iodide salts did not have any statistically significant impact on the other maternal and child health conditions investigated in this study ($P > .05$).

Table 5. The impact of using iodide salts on selected women and child health conditions.

	Mean Square	F	Sig.
No. of fetal death in previous pregnancies	.389	2.321	.128
Pre-eclampsia	.004	.045	.816
Placenta previa	.075	.834	.362
Fertility conditions	.178	1.883	.171
Abruptio placenta	.001	.011	.917
Low birth weight	.241	2.509	.114
History of early deliveries	.113	1.129	.288
Post-partum hemorrhage	.295	4.119	**.043**
Number of children with cerebral palsy	.241	2.509	.236
Number of children with learning difficulties	.346	6.847	**.009**

There was no statistically significant correlation between the weekly consumption of fish- containing meal and complications related to iodine deficiency (P=.832), TSH level (P=.415), and FT4 level (P=.517). In addition, the results showed that dietary habits (iodide salts, rich iodine diet, fish), goiter and thyroid function test did not have any statistically-significant impact on the prevalence of iodine deficiency. This finding might be related to the inadequate iodine component within these dietary materials. As illustrated in table 6, there were statistically-significant effects of FT4 and TSH serum levels on hemoglobin serum levels among pregnant women, but the results showed that higher FT4 levels were associated with higher serum hemoglobin levels.

Table 6. The impact of FT4 serum level on hemoglobin in pregnant women.

	Sum of Squares	Mean Square	F	Sig.
Free T4 * Hemoglobin	860.682	3.571	4.139	.000
TSH * Hemoglobin	690.755	2.890	1.914	.000

3.4.3. Knowledge about Iodine Role in Pregnancy and TFT

As the results show, the knowledge level among the participant women did not have any statistically-significant impact on the thyroid function tests in this study (Table 7).

Table 7. The impact of dietary habits on FT4 and TSH levels.

		Sum of Squares	Mean Square	F	Sig.
Free T4	Between Groups	370.041	370.041	.098	.755
TSH	Between Groups	72.457	72.457	.142	.706

3.5. Knowledge about the Importance of Iodine Consumption during Pregnancy

Most women (90.6 %, n=453) had very low knowledge level about the importance of iodine during pregnancy, and its relevance to several health conditions for the mothers and their babies. For the remaining small portion of the sample (9.4%, n=47), the sources of information included nursing students, the internet and mass media, books and magazines, and friends and family, respectively (Table 8). Only 27.6 % of the participating women knew about the importance of fish-containing diets as a source of iodine essential for the body mechanisms. This percentage went higher to 70.4 % when women were asked whether they were using iodide salts, but more than half of the women added these salts routinely after cooking.

Table 8. Sources of Information about Iodine, Time of Using Salts and Ca Interaction.

Item	N (%)
Source of data	
No source	453 (90.6 %)
Nursing students	25 (5.0 %)
Internet and mass media	14 (2.8 %)
Books and magazine	5 (1.0 %)
Friends, family	3 (.6 %)
Time of using salt	
Before cooking	441 (88.2 %)
After cooking	59 (11.8 %)
Ca interaction	
Poisoning	495 (99.0 %)
Iodide interaction	5 (1 %)

Women in this study did not associate the use of iodide salts to health conditions, but rather to taste. On the contrary, some women mentioned that they used salt carefully because of its impact on arterial blood pressure as they heard in the mass media (i.e. television). Women also reported that this practice of adding iodide salts after cooking was not based on their awareness of the significance of iodine, but for taste preferences. A few number of women (10 %) knew about the complications of iodine deficiency, iodine supplements (1 %), oil fish (3.6 %), and only 1.4 % of the women knew about goitrogenics (Table 9).

Table 9. Iodine containing food consumption and knowledge about iodine-deficiency related conditions.

Item	NO	YES
Consumption of fish within the meal/week	362 (72.4%)	138 (27.6%)
Iodide salt	148 (29.6%)	352 (70.4%)
Iodine supplement	495 (99.0%)	5 (1%)
Supplement of oil fish	482 (96.4%)	18 (3.6%)
Knowledge about goitrogenic	493 (98.6%)	7 (1.4%)
Knowledge about goiter	488 (97.6%)	12 (2.4%)
Knowledge about complications related to iodine deficiency	448 (89.6%)	52 (10.4%)

4. Discussion

This study showed that the knowledge level and dietary habits of women to consume iodine and avoid iodine-related health conditions are still below the needed levels. This appears clearly from the relatively substantial proportion of women, who were reported having a history of different problems during their previous pregnancies, including fetal deaths and abortion (see table 1). Although women in this study were young, fertile, and did not have major chronic or acute health conditions, such as hypertension and diabetes mellitus, many of them reported passing through major challenges in the past without realizing that these conditions were related to iodine-deficiency and hypothyroidism. Clearly, many agencies within Europe and North America emphasize the importance of providing supplemental iodine for pregnant women as well as for children during their early school levels (EFSA, 2014; WHO, 2014). However, similar emphasis could not be seen in Jordan.

Women in this study were aged less than 47 year/old, but approximately half of them reported having major challenges in previous pregnancies, experiencing delayed pregnancy (secondary to infertility with no apparent reasons), and had conditions during or after delivery. Comparable findings, but with a relatively higher age of women, have been reported by other studies, such as Almomin *et al*. (2016), and Bocos-Terraz *et al*. (2009). Therefore, it is crucial to improve the food habits of pregnant women with regard to the iodine consumption especially that nearly all the participants in this study expressed their plan to have more babies in the future. Based on the findings of the current study, women need to receive adequate knowledge about the role of iodine in the thyroid function and body mechanisms, in addition to information about the dietary sources of iodine, the conditions associated with low-serum iodine and other issues important for the health of the mother and her fetus.

The results of this study indicated the presence of seventy-three women with TSH levels higher than normal, and sixty-three women with FT4 serum levels below the international refereed normative values for the three trimesters. However, only fifty-two women required medical follow-up, and the remaining number of women were prescribed supplements with no clinically significant symptoms. According to Alexander *et al*. (2017), referenced intervals for TSH and FT4 vary significantly in different populations. Examples of the variation could be

found in the TSH serum levels reported by different agencies in the world. In Japan, for example, it was observed that healthy pregnant women with a normal thyroid function had levels lower than .6 mU/L (Orito *et al*., 2009, while in the USA the levels were below .4 mU/L (Kahric-Janicic *et al*., 2007). The thyroid gland is overstimulated during pregnancy resulting in changes in the concentration and excretion of its hormones (Soldin, 2006). Again, the proper and adequate knowledge about the impact of iodine, its sources, and symptoms related to its deficiency is essential to those women even prior to pregnancy so as to avoid transferring this deficiency to the born children.

Findings also indicated that more than 40 % (n=206) of the women had serum hemoglobin levels below 11 mg/dl, which fell under the anemia category according to the guidelines. This finding has not been well-studied in the literature, but it could be related to several factors, including dietary habits and the expansion of the mother circulation (Bencaiova and Breymann, 2014). In part, it could also be a manifestation related to hypothyroidism and the decreased serum iodine in pregnant women (Erdogan *et al*., 2012), especially when anemia was found alongside all trimesters and did not cluster at one interval of pregnancy.

The frequent use of iodide salts (with no definite amount) has been associated positively with a decreased prevalence of post-partum hemorrhage in this study. Unfortunately, urinary iodine concentration has not been investigated to reflect the real picture clearly due to limited resources. We also found that the weekly consumption of a fish meal was positively associated with a decreased number of fetal deaths, infertility and premature deliveries. Kim *et al*. (2014) investigated iodine deficiency in the Philippines, a country high in its resources of sea food. They have found that iodine deficiency exists among school children despite the governmental efforts to eliminate this condition. Kim *et al*. (2014) argued that most students, especially the females, did not acknowledge the importance of iodine deficiency for pregnant women and their babies. The limited knowledge, as this study shows, partially led to iodine deficiency health-related conditions during pregnancy. In a country like Jordan with limited seafood resources, further efforts should be directed to improve the level of knowledge and the dietary habits to increase the awareness, and decrease the conditions associated with the iodine deficiency during the early stages of life, such as school years.

A very interesting point in this study was related to the knowledge component in relation to the iodine role in the health of the mother and her fetus (child after delivery). Although women reported that it was important to improve their knowledge about iodine, they did not report obtaining information from reliable sources. In fact, most women (90.6 %, n= 453) did not seek any information about iodine. The remaining portion of the sample (9.4 %, n=47) obtained their information mainly from students, the internet and mass media. The information received by the participants could be unreliable or even misinterpreted. Therefore, there is a need to have control over the type of information provided to pregnant women and the public by providing alternative and more reliable resources, such school books and brochures developed and distributed by the ministry of health or any other specialized health agency. Similarly, Garnweidner-Holme *et al*. (2017) reported comparable results when they assessed information about iodine during pregnancy and lactation among Norwegian women. But Garnweidner-Holme *et al*. (2017) indicated that well-educated women and those who received education on the iodine role in pregnancy scored significantly higher mean scores than those who did not. This finding indicates that the learning sessions of the females could improve the knowledge level and practice concerning the iodine consumption during pregnancy and lactation (O'Kane *et al*., 2016).

Women reported that fish was an important source of iodine, but most of them did not know that iodine deficiency is associated with maternal and child health conditions. The practice of consuming higher amounts of food rich in iodine by women could be improved when providing them with information about the [good] sources of iodine, and what serious impacts iodine could have on their babies' health supported by evidence from the literature. Such serious impacts include future child learning difficulties resulting from delayed neurological development (Hynes *et al*., 2013). Combet *et al*. (2015) reported in a study that included 1026 women in the UK that women knowledge concerning nutritional requirements was high (96 %) reflecting an adequacy of knowledge and healthy practices. However, iodine knowledge was low compared with other nutrients (12 %). In addition, Combet *et al*. reported that the median pregnancy iodine intake was 190 µg/day, which is lower than the 2014 WHO recommended intake for pregnant women of 250 µg/day. They concluded that dietary recommendations during pregnancy in the UK and their dissemination did not supply women with the needed requirements of iodine (Combet *et al*., 2015). Evidence from the literature determines the impact of education on women compliance to iodine rich diets in order to avoid health conditions associated with iodine deficiency during pregnancy and in the aftermath.

A very limited number of the women had iodine (1%, n=5) and oil fish (3.6%, n=18) supplements prior to the study. Perhaps the participants never tested iodine and the thyroid state until being enrolled in this study and discovering they had a deficiency. Similarly, the women did not appear to have adequate knowledge and healthy practices concerning their iodine intake, which might have caused a reasonably high prevalence of different complications during their previous pregnancies. Comparable conclusions were made by authors, like Hynes *et al*. (2013) and Delange (2007). A study by Charlton *et al*. (2010) addressed knowledge level and practice of pregnant women in Australia, and concluded that there was an urgent need for decision-makers to set public health strategies guiding nutrition, education and supplementation to improve the pregnant women iodine-state. The current study found that information provision is extremely limited for women during and before pregnancy. This finding indicates the need to develop readily accessible sources of information on iodine, especially for women attending maternal and child health centers.

5. Limitations

The number of women who participated in this study was relatively low and did not represent all regions of Jordan. Longitudinal studies would achieve more tentative results reflecting the development of pregnant women health over the three trimesters and during breastfeeding, which cross-sectional studies, like this one, usually misses. The use of drugs interfering with iodine serum levels has been screened by a single question asking directly about the medications that these women took regularly. This point needs further elaborative questions, which would determine the drugs women might have taken not knowing they would influence iodine and the thyroid function. In addition, the impact of overweight on iodine levels and the thyroid function was not covered in this study due to limitations in resources.

In addition, this study did not address urinary iodine levels as an indicator of thyroid function among pregnant women. It also did not explore items like fish meal consumption in more details. This study questioned women about the weekly fishmeal, but did not ask about the type fish, how it was consumed (raw, cooked, etc.), and the amount consumed by the women. This is an important question since there is a wide range of iodine levels in the diverse fish types. Furthermore, the method of storing and cooking plays a key role in maintaining the iodine composition with the fish. In addition, due to the substantial proportion of women, who had hemoglobin less than 11mg/dl, there was a need to perform anemia tests, such as serum iron and folic acid, all of which could interfere with the iodine serum levels.

6. Conclusions and Recommendations

Findings in this study indicated that the participating women were not aware of the impact of iodine on their pregnancy and their babies. Educational programs and materials should be made available for women in the clinics. Schools should also be involved in a national program to raise the students' awareness regarding the impact of iodine on the mother and her child. In addition, the role of mass media in increasing this awareness is very important as it could reach even the most remote areas in the country. Therefore, further efforts should be made to present educative materials for women utilizing all available tools of communication.

It has been widely reported in the literature that iodine deficiency is among the most prevalent diet-related health conditions in the world. The need for extra supplements of iodine for pregnant women has been emphasized by many organizations across the USA and Europe. Similar emphasis is needed in Jordan. The impact of adding iodine to table salts and other iodine-rich food products on decreasing the prevalence of hypothyroidism, particularly amongst pregnant women, is well-documented. However, comparable results have not been found in this study. In Jordan, there is a need to ensure that adequate iodine is added to the dietary preparations. Furthermore, as Jordan is limited in its resources of seafood, alternative supplementary foods should be considered for mothers and children, such as oil fish supplements. There is a need to include biomarkers in the assessment of iodine levels among pregnant women, including dietary assessments (food diaries, or 24-h food intake, recall and weighed food records), urinary iodine concentration (UIC), TSH, thyroglobulin, T4/FT4, and goiter assessment.

Finally, this study had some limitations since it did not address issues concerning the dietary habits, amounts of iodide salts used, frequency of using iodide salts, and the consumption of seafood by the pregnant women and history of thyroid conditions. Therefore, we recommend the conduction of further studies addressing TFT levels among pregnant women. The formulation of a national policy development of supplementary iodine and fish oil preparations for pregnant women.

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