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THE MAIN AND INTERMEDIATE FACTORS CONTRIBUTING TO GOITER IN SOUTHERN JORDAN

Maysa' a Ibrahim Alhilalat

Part-Time Lecturer, Faculty of Nursing, Department of Nursing, Al-Hussein Bin Talal University, Ma'an, Jordan, Maysaahilalat@gmail.com

Abstract
The study aimed to explore the problem of increased goiter among patients with hypothyroidism in southern Jordan and the lack of knowledge on the interacting clinical, behavioral, nutritional, and environmental factors that contribute to its severity. The objective of this study was to determine the main and intermediate causes of goiter in patients with hypothyroidism in some selected governmental hospitals in southern Jordan. A quantitative cross-sectional study design was employed using SmartPLS. The study sample comprised 200 patients with hypothyroidism at Al-Karak Governmental Hospital, Al-Tafilah Governmental Hospital, Ma'an Governmental Hospital, and Queen Rania Al-Abdullah Hospital in Jordan. The findings showed that the severity of goiter was significantly related to thyroid follow-up behavior, lifestyle, and environmental exposure, medication compliance, family history, and dietary iodine practices, but not to health awareness. Additionally, the effects of the independent variables on goiter severity were significantly mediated by thyroid follow-up behavior, lifestyle, and environmental exposure. The study recommends improving the structured follow-up programs, promoting healthy lifestyle practices, enhancing the nutritional guidance, and increasing the integrated healthcare interventions to reduce the severity of goiter among hypothyroidism patients.

KEYWORDS: goiter; hypothyroidism; iodine deficiency; lifestyle factors, Southern Jordan.

1. INTRODUCTION

Thyroid dysfunction is one of the significant health issues in Jordan due to the high number of undiagnosed, uncontrolled, or poorly understood cases (Ajlouni et al., 2022). In Southern Jordan, the matter is even more critical as goiter among patients with hypothyroidism may be an indicator of underlying health-related nutritional, autoimmune, environmental, and healthcare-related deficiencies (Abu-Helalah et al., 2019).

Goiter is typically determined as an enlarged thyroid gland, yet it should not be treated as a neck swelling, which can be treated just like other swellings, because it may indicate a long-term thyroid imbalance (Sembukuttige et al., 2025). Goiter can develop in the case of hypothyroidism, when the thyroid gland is repeatedly stimulated by thyroid-stimulating hormone due to the lack of iodine or the presence of autoimmune foci on the thyroid gland (Zimmermann & Boelaert, 2015). This implies that goiter is not only a symptom but also a pointer to other biological and social factors that should be closely investigated (Delange, 1994).

Ajlouni et al. (2022) report that the prevalence of thyroid dysfunction in Jordan ranged between 11.9% and 19.2%. They add that its prevalence among adults ranged between 3.1% and 17.2%. Its prevalence is higher than the widely reported global estimate of about 3% in overt hypothyroidism in iodine-sufficient areas. According to Taylor et al. (2018), the high prevalence of thyroid dysfunction implies that there remain hidden gaps in detecting and diagnosing thyroid dysfunction. This problem is experienced in Jordan as 76% of the cases of thyroid dysfunction are not diagnosed (Abu-Helalah et al., 2019). This suggests that thyroid dysfunction constitutes a challenge to public health in Jordan.

Al Shahrani et al. (2016) indicate that the prevalence of goiter in Arab countries ranges from 1.7% to 86%. They add that its prevalence varies widely among countries. Nevertheless, these local estimates cannot be generalized to Southern Jordan, as most of the reviewed studies are cross-sectional and do not describe how various risk factors interact (Al Shahrani et al., 2016). Thus, the research of hypothyroid patients in Southern Jordan is significant since such patients are at risk of developing goiter (Kargar et al., 2024).

Iodine imbalance and autoimmune thyroiditis are the most common causes of goiter (Zimmermann & Boelaert, 2015). The common cause of goiter is the deficit of hormone production, which occurs due to the lack of Iodine (Delange, 1994). In the meantime, excess of iodine can also contribute to the emergence of autoimmune thyroid disease. This requires taking into account the lack and excess as opposed to assuming that iodine supplementation is always protective (Kalarani and Veerabathiran, 2022).

In particular, Hashimoto thyroiditis is considered to be a major cause of primary hypothyroidism in an iodine-sufficient or slightly deficient environment (Srivastav et al., 2023). However, not every patient with autoimmunity will develop goiter, and others may end up developing glands enlargement, and some patients may end up developing thyroid atrophy (Phagoora et al., 2023). Such a difference suggests that middle factors, such as selenium deficiency, vitamin D insufficiency, iron deficiency, smoking, stress, infections, and exposure to drugs, may mediate whether hypothyroidism develops with or without goiter (Hu & Rayman, 2017).

The nutritional factors are highly significant since the functioning of the thyroid requires a number of micronutrients, not iodine alone (Vanderpas, 2006). Selenium plays a role in the metabolism of thyroid hormones and immune regulation, and, therefore, a deficiency can exacerbate autoimmune thyroid damage and thyroid enlargement (Hu & Rayman, 2017). Iron deficiency can also lead to deterioration of thyroid hormone synthesis, which can also increase thyroid stimulation and contribute to the development of goiters (Taylor et al., 2018). The lack of vitamin D has also been implicated in autoimmune thyroiditis, and it was suggested that immune and nutritional pathways could coincide in patients with hypothyroidism (Cyna et al., 2024).

In Southern Jordan, environmental and behavioral determinants should also be taken into account since goiter can reflect local living conditions, rather than the individual biology (Vargas-Uricoechea, 2023). Several risk factors have been reported in the regional and international literature as leading to a thyroid disease and goiter among population, such as smoking, family history, gender, age, diabetes, radiation exposure, and dietary habits (Manji et al., 2006). This implies that the literature should differentiate between primary factors, including iodine status and autoimmunity, and intermediate factors, including lifestyle, comorbidities, micronutrient status, and environmental exposure (Al Shahrani et al., 2016).

The previous global studies report that goiter commonly lingers in a region where the knowledge of the population, the food habits, and the use of iodized salt is poor (Zekarias et al., 2020). To elucidate, salt washing, long salt storage, cassava consumption, and poor knowledge of iodized salt were associated with goiter (Zekarias et al., 2020). In their study, Tuke et al. (2025) maintain that the prevalence of goiter accounts for 37.6% among school-aged children in Ethiopia. They add that the leading factors behind its occurrence are frequent consumption of cabbage, absence of food diversification, rural living, and female gender. Although these studies pinpoint the factors leading to goiter, they cannot be generalized to Jordanian patients. To support this claim, Sembukuttige et al. (2025) indicate that the factors contributing to goiter differ based on context, age cohorts, and populations.

A thorough reading of the reviewed literature regarding the factors contributing to goiter shows that these studies focused on knowledge, attitudes, and practices of thyroid dysfunction (Abu-Humaidan et al., 2025). However, they overlooked the specific mechanisms of goiter among hypothyroid patients. According to Ajlouni et al. (2022) the literature does not clearly state why some patients develop goiter and others do not. Thus, a local study is needed to determine the major direct and indirect factors responsible for goiter in the clinical and environmental setting of southern Jordan (Abu-Helalah et al., 2019).

Based on this, the objectives of this study are to explore the primary and intermediate causes of goiter among patients with hypothyroidism in Southern Jordan with particular reference to the iodine status, autoimmune thyroiditis, nutritional deficiencies, comorbidities, lifestyle, family history, and environmental exposures (Zimmermann and Boelaert, 2015).

1.1 Research Questions

1. What are the main individual-level factors contributing to goiter among hypothyroidism patients in southern Jordanian hospitals?
2. Do intermediate factors mediate the relationship between main contributing factors and goiter development among hypothyroidism patients in southern Jordanian hospitals?

2. LITERATURE REVIEW

2.1 Theoretical and Conceptual Background of Thyroid Disorders and Goiter

Thyroid disorders form a wide-ranging and dynamic spectrum of endocrine diseases that cannot be adequately understood by conventional classifications that consider thyroid function or other observable manifestations like goiter (Monaco, 2003). The other theoretical models that had been developed earlier largely defined thyroid disease in terms of the presence of hyperthyroidism, hypothyroidism, or thyroid enlargement, but with limited attention being given to the underlying etiological, biological, and environmental processes that shape disease progression over time (Monaco, 2003). Recently, however, the scholars' views are inclined towards integrative models that include autoimmune diseases, iodine-related dysfunctions, iatrogenic causes, and temporary thyroid abnormalities as part of a dynamic disease model (Monaco, 2003). These views claim that thyroid disorders should be considered dynamic and continuously evolving conditions rather than diagnostic categories (Chaker et al., 2022).

This conceptual change is especially critical in the context of hypothyroidism-related goiter, where structural abnormalities and dysfunction of hormones may not necessarily be directly correlated (Zimmermann & Boelaert,

2015). In numerous instances, the development of hypothyroidism may be preceded by the enlargement of the thyroid gland, whereas in others, hypothyroidism progresses without the thyroid gland being evidently enlarged (Jain et al., 2020). This complexity implies that thyroid disorders occur not only due to a single determinant (Shah, 2020).

It is generally accepted that the concept of goiter is characterized by the enlargement of the thyroid gland; this definition, however, is simplistic since goiter is a condition, which is accompanied by a variety of pathophysiological processes (Sembukuttige et al., 2025). Goiter is a multifactorial disease with a variety of causes, including iodine deficit, excessive stimulation of the thyroid-stimulating hormone (TSH), hereditary susceptibility, diet, smoking, and deficiency of micronutrients (Knobel, 2016). Clinically, goiter may be diffuse or multinodular and may be either toxic or non-toxic, with each type having a specific clinical implication and risk, such as malignant transformation or altered thyroid functioning (Knobel, 2016). Remarkably, goiter can also be related to either euthyroid, hypothyroid, or hyperthyroid conditions, which confirms the fact that the enlarged gland of the thyroid is not necessarily an indication of the lack of hormones (Dalili et al., 2022).

Hypothyroidism is mainly regarded as a primary thyroid disorder, which occurs in almost 95-99% of cases, and is often associated with autoimmune thyroiditis or iodine deficiency (Chaker et al., 2022). The early detection and treatment of hypothyroidism is difficult because it is considered to be clinically common, and its symptoms are vague and nonspecific. In this context, Shah (2020) indicates that the common symptoms of goiter are fatigue, depression, and weight gain. Besides, the data indicate that a considerable prevalence of patients continue to report having experienced the symptoms and still have the biochemical control of the condition with levothyroxine treatment. Based on these findings, it can be inferred that the laboratory indicators, such as thyroid-stimulating hormone (TSH) and free thyroxine (free T4), may not well represent the well-being and disease burden of the patient (Jonklaas, 2021). According to Chaker et al. (2022), poorly controlled hypothyroidism is the cause of cardiovascular, metabolic, and psychological consequences. This shows how the goiter systemically affects the overall health of patients.

In this context, the co-occurrence of hypothyroidism and goiter is a clinically important interaction between structural abnormalities of the thyroid gland and hormonal dysfunction (Zimmermann & Boelaert, 2015). Extreme cases of iodine deficiency may be a direct cause of hypothyroid goiter, whereas autoimmune conditions like Hashimoto thyroiditis may be an initial cause of thyroid enlargement before proceeding to thyroid atrophy and dysfunction (Monaco, 2003). Clinical evidence also shows that most patients with a thyroiditis of Hashimoto exhibit goiter despite a large variability in serum levels of thyroid hormones. It has been further indicated that goiter should be interpreted as a part of a broader spectrum of thyroid pathology and not merely as a hormonal disorder (Jain et al., 2020).

2.2 Main and Intermediate Factors Contributing to Goiter Development

The literature suggests that the development of goiters in hypothyroid patients is mediated by a set of both direct and intermediate determinants that have complex interactions. Dietary iodine deficiency is one of the most essential primary factors that stay among the leading environmental causes of thyroid enlargement in the global world (Zimmermann and Boelaert, 2015). Though the association between iodine deficiency and hypothyroid goiter and hyperthyroidism has always been viewed as a linear relationship, studies reveal that mild-to-moderate deficiency may also lead to toxic nodular goiter and hyperthyroidism (Zimmermann and Boelaert, 2015). The prevalence of iodine deficiency in hypothyroid populations can be extremely high, sometimes reaching up to 88%, thus, it might be inadequate to rely on pharmacological management without parallel nutrition interventions (Shah, 2020). Although salt iodization programs have been implemented in most countries, their success is often undermined by poor storage and poor policy implementation, as well as poor public awareness about iodine consumption (Zekarias et al., 2020).

Health awareness is also an important determinant of goiter persistence and progression. The early signs of thyroid malfunction remain unnoticed among many people since hypothyroidism often manifests itself through nonspecific complaints that can be confused with other diseases or mental disorders (Shah, 2020). Evidence of regional settings also suggests that the general knowledge about thyroid disease is commonly moderate or poor, and that misconceptions about the disease, like the belief that goiter is harmless, may also contribute to the delay in healthcare-seeking behavior and improper disease management (Abu-Humaidan et al., 2025). The results highlight the fact that educational programs and better public awareness are needed to decrease the burden of thyroid disease and promote early diagnosis.

Family history is another important factor, which includes the presence of an inherited genetic predisposition to depression and the family environment (Knobel, 2016). The high prevalence of thyroid abnormalities and goiter in subjects having relatives with a thyroid disease illustrates the importance of targeting screening and prevention in high-risk populations (Kocak et al., 2014). Family patterns may also help determine a genetic disorder, such as inherited thyroid disorders, which is a disorder that is often missed when diagnosis is based on symptoms rather than on a search for the cause of the disorder (Dalili et al., 2022).

Medication compliance is also the key factor in the management of hypothyroidism and the prevention of the continued enlargement of the thyroid gland. The lack of good adherence to levothyroxine therapy has been identified as the cause of the failure to achieve the proper level of TSH regulation, which prevents further progression of goiter

or the absence of its regression (Scavone et al., 2016). It is also demonstrated that a significant number of patients do not adhere to the administration recommendations, especially in terms of the timing of the medication intake in relation to meals, which weakens the treatment effect and the maintenance of hormonal levels (Mehuys et al., 2023). The recent pharmaceutical innovations, such as liquid and soft-gel levothyroxine formulations, have proven to improve adherence and better hormonal regulation, with a special emphasis on patient-centered therapeutic strategies (Scavone et al., 2023).

Besides these direct determinants, there are some intermediate or mediating. Thyroid follow-up behavior is one of the significant factors. Clinical follow-up is very crucial as thyroid disorders are usually progressive and both structural and functional changes can occur over time (Monaco, 2003). Poor monitoring can lead to the undiagnosed development of goiter or uncontrolled hypothyroidism, and inconsistent testing practices may cause diagnostic bias and delay the appropriate intervention (Mehuys et al., 2023). The literature therefore indicates that systematic and structured protocols of follow-ups are essential to manage thyroid diseases.

The environmental exposure and lifestyle are also important mediators of thyroid health. Smoking is an example of a goitrogen that interrupts the uptake of iodine and may make individuals more susceptible to thyroid enlargement when they are iodine-deficient (Knudsen et al., 2002). Furthermore, unhealthy lifestyle habits like unhealthy diet, long screen time, sedentary lifestyle can result in metabolic imbalance and drop in thyroid function (Mao et al., 2024). The results indicate that nutritional, behavioral and environmental factors influence thyroid dysfunction.

Goiter has been continuously reported as having high rates of prevalence among empirical research on the condition in different countries (Tuke et al., 2025). The literature indicated that the prevalence rates of goiter were more than 37% and that goiter was significantly correlated with gender, dietary patterns, and socioeconomic status (Tuke et al., 2025). The same outcome in women of reproductive age demonstrated the importance of knowledge about iodized salt and healthy eating habits to decrease the risk of disease (Zekarias et al., 2020). Environmental studies also emphasize the role of micronutrients like iodine and selenium in thyroid disease development and progression (Sembukuttige et al., 2025).

The existing studies in the Jordanian context have been mainly related to perception and awareness of thyroid disease, while the clinical and structural characteristics of goiter among those suffering from hypothyroidism (Abu-Humaidan et al., 2025) have been neglected. The current evidence suggests moderate awareness rates and a plethora of misinformation about thyroid enlargement may lead to delayed diagnosis and seeking medical attention (Abu-Humaidan et al., 2025). Substantial signs of chronic burdens of hypothyroidism and goiter in places like Pakistan and Turkey also indicate the existence of the wider problem where the nutritional intervention may be insufficient without the establishment of larger behavioral and other healthcare-related interventions (Shah, 2020; Kocak et al., 2014). Nonetheless, there is a massive gap in the literature that lacks the interaction of the clinical, behavioral, environmental, and healthcare-related factors among the hypothyroid patients in Southern Jordan.

In this regard, the literature review shows that goiter in patients with hypothyroidism is predetermined by a complex interplay of direct and intermediate determinants, iodine deficiency, health awareness, family history, medication adherence, follow-up behavior, and lifestyle factors (Zimmermann and Boelaert, 2015). Although there is an increasing amount of international evidence, the research has limited studies examining these interacting determinants in the context of the Jordanian context, especially among the high-risk population of hypothyroid patients (Abu-Humaidan et al., 2025). Thus, the study of these factors in the Southern part of Jordan is crucial to provide context-specific evidence that could support targeted interventions and increase successful thyroid health outcomes in the country.

3. METHODOLOGY

3.1 Study Design

In this study, the research design is a quantitative, cross-sectional research design. It aims to examine the main and intermediate factors contributing to goiter in patients diagnosed with hypothyroidism in southern Jordan. The cross-sectional method is suitable because it allows the researcher to gather data at one point in time and analyze the relationship between variables without any manipulation of the study environment. The design is especially relevant to test structural relationships between independent, mediating, and dependent variables using Structural Equation Modeling (SEM) through SmartPLS. The research aims at revealing both direct and indirect effects; thus, one can gain a comprehensive view of how behavioral, medical, and environmental factors cause goiter severity.

3.2 Study Setting

The study was carried out in selected governmental hospitals situated in southern Jordan, specifically, Al-Karak Governmental Hospital, Al-Tafilah Governmental Hospital, Ma'an Governmental Hospital, and Queen Rania Al-Abdullah Hospital. The patients diagnosed with hypothyroidism at these hospitals serve a broad population, and provide the relevant clinical environments to investigate the conditions related to thyroids. The sampling of these

hospitals guarantees the representation of patients with various geographical and socio-economic backgrounds in southern Jordan.

3.3 Sample of the Study and Sampling Technique

The target population of this study will be the patients diagnosed with hypothyroidism who received medical care in the selected hospitals. The research was based on a non-probability purposive sampling strategy because the subjects were recruited based on certain inclusion criteria. These criteria include having a confirmed diagnosis of hypothyroidism and being currently under medical follow-up in one of the selected hospitals.

The anticipated sample size was calculated in accordance with the SEM requirements of SmartPLS analysis to ascertain sufficient statistical power. It is believed that a minimum sample size of 200 respondents would be sufficient to test the proposed structural model and to obtain reliable estimates of the paths. This sample size is appropriate based on the partial least squares structural equation modeling, especially when the model contains multiple constructs and mediating variables.

3.4 Instrument of the Study

The study used a structured questionnaire to collect data, which was designed after a thorough reading of the literature. The instrument was further subdivided into two major sections: demographic data and measurement scales for measuring the study variables.

The first section consists of six demographic questions that captured the gender, age, marital status, level of education, affiliation to a particular hospital, and the duration of hypothyroidism diagnosis among the participants. These variables offered a background on the data that might affect the study results.

The second section consisted of 70 items distributed among seven constructs. Each construct included 10 items. These items measured certain aspects of the study variables. The independent variables included dietary practices of iodine, health awareness, family history, and medication adherence. It is worth mentioning that each construct addressed the behavior, knowledge, and medical practices regarding thyroid health. The mediating variables are thyroid follow-up behavior and lifestyle/environmental exposure, with a focus on patient interaction with the healthcare services and environmental factors. Goiter severity is the dependent variable that measures the symptoms, physical appearance, and the perceived effect of goiter on everyday life.

Each of the items is rated using a five-point Likert scale (strongly disagree (1) to strongly agree (5)). The items captured individual-level perceptions, behaviors, and experiences regarding hypothyroidism and goiter development.

3.5 Validity and Reliability

The researcher consulted a panel of experts specialized in public health and endocrinology to establish the content validity of the instrument. Their feedback was used to refine the wording of items, ensure their representativeness and clarity to measure the constructs of the study.

Construct validity is evaluated at the stage of data analysis using SmartPLS. This involves assessment of both convergent and discriminant validity by factor loadings and Average Variance Extracted (AVE), and cross-loadings. These processes guaranteed that each construct measures a different concept.

The study tested the reliability of the instrument using Composite Reliability (CR) and Cronbach's Alpha. When the internal consistency of the items in each construct resulted in 0.70 or more, then this implies that the instrument yields reliable and consistent results.

3.6 Data Collection

The study sent the questionnaire to the respondents through the use of electronic means, Google Forms. The electronic format allows easy access and allows participants to answer questions regarding the survey at their convenience. The questionnaire link was administered to the patients through the hospital coordination, healthcare providers, and social communication channels, where applicable.

The subjects were made aware of the purpose of the study and that their participation in the study was voluntary. Their ethics, including confidentiality and anonymity, were considered in the process of data collection. Google Forms will ensure the data management is efficient, minimize errors when entering data, and allow the exportation and statistical processing of the responses.

3.7 Data Analysis

The data obtained were analyzed using SmartPLS software, which is suitable for modeling the complex relationships between variables and testing mediation effects. The analysis consists of two steps, namely, measurement model analysis and structural model analysis. On the one hand, the measurement model contains statistical treatments that include assessing the reliability of indicators through factor loading, internal consistency reliability through Cronbach's Alpha, and Composite reliability and convergent validity through AVE. On the other hand, discriminant

validity is tested using the Fornell-Larker criterion and the Heterotrait-Monomethod (HTMT) ratio. Path coefficients are estimated using the structural model to ascertain the strength and direction of the relationships among variables. The exploration power of the model is measured in terms of the coefficient of determination (R 2), and the contribution of each independent variable is measured in terms of the effect size (f 2). Also, the predictive relevance (Q 2) is computed to assess the predictive ability of the model. Mediation analysis is performed to examine the role of the intermediate variables, whether thyroid follow-up behavior and lifestyle factors are significant in mediating the relationship between the main contributing factors and goiter severity. These statistical treatments will give a detailed perspective of direct and indirect effects within the proposed research model.

4. Findings

4.1 Respondents Demographic Profile

Table 1. illustrated that Table 1 shows that females constituted 56.6% of the respondents, compared to 43.4% males. Regarding the respondents' ages, 32.4% of the aged between 30-39 years. Beside, 56% of respondents were married, 43% held a bachelor's degree, and 29.5% had visited Karak Hospital. As for the duration of hypothyroidism diagnosis, 31.5% of the respondents had been diagnosed 1-3 years prior, while 29% had been diagnosed more than 6 years prior.

Table1. Respondents Demographic Profile (n=200)

Demographic	Categories	N(%)
Gender	Male	87 (43.4%)
	Female	113 (56.6%)
Age	Less than 20 years	11 (5.3%)
	20–29 years	38 (19.1%)
	30–39 years	65 (32.4%)
	40–49 years	57 (28.7%)
	50 years and above	29 (14.5%)
Marital Status	Single	65 (32.5%)
	Married	112 (56.0%)
	Divorced	15 (7.5%)
	Widowed	8 (4.0%)
Educational Level	Primary or less	18 (9.0%)
	Secondary	42 (21.0%)
	Diploma	38 (19.0%)
	Bachelor’s degree	86 (43.0%)
	Postgraduate	16 (8.0%)
Hospital	Al-Karak Hospital	59 (29.5%)
	Al-Tafilah Hospital	44 (22.0%)
	Ma’an Hospital	40 (20.0%)
	Queen Rania Al-Abdullah Hospital	57 (28.5%)
Duration of hypothyroidism diagnosis	Less than 1 years	27 (13.5%)
	1–3 years	63 (31.5%)
	4–6 years	52 (26.0%)
	More than 6 years	58 (29.0%)

Descriptive Statistics

Means and standard deviations of the constructs were calculated using descriptive analysis. Table 2. indicate that mean for dietary iodine practices was 3.79 with a standard deviation of 0.48. Health awareness score mean of 3.90 with a standard deviation of 0.49. Family history score mean of 3.74 with a standard deviation of 0.49. Medication Adherence score mean of 4.06 with a standard deviation of 0.48. Goiter severity score mean of 3.94 with a standard deviation of 0.53. Mean of thyroid follow-up behavior was 4.09 with a standard deviation of 0.46. Lifestyle and environmental exposure score a mean of 3.85 with a standard deviation of 0.49.

Table 2. Descriptive Statistic of Constructs*

Constructs	Mean ±SD
IV: Dietary Iodine Practices	3.79±0.48
IV: Health Awareness	3.90±0.49
IV: Family History	3.74±0.49

IV: Medication Adherence	4.06±0.48
DV: Goiter Severity / Goiter-Related Symptoms	3.94±0.53
MV: Thyroid Follow-up Behavior	4.09±0.46
MV: Lifestyle and Environmental Exposure	3.85±0.49
*** IV: Independent variable, MV: Mediating variables, DV: Dependent variable**	

4.2 Measurement Model

To test measurement model in this study, there are several criteria, which are as follows:

4.2.1 Convergent Validity

To test convergent validity of variables, loading factors and average variance extracted-AVE were calculated. Hair et al., (2021) noted that the model achieved convergent validity requirements when loading factors value ≥ 0.50 and AVE values ≥0.50. Table 3. Indicated that loadings factors of dietary iodine practices items were ranged (0.661-0.780), for health awareness items were ranged (0.657-0.811), for family history were ranged (0.668-0.790), for medication adherence (0.664-0.777). Thyroid Follow-up Behavior items scored loading factors were ranged (0.669-0.776), while lifestyle and environmental exposure items scored loading factors were ranged (0.708-0.764), goiter severity items scored loading factors were ranged (0.808-0.861). Moreover, the results related to AVE showed that all constructs achieved convergent validity requirements related to AVE were AVE values were above 0.50, goiter severity scored highest AVE value (0.682) while dietary iodine practices scored lowest AVE value (0.529).

Table3. loading factors and AVE of items and constructs

Constructs	Items	Loading Factors	AVE
Dietary Iodine Practices	DI1	0.694	0.529
	DI2	0.757	
	DI3	0.741	
	DI4	0.661	
	DI5	0.738	
	DI6	0.780	
	DI7	0.737	
	DI8	0.710	
	DI9	0.770	
	DI10	0.677	
Health Awareness	HA1	0.778	0.544
	HA2	0.708	
	HA3	0.811	
	HA4	0.657	
	HA5	0.757	
	HA6	0.726	
	HA7	0.775	
	HA8	0.700	
	HA9	0.711	
	HA10	0.743	
Family History	FH1	0.713	0.541
	FH2	0.760	
	FH3	0.729	
	FH4	0.790	
	FH5	0.727	
	FH6	0.698	
	FH7	0.751	
	FH8	0.688	
	FH9	0.776	
	FH10	0.719	
Medication Adherence	MA1	0.759	0.544
	MA2	0.777	
	MA3	0.737	
	MA4	0.715	
	MA5	0.758	

	MA6	0.727	
	MA7	0.664	
	MA8	0.727	
	MA9	0.749	
	MA10	0.753	
Thyroid Follow-up Behavior	TF1	0.723	0.537
	TF2	0.737	
	TF3	0.747	
	TF4	0.752	
	TF5	0.721	
	TF6	0.669	
	TF7	0.776	
	TF8	0.722	
	TF9	0.737	
	TF10	0.741	
Lifestyle and Environmental Exposure	LE1	0.754	0.550
	LE2	0.746	
	LE3	0.719	
	LE4	0.741	
	LE5	0.751	
	LE6	0.745	
	LE7	0.708	
	LE8	0.727	
	LE9	0.761	
	LE10	0.764	
Goiter Severity	GS1	0.861	0.682
	GS2	0.834	
	GS3	0.824	
	GS4	0.816	
	GS5	0.811	
	GS6	0.808	
	GS7	0.813	
	GS8	0.828	
	GS9	0.814	
	GS10	0.846	

4.2.2 Discriminant Validity

The model constructs were verified to meet the discriminant validity requirements through:

- **Heterotrait-Monotrait Ratio (HTMT)**

Hair et al., (2021) stated that constructs meet discriminant validity related to HTMT, when HTMT values were below (0.90). Table 4. Showed that HTMT values of construct were ranged (0.084-0.785) which is mean construct achieved HTMT requirements where HTMT below 0.90.

Table 4. Heterotrait-Monotrait Ratio (HTMT)

	1.	2.	3.	4.	5.	6.	7.
1. Dietary Iodine Practices							
2. Family History	0.104						
3. Goiter Severity	0.346	0.38					
4. Health Awareness	0.094	0.119	0.448				
5. Lifestyle and Environmental Exposure	0.328	0.25	0.737	0.505			
6. Medication Adherence	0.116	0.084	0.515	0.151	0.391		
7. Thyroid Follow-up Behavior	0.359	0.322	0.785	0.478	0.552	0.455	

- **Fornell-Larcker Criterion**

Discriminant validity was assessed using the Fornell–Larcker criterion. According to Fornell, & Larcker (198) discriminant validity is achieved when the square root of the Average Variance Extracted (√AVE) is above the correlation of the construct with other constructs. Table5, shows that √AVE values for the model constructs are above the correlations between the constructs, which mean that the model achieves discriminant validity related to Fornell–Larcker criterion.

Table5. Fornell–Larcker criterion*

	1.	2.	3.	4.	5.	6.	7.
1. Dietary Iodine Practices	**0.728**						
2. Family History	0.048	**0.736**					
3. Goiter Severity	0.329	0.369	**0.826**				
4. Health Awareness	-0.011	0.023	0.426	**0.738**			
5. Lifestyle and Environmental Exposure	0.308	0.241	0.688	0.473	**0.742**		
6. Medication Adherence	0.001	0.041	0.487	0.139	0.365	**0.737**	
7. Thyroid Follow-up Behavior	0.334	0.308	0.728	0.44	0.502	0.422	**0.733**

Notes: √AVE " values displayed in bold and shaded.

4.3 Reliability

Reliability was verified by calculating Cronbach's alpha-α coefficients and composite reliability (rho-a). Hair et al., (2021) stated that reliability coefficients of model constructs must be above 0.70 to be considered reliable. Table6. show that the Cronbach's alpha values of model constructs were ranged (0.901-0.948) and composite reliability values were ranged (0.905-0.948) which are above the statistically recommended threshold of 0.70. Therefore, the study model is reliable.

Table 6. Model Reliability

Constructs	α	rho-a
Dietary Iodine Practices	0.901	0.910
Family History	0.907	0.917
Goiter Severity	0.948	0.948
Health Awareness	0.907	0.914
Lifestyle and Environmental Exposure	0.909	0.910
Medication Adherence	0.907	0.913
Thyroid Follow-up Behavior	0.904	0.905

Structural Model

To confirm the theoretical framework's robustness, structural model was evaluated. This involves assessing the relationships between latent variables and verifying the model's predictive power and quality using various metrics, including VIF, R^2, f^2 and Q^2.

- **Collinearity Issues (VIF)**

Structural equation modeling (SEM) required that independent variables are free from li multi-collinearity. Variance inflation coefficient (VIF) was calculated to verify, which should be less than 3 (Hair et al., 2019). Table7. Presented that the values of VIF of independent constructs were ranged (1.346-2.690) which were less than the statistical threshold of (3), therefore we independent constructs are free from the problem of multi-collinearity.

Table7. Model Reliability

Constructs	VIF
Dietary Iodine Practices □ Goiter Severity	1.370
Dietary Iodine Practices □ Lifestyle and Environmental Exposure	1.002
Dietary Iodine Practices □Thyroid Follow-up Behavior	1.002

Family History □ Goiter Severity	1.219
Family History □ Lifestyle and Environmental Exposure	1.004
Family History □Thyroid Follow-up Behavior	1.004
Health Awareness □ Goiter Severity	1.639
Health Awareness □ Lifestyle and _Environmental Exposure	1.020
Health Awareness □ Thyroid Follow-up Behavior	1.020
Lifestyle and Environmental Exposure □ Goiter Severity	1.836
Medication Adherence □ Goiter Severity	1.426
Medication Adherence□Lifestyle and Environmental Exposure	1.021
Medication Adherence □ Thyroid Follow-up Behavior	1.021
Thyroid Follow-up _Behavior □ Goiter Severity	2.054

- **Determination coefficients- R^2, Effect Size -f^2 and Predictive Relevance-Q^2.**

Determination coefficients- R^2 is an important criterion for assessing the model 'quality (Hair et al., 2011). The amount of variance explained by each external construct is indicated by the R^2 value. Table 8. demonstrated that independent and mediating variables explain 71.1% of the variance in goiter severity. Besides, independent variables explain 45.4% of the variance in lifestyle and environmental exposure and 51.2% in thyroid follow-up behavior.

Table8. Determination coefficients- R^2

	R-square	R-square adjusted
Goiter Severity	0.711	0.702
Lifestyle and Environmental Exposure	0.454	0.443
Thyroid Follow-up Behavior	0.512	0.502

Moreover, effect size (f^2) measures the impact power of independent variables on dependent by calculating the change in R^2 when a predictor is included or excluded (Chin, 2010). Cohen's thresholds classify f^2 values of 0.02, 0.15, and 0.35 as small, medium, and large, respectively. Table 9. Illustrated that all effect size of independent and mediating variables were medium.

Table9. Effect size-f^2

	f-square	**Effect**
Dietary Iodine _ Practices □ Goiter Severity	0.026	Medium
Dietary Iodine Practices □ Lifestyle and Environmental Exposure	0.167	Medium
Dietary Iodine Practices □ Thyroid Follow-up Behavior	0.216	Medium
Family History□Goiter Severity	0.077	Medium
Family History □ Lifestyle and Environmental Exposure	0.076	Medium
Family History □ Thyroid Follow-up Behavior	0.147	Medium
Health Awareness □ Goiter Severity	0.015	Medium
Health Awareness □ Lifestyle and Environmental Exposure	0.332	Medium
Health Awareness □ Thyroid Follow-up Behavior	0.302	Medium
Lifestyle and Environmental Exposure □Goiter Severity	0.198	Medium
Medication Adherence □ Goiter Severity	0.095	Medium
Medication Adherence□Lifestyle and Environmental Exposure	0.158	Medium
Medication Adherence □ Thyroid Follow-up Behavior	0.255	Medium
Thyroid Follow-up Behavior □ Goiter Severity	0.220	Medium

In addition to, predictive relevance (Q^2) assess whether dependent variables are explained using predictor factors (Hair et al. 2014). Table9. indicated that Q^2 values were above (0). Therefor the independent variables showed predictive relevance.

Table9. Predictive Relevance - Q^2

	Q^2predict
Lifestyle and Environmental Exposure	0.42
Thyroid Follow-up Behavior	0.481
Goiter Severity	0.559

Assessing main individual-level factors contributing to goiter among hypothyroidism patients in southern Jordanian hospitals

Researcher adopted bootstrapping option in SMART PLS 4.5.1. Bootstrapping, a non-parametric resampling technique, is applied to estimate the stability of path coefficients and their statistical significance (Chin, 2010). The criteria of $t > 1.96$ and $p < 0.05$ were adopted to confirm the significance of the relationships. When Beta values closer to +1 indicate statistically significant positive relationships, while values closer to 0 indicate weaker relationships (Hair et al., 2021). Table 10. Showed that:

1. Dietary iodine practices had a positive impact on goitre severity ($\beta = 0.101$, $t = 1.999$, $p < 0.05$).
2. Family history had a positive impact on goitre severity ($\beta = 0.165$, $t = 3.860$, $p < 0.05$).
3. Health awareness had no impact on goitre severity ($\beta = 0.083$, $t = 1.520$, $p > 0.05$).
4. Lifestyle and environmental exposure had a positive impact on goitre severity ($\beta = 0.324$, $t = 6.271$, $p < 0.05$).
5. Medication adherence had a positive impact on goitre severity ($\beta = 0.197$, $t = 4.236$, $p< 0.05$).
6. Thyroid follow-up behavior had a positive impact on goitre severity ($\beta = 0.361$, $t = 6.003$, $p < 0.05$).

Table 10. Assessing main individual-level factors contributing to goiter among hypothyroidism patients in southern Jordanian hospitals

	Beta	**SE**	**T-Stat**	**P Values**	**Decision**
Dietary Iodine Practices □ Goiter Severity	0.101	0.050	1.999	0.046	Supported
Family History □ Goiter _Severity	0.165	0.043	3.860	0.000	Supported
Health Awareness □ Goiter _Severity	0.083	0.055	1.520	0.129	Unsupported
Lifestyle and Environmental Exposure □ Goiter _Severity	0.324	0.052	6.271	0.000	Supported
Medication Adherence □ Goiter _Severity	0.197	0.047	4.236	0.000	Supported
Thyroid Follow-up Behavior □ Goiter _Severity	0.361	0.060	6.003	0.000	Supported

Intermediate factors mediate the relationship between main contributing factors and goiter development among hypothyroidism patients in southern Jordanian hospitals

To assess intermediate factors mediate the relationship between main contributing factors and goiter development among hypothyroidism patients in southern Jordanian hospitals, mediating effect were testes. Table 11. illustrated that:

1. Thyroid follow-up behaviour mediates the relationship between dietary iodine practices and goitre severity ($\beta = 0.118$, $t = 4.409$, $p < 0.05$).
2. Thyroid follow-up behaviour mediates the relationship between family history and goitre severity ($\beta = 0.097$, $t = 3.882$, $p < 0.05$).
3. Thyroid follow-up behaviour mediates the relationship between health awareness and goitre severity ($\beta = 0.140$, $t = 5.235$, $p < 0.05$).
4. Thyroid follow-up behaviour mediates the relationship between medication adherence and goitre severity ($\beta = 0.129$, $t = 4.502$, $p < 0.05$).
5. Lifestyle and environmental exposure mediate the relationship between dietary iodine practices and goitre severity ($\beta = 0.098$, $t = 4.018$, $p < 0.05$).
6. Lifestyle and environmental exposure mediate the relationship between family history and goitre severity ($\beta = 0.066$, $t = 3.225$, $p < 0.05$).
7. Lifestyle and environmental exposure mediate the relationship between health awareness and goitre severity ($\beta = 0.139$, $t = 4.593$, $p < 0.05$).
8. Lifestyle and environmental exposure mediate the relationship between medication adherence and goitre severity ($\beta = 0.096$, $t = 4.624$, $p < 0.05$).

Table 11. Intermediate factors mediate the relationship between main contributing factors and goiter development among hypothyroidism patients in southern Jordanian hospitals

	Beta	SE	T-Stat	P Values	Decision
Health Awareness □ Lifestyle and Environmental Exposure □ Goiter Severity	0.139	0.030	4.593	0.000	Supported
Medication Adherence □ Thyroid Follow-up _Behavior □ Goiter _Severity	0.129	0.029	4.502	0.000	Supported
Medication Adherence □ Lifestyle and Environmental Exposure□Goiter Severity	0.096	0.021	4.624	0.000	Supported
Dietary Iodine Practices □ Thyroid Follow-up _Behavior □ Goiter _Severity	0.118	0.027	4.409	0.000	Supported
Family History □ Thyroid Follow-up Behavior□Goiter _Severity	0.097	0.025	3.882	0.000	Supported
Dietary Iodine Practices □ Lifestyle and Environmental Exposure □Goiter Severity	0.098	0.024	4.018	0.000	Supported
Family History □ Lifestyle and Environmental Exposure □ Goiter Severity	0.066	0.021	3.225	0.001	Supported
Health Awareness □ Thyroid Follow-up _Behavior □ Goiter Severity	0.140	0.027	5.235	0.000	Supported

Figure1showed the main individual-level factors contributing to goiter among hypothyroidism patients in southern Jordanian hospitals.

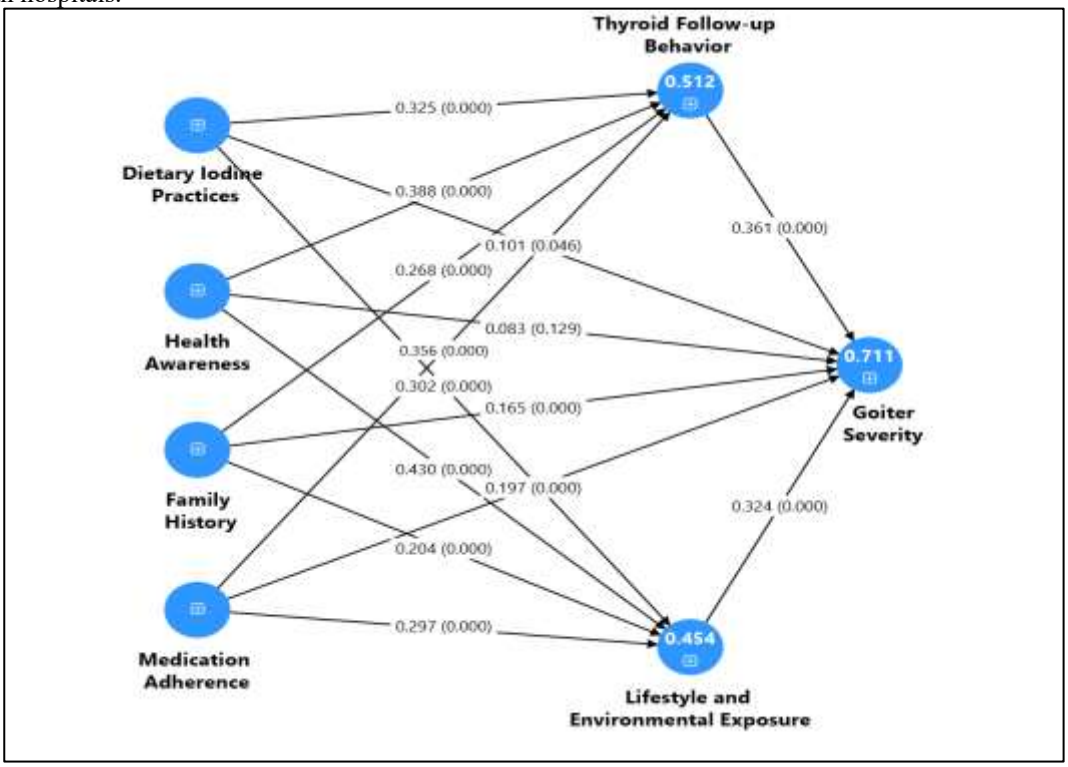

Figure1. Model Relationships

5. DISCUSSION

5.1 Main Individual-Level Factors Contributing to Goiter among Hypothyroidism Patients

The results of the study show that several individual factors can affect the severity of goiter in the hospitals of the South region of Jordan among patients suffering from hypothyroidism. The structural model accounted for a considerable proportion of variance ($R^2 = 0.711$) for the severity of goiter. The dietary iodine practices and family history, general health awareness, adherence to medicines, thyroid follow-up behavior, and lifestyle and environmental exposure accounted for 71.1% of the variation in goiter severity. Hence, goiter results from a combination of nutritional, genetic, behavioral, clinical, and environmental factors. This result aligns with the findings found in the previous literature, which revealed that goiter is a multifactorial disorder affected by various factors such

as iodine deficiency, genetic, dietary, lifestyle, and micronutrient status (Knobel, 2016; Zimmermann & Boelaert, 2015).

The strongest direct association with the degree of goiter was thyroid follow-up behavior ($\beta = 0.361$; $t = 6.003$; $p = 0.000$). It means that there is a close correlation between follow-up behavior and the severity of goiter among the respondents. Possibly, patients with more severe symptoms are more likely to attend follow-up visits since their condition demands continuous monitoring. Alternatively, follow-up may reflect that hypothyroidism and goiter are chronic and persisting condition. The finding agrees with Monaco (2003), who has stated that thyroid disorders are a continuing illness and that they should be monitored continuously. Delayed goiter testing and follow-up lead to delayed treatment (Mehuys et al., 2023). Therefore, early diagnosis is critical.

Also, lifestyle and environmental exposure had a significant positive influence on the severity of goiter ($\beta = 0.324$, $t = 6.271$, $p = 0.000$). This finding implies that some of the lifestyle activities and environmental factors might contribute to the development and persistence of goiter. This is consistent with Knudsen et al. (2002), who found that smoking may have a detrimental effect on the thyroid iodine uptake and increase the risk of thyroid enlargement. In fact, unhealthy life practices like following unhealthy food dietary habits and a lack of exercise contribute to the severity of goiter (Mao et al., 2024).

Therefore, mitigating the severity of goiter relies heavily on medication adherence ($\beta = 0.197$, $t = 4.236$, $p = 0.000$), which has a significant positive impact on its severity. In addition, compliance is typically associated with the ability to reduce the progression of disease. However, this association may be because the more severe the goiter, the more noticeable the symptoms are, which prompt patients to adhere more closely to the treatment. Also, Scavone et al. (2016) reported that lack of adherence to levothyroxine decreases the chance of goiter regression.

Likewise, Mehuys et al (2023) found that administering the medication at an inappropriate time can reduce the effectiveness of the drug. Family history is one of the significant factors behind the severity of goiter ($\beta = 0.165$, $t = 3.860$, $p = 0.000$). Such a result indicates a hereditary tendency towards thyroid enlargement. This finding supports Knobel (2016), who concluded that one of the causes of goiter is hereditary susceptibility. Furthermore, patients with a family history are more likely to experience thyroid abnormalities (Kocak et al., 2014).

Iodine nutrition practice also had a significant positive effect on the occurrence of Goiter severity ($\beta = 0.101$, $t = 1.999$, $p = 0.046$), but the effect size was small in magnitude. This finding points to a significant role of dietary habits related to iodine intake in relation to thyroid-related diseases. These findings are similar to those of Zimmermann and Boelaert (2015), who determined iodine deficiency as one of the most important environmental factors that cause thyroid enlargement. The weak effect indicates, however, that clinical, behavioral, and environmental factors may also play a role in the severity of goiter.

The study revealed that there was no statistically significant effect of health awareness on the severity of goiter ($\beta = 0.083$, $t = 1.520$, $p = 0.129$). This may indicate that it would be necessary to carry out regular medical monitoring, healthy life habits, and proper adherence to medication in order to reduce the severity of goiter. This somewhat contrasts with a study by Abu-Humaidan et al. (2025), which associated low awareness of the thyroid and misconceptions with delays in seeking healthcare.

5.2 Mediating Role of Intermediate Factors in Goiter Development

The second research question examined the association of thyroid follow-up with lifestyle/environmental exposures on the severity of goiter at various ages. The findings revealed the significant mediation effect of all of the mediation pathways tested. Thus, dietary habits of iodine, family history regarding health awareness and compliance/usage of medicines, behavioral/environmental factors, and severe goiter status are directly associated with the development of goiter. The study's results are consistent with the theory that both thyroid disease and the prevalence of goiter in the population result from the interactions of various biological, behavioral, and environmental factors (Monaco, 2003; Chaker et al., 2022).

The mediating effect of the behavior of the thyroid follow-up was significant between the dietary iodine practices and severity of goiter ($\beta = 0.118$; $t = 4.409$; $p = 0.000$). This indicates that the iodine-related dietary habits might help determine the severity of goiter through patients' participation in medical follow-up and monitoring. The dietary lifestyle of patients could also influence the likelihood of seeking a doctor's advice and regular follow-up, and therefore influence the severity of goiter symptoms. The finding is similar to that of Zimmermann and Boelaert (2015), who observed that iodine deficiency was one of the factors responsible for thyroid enlargement. Besides, it is consistent with Monaco (2003), who underscored the importance of constant monitoring of thyroid disorders.

Also, thyroid follow-up was among the intermediate association factors with the severity of goiter ($\beta = 0.097$, $t = 3.882$, $p = 0.000$). This could be because people eager to follow up thyroid disease regularly have a history of thyroid disease amongst their family members or have a family history associated with a high-risk for thyroid disease. This is aligned with the findings of Kocak et al. (2014), who found that the high prevalence of thyroid abnormalities has been observed among patients with a family history of thyroid disorders. Additional research conducted by Dalili et al. (2022) also correlated the familial history and the risk of acquiring thyroid disorders from affected family members.

The interesting finding is that the association between health awareness and goiter severity (beta = 0.140, t = 5.235, p = 0.000) is not significant but is mediated by thyroid follow-up behavior.
This means that increasing awareness will only have an impact on goiter prevalence if followed by regular critical follow-up activities and appropriate healthcare consultation. This result illustrates the lack of direct correlation of awareness to the severity of goiter. This agrees with findings by Abu-Humaidan et al. (2025), which revealed a lack of knowledge on thyroid disease, and the misconceptions related to thyroid disease were found to influence the delay of seeking healthcare.
Medication adherence ($\beta = 0.129$, $t = 4.502$, and $P = 0.000$) was another direct or indirect influence on thyroid follow-up, as was taking medication ($p < 0.05$). This indicates that perhaps higher numbers of appointments and follow-up measurements would be available at follow-ups with MDR-LTBs. This helps to emphasize the importance of adhering to levothyroxine therapy for the management of hypothyroidism. In this context, Scavone et al. (2016) and Mehuys et al. (2023) highlight the importance of regular monitoring of hypothyroidism and medication adherence.
Also, lifestyle and environmental exposure were important mediators for all relationships tested. They mediated the relationship between dietary iodine practices and goiter severity ($\beta = 0.098$, $t = 4.018$, $p = 0.000$), family history and goiter severity ($\beta = 0.066$, $t = 3.225$, $p = 0.001$), health awareness and goiter severity ($\beta = 0.139$, $t = 4.593$, $p = 0.000$), and medication adherence and goiter severity ($\beta = 0.096$, $t = 4.624$, $p = 0.000$). The outcome indicates that the patient's lifestyle and the environment may influence the severity of Goiter. This finding is parallel with the results of Knudsen et al. (2002), who observed smoking to be associated with thyroid enlargement.
Mao et al. (2024) showed that some unhealthy lifestyle habits lead to the irregular functioning of the thyroid gland. The mediating role of environment and goiter-related factors was also found to be a strong predictor for the development of goiter. These results suggest that promotion of healthy thyroid function should focus not only on iodine supplementation and thyroid treatment. The study recommends having a comprehensive intervention model that includes additional actions such as reduction of environmental risk exposure, timely screening, health promotion activities, and adopting a healthy lifestyle.

6. CONCLUSION

The purpose of this study was to assess the primary and secondary factors influencing the severity of goiter in hypothyroid patients in southern Jordan. The specific focus was laid on the iodine in the dietary habits, health awareness, family history, taking thyroid medication, follow-up thyroid behavior, lifestyle, and environmental exposure. The study adopted the quantitative cross-sectional research design employing the structural equation modeling (SEM) technique using Smart PLS to investigate the direct and mediating relations among the variables. The study collected data from 200 hypothyroid patients from Al-Karak Governmental Hospital, Al-Tafilah Governmental Hospital, Ma'an Governmental Hospital, and Queen Rania Al-Abdullah Hospital in Jordan. The results indicated that the following variables had a statistically significant positive effect on goiter severity: follow-up thyroid behavior, lifestyle and environmental exposure, taking thyroid medication, family history, and dietary iodine intake.
The findings showed that health consciousness was not a significant predictor of the severity of goiter. Follow-up thyroid behavior, lifestyle, and environmental exposure substantially affected goiter severity directly and indirectly. Overall, the results suggest that the goiter severity is affected by many factors, including health care access, genetic predisposition, environmental exposure, and behavioral and dietary practices. No single factor could account for the severity of goiter. The present study contributes to the literature by providing context-specific evidence on the severity of goiter among hypothyroid patients in southern Jordan. It also analyzes the direct and mediating effects between the variables of the study through a comprehensive structural equation model. In addition, the present study explored the behavioral and environmental mediating factors affecting the severity of goiter among hypothyroid patients in Jordanian hospitals. However, the study had some methodological limitations, such as its cross-sectional design, purposive sampling, and self-administered questionnaire, which might affect the generalizability and causal inference of the results. Thus, the study recommends improving the thyroid follow-up programs, increasing health awareness, promoting healthy lifestyle practices, and incorporating nutritional and environmental factors in the management of thyroid disease.

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