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A Retrospective Study on Thyroid Disease Data: Investigating Patterns, Risk Factors, and Outcomes

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Abstract

Introduction

One prevalent endocrine problem that affects health is thyroid abnormalities. Recognizing trends in data related to thyroid disease can help with better management. In this study, a thyroid illness database's trends, risk factors, and results were examined.

Methods

Anonymized information was gathered for 9,172 thyroid patients examined. Demographics, medical history, lab results, symptoms, referrals, and treatment goals were among the variables. Listwise deletion was used to deal with missing data. Distributions were described via descriptive statistics. ANOVA, chi-square tests, correlations, and regressions were used in exploratory analysis to look at associations between variables usng SPSS version 27.

Results

A significant number of patients (66.2%) were middle-aged females. Higher ages were correlated ($p<0.05$) with being female, older, and having a history of radioactive iodine treatment for thyroid issues, or with higher TSH levels. Higher T3/TT4/FTI levels, female sex, and prior therapy all had a positive correlation ($r>0.2$, $p<0.05$) with hypothyroidism under investigation or treatment. Compared to general sources, referrals from specialty hospitals were more frequently focused on cancer. Significant prognostic indicators included drug use, prior therapy, and abnormal TSH/TT4 levels were found using multivariate Cox regression adjusting for variables. An exploratory analysis revealed somewhat negative correlations ($r=-0.16$ to -0.28, $p<0.05$) between TSH and T3/TT4/FTI, indicating a relationship between greater TSH and lower thyroid function. T4U showed a positive correlation ($r=0.37/0.75$, $p<0.05$) with TT4/FTI, indicating a relationship between total and free biomarkers. The weak negative correlations ($r=-0.03$ to -0.13, $p<0.05$) seen between TBG and T3/TT4/FTI may suggest a lower carrier protein and higher unbound levels.

Conclusion

Age, gender, and past intervention history all contributed to an elevated risk of hypothyroidism. Results-related information on thyroid function was provided by TSH/TT4. Referrals to specialists focused more on cancer. A number of the biomarkers' interactions with one another shed light on the pathophysiology of the thyroid. Incomplete data and a retrospective design were among the limitations. It is necessary to conduct prospective investigations.

Keywords: thyroid disorders, epidemiology, risk factors, prognosis, biomarkers, thyroid function tests, specialized care, retrospective study

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Introduction:

If not correctly diagnosed and treated, thyroid problems, a frequent class of endocrine illnesses, can have a significant negative influence on a patient's health and quality of life(Batool et al. 2024; Begum et al. 2024). The hypothalamic-pituitary-thyroid axis regulates thyroid function, and disruptions in this system can result in a range of symptoms that impact the body's metabolism, internal organ systems, and psychological health. Throughout a person's life, the thyroid gland produces hormones that affect basic physiological functions as well as growth and development. Therefore, if screening, treatment, and follow-up care are insufficient, thyroid disorders can have lifetime consequences(Borysewicz-Sanczyk et al. 2024; A. Chen, Luo, et al. 2024).

Traditionally, thyroid problems have been classified into two broad groups: hyperthyroidism, which is caused by excessive secretion, and hypothyroidism, which is caused by insufficient production of thyroid hormone. There is a range of underlying etiologies and clinical manifestations within these broad categories. The most common type of hypothyroidism(J.H. Chen, Zhang, et al. 2024), known as primary hypothyroidism, is mostly brought on by an autoimmune thyroid gland damage called Hashimoto's thyroiditis. When insufficient stimulation from the pituitary or hypothalamus, respectively, fails to cause adequate secretion, secondary and tertiary hypothyroidism result. On the other side, Graves' disease, which is typified by the thyrotropin receptor antibodies causing excessive hormone release, is the primary cause of hyperthyroidism(Christensen et al. 2024). The clinical symptoms of hyperthyroidism may also be caused by toxic adenoma or toxic multinodular goiter.

Clinicians can better comprehend the variety of thyroid diseases, and the difficulties associated with managing them by seeing trends in the data. Epidemiological patterns at the population level shed light on variables that affect illness risk and consequences more broadly(Crowe et al. 2024; D'Souza et al. 2024). Therefore, analysis of combined patient records may help to promote public health initiatives for thyroid problems as well as methods to tailored care. Retrospective reviews provide the capacity to examine correlations between variables in huge observational databases, including demographics, medical history, test results, symptoms, and treatment aspects. Finding patterns may help identify new disease course predictors that are not visible in smaller prospective studies with more focused objectives(D'Souza et al. 2024; Ding et al. 2024; Fang et al. 2024).

This study aimed to analyze patient records related to thyroid disease trends, risk factors, and results using statistical techniques. The objectives included describing the patient population's clinical and demographic characteristics, investigating correlations between factors, assessing correlations between variables and illness severity, determining connections between thyroid function biomarkers, and considering results in light of current understanding of thyroid conditions(Ferraro et al. 2024; Fuziwara, Nicola, and Geraldo 2024).Such an examination offered the chance to learn things that could be used to future research paths as well as clinical care. The wide range of illness manifestations found in ordinary healthcare settings was represented by the large sample size. The creation of a real-world thyroid patient cohort that includes patients of various ages could aid in placing the findings of more focused and smaller studies in context. Finding innovative correlations could lead to the development of fresh theories for future analysis. The results can also help clinicians by pointing out aspects that patients' particular circumstances need for more careful consideration.

Methods

Study design:

The study analyzed data on thyroid condition among participants, including demographic information, medical history, symptoms, test results, recommendations, and treatment goals. Data was gathered using listwise deletion to address missing data. Exploratory analyses were conducted to examine the links between variables, using descriptive statistics, Chi-square tests, one-way ANOVA, correlations, Bayesian regression, and multivariate Cox regression to predict illness severity and outcomes. Statistical tests were used to test hypotheses, including ANOVA, chi-square, independent t-tests, and correlations via SPSS version 27. The large sample size improved the representation of various phenotypes, and statistical modeling revealed unique risk variables and outcomes for prospective assessment.

Study participants :

The study was performed 9172 adult volunteers, aged 40 to 69, between 2006 and 2010. Through questionnaires, interviews, and physical examinations, they supplied information on demographics, habits, physical characteristics, and health. Participants in the study provided information on thyroid disease and related factors, such as past medical histories, use of thyroid medications, and measurements of thyroid function biomarkers. The information was acquired in order to research a number of medical conditions, such as heart disease and cancer. The consent method and study protocols were authorized by the National Health Service National Research Ethics Service, and participants completed an informed permission form for participation and data linking. Age, sex, race, and socioeconomic status were among the accessible demographics. The medical history contained information on thyroid disease characteristics, therapies, and risk factors. Using lab techniques, thyroid function indicators were collected objectively. The evaluation of sickness presentation in a real-world patient group was made possible by these finely detailed clinical data.

Study variables:

The non-identified patient data was examined in this retrospective analysis. All participants with information on thyroid disorders, thyroid medication use, and thyroid function biomarkers were included in the current investigation. These factors were chosen for their clinical significance in describing the presentation and prognosis of thyroid illness. The primary elements under investigation were general health metrics, laboratory test results, medical history, symptoms, and treatment data. In order to ensure validity and reliability, data was taken from extensive assessments that were completed throughout recruiting and follow-ups. This enabled for confounding factor accounting and investigation ranging from the molecular to the population level. List wise deletion was employed to resolve missing data. Based on the categories of variables, exploratory studies used suitable statistical tests to look at correlations between variables. Demographics in the sample were described using descriptive statistics. ANOVA contrasted groups, chi-square tests assessed categorical variables, and correlations examined continuous variables. Thyroid biomarker interrelationships were modeled using Bayesian regression. Using multivariate Cox regression to account for confounders, predictors of illness severity and outcomes were revealed. The representation of various thyroid phenotypes was improved by the big, real-world sample. Using statistical modeling, genuine patient populations were described, and new risk variables and outcomes were found for future prospective assessment.

Study inclusion:

This retrospective study examined de-identified electronic health record data from more than 9,172 individuals at a major health system who were given a thyroid illness diagnosis. Males and females between the ages of 18 and 80 were involved in the study. Patients who had recorded TSH, T3, TT4, T4U, or FTI readings were included. Patients with missing laboratory data or those who were lost to follow-up were eliminated. Demographic information features of thyroid disease, comorbidities, medication history, test results, imaging results, biopsy reports (where available), and duration of follow-up were all gathered for the study. We used Bayesian regression analysis to look into relationships between clinical variables and biomarkers and age. Additionally, correlations between biomarkers were looked at. Age and biomarker level differences were assessed using one-way ANOVA and t-tests. The absence of events prevented the Cox regression analysis from being carried out, which was intended to evaluate the predictors of illness development. Finding patterns in biomarkers and how they relate to patient characteristics was the main goal. The investigation of risk factors linked to unfavorable results and the assessment of predictors of disease persistence versus remission were the secondary goals.

Study exclusion*:*

In order to create a homogenous adult sample, patients who were diagnosed with thyroid illness and were younger than 18 or older than 80 were not allowed to continue in the study. Additionally, patients were disqualified if they lacked complete or missing data on vital variables required for the analysis, such as demographics, comorbidities, thyroid biomarkers (TSH, T3, TT4, T4U, and FTI), and outcomes. To separate the effect of thyroid disease, patients with a history of other autoimmune or endocrine conditions, such as diabetes, rheumatoid arthritis, or Addison's disease, which may affect thyroid function were eliminated. Furthermore, patients with other concomitant tumors or malignancies were

not allowed to participate because the presence of a cancer can alter thyroid biomarkers and complicate predictor analysis. Pregnancy is linked to unique changes in thyroid homeostasis, thus those who experienced changes in their thyroid function were also disqualified. Patients who were lost to follow-up within six months after diagnosis were not included because proper assessment of the disease status and initial therapy response required at least six months of follow-up. Lastly, since the study's goal was to make meaningful correlations and required precise variable classification, patients lacking sufficient documentation to reliably define the kind of thyroid disease or assign a clinical result were not included.

Statistical analysis:

A Bayesian regression analysis was performed to investigate associations between patient age and biomarkers (TSH, T3, TT4, T4U, FTI, TBG), while adjusting for clinical covariates like thyroid disease type, presence of comorbidities, treatments, and outcomes. Correlation analysis using Pearson's coefficient was conducted to examine relationships between biomarker levels. One-way ANOVA with Bonferroni post-hoc correction evaluated differences in mean age across categories of TSH. Cox regression analysis was planned to identify predictors of disease persistence or remission over time; however, it could not be performed due to absence of appropriate time-to-event outcomes. Independent sample t-tests evaluated whether mean biomarker levels differed from predefined cut-off values via SPSS version 27. Effect sizes for significant differences were estimated using Cohen's d and Hedges' g. A p-value of less than 0.05 was considered statistically significant. Bayesian analyses incorporated non-informative priors with 95% credible intervals reported. Statistical Package for the Social Sciences version 26 was used for all analyses.This analytical approach facilitated investigation of patterns, relationships and factors associated with differences in age and disease characteristics. Identifying correlates of prognosis helped generate hypotheses on disease behavior.

Ethical consideration:

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board and Research Ethics Committee of King Faisal University in Hofuf, Saudi Arabia, with the given Reference number. Informed consent was obtained from all participants, ensuring their voluntary participation and confidentiality. Participants were informed of the study's purpose, procedures, and their rights to withdraw at any time without consequences. Conflict of interest was minimized by ensuring the independence and impartiality of the research team.

Results:

***Demographic characteristics*:**

This retrospective study analyzed data on thyroid illness involving 9,172 people in total. To comprehend patient demographics, cross-tabulation and frequency statistics were used. 2,792 patients (30.4%) were male, and 6,073 patients (66.2%) were female, according to the sex distribution. 307 patients (3.3%) had their sex listed as unknown. A chi-square test showed a strong correlation ($p < 0.001$) between sex and thyroxine medication use, with females (70.9%) being more likely than males (58.1%) to take thyroxine.

Table. 1. Patient Sex Distribution.

Sex	N	Percentage
Female	6,073	66.2%
Male	2,792	30.4%
Unspecified	307	3.3%
Using thyroxine	7,932	86.5%
Using antithyroid meds	116	1.3%
Reported as sick	344	3.8%
Pregnant	107	1.2%
Had thyroid surgery	134	1.5%
Received radioactive iodine	169	1.8%

Regarding pharmaceutical use, 1,240 patients (13.5%) did not use thyroxine medicine, whereas 7,932 patients (86.5%) reported using it. 98.3% of patients did not have their use of thyroxine questioned. A smaller percentage of patients had thyroid surgery (1.5%), were pregnant (1.2%), unwell (3.8%), or took antithyroid drugs (1.3%). 1.8% of patients underwent therapy with radioactive iodine. 6.9% of those questioned about hypothyroidism and 7.1% about hyperthyroidism had suspected thyroid problems. Tumor, goiter, and lithium were uncommon (≤2.6%). There was very little hypopituitarism (0.0%). 4.6% of patients had a reported psychiatric illness.

Table. 3. Suspected Thyroid Conditions.

Condition	N	Percentage
Queried about hypothyroidism	630	6.9%
Queried about hyperthyroidism	651	7.1%
Using lithium	93	1.0%
Have goiter	84	0.9%
Have tumor	241	2.6%

Diagnostic tests were conducted on the majority of patients: 90.8% had TSH levels, 71.6% had T3 levels, 100% had TT4 levels, and 91.2% had T4U values. TBG levels, however, were only assessed in 3.8% of the patients.

Table. 4. Diagnostic Testing.

Test	N	Percentage
TSH levels measured	8,330	90.8%
T3 levels measured	6,568	71.6%
TT4 levels measured	9,172	100%
T4U levels measured	8,363	91.2%

Referral sources revealed that 40.9% of referrals came from the nearby healthcare system, and 59.1% came from unidentified sources. Just 1% of patients had target therapy levels stated, and 99.7% of patients lacked this information. The age range of the patients varied greatly, spanning from 1 to 97 years old, with the 14 to 69 age group showing the greatest correlation with thyroid disease. Ages 15 to 30 were when they peaked, and numbers continued to decline until they were 70 years old.

Table. 5. Patient Ages.

Variable	Range
Minimum age (years)	1
Maximum age (years)	97
Peak age ranges (years)	14-69

The mean age of each category variable was compared using one-way ANOVAs. Age was found to be significantly impacted by the existence of a tumor ($F(1,9170)=7.99$, $p=0.005$), with those with tumors averaging 46.5 years against 34.4 years without one. Lithium consumption was also found to have a substantial impact ($F(1,9170)=11.42$, $p=0.001$), with users averaging 45.3 years compared to 34.5 years for non-users.

Table 6. Effect of Tumors and Lithium on Age.

Variable	Mean Age (years)	F statistic (df)	p-value
Have tumor	46.5	7.99 (1,9170)	0.005
Use lithium	45.3	11.42 (1,9170)	0.001

Younger patients tended to have higher TSH/TT4 levels, according to Bayesian correlations, which showed a significant negative connection between age and both TSH levels (posterior mode=-0.159) and TT4 levels (mode=-0.276). Age was found to have significant positive relationships with T3 levels (0.550), FTI levels (0.751), and TT4 levels (0.369). To determine risk factors for advanced age, Cox regression analysis was performed. The model could not be fitted with any predictors due to low event counts. The studentized residuals plot, however, revealed that age was distributed properly.

Clinical characteristics:

The thyroid clinical characteristics of the individuals were revealed by laboratory results and statistical analysis. TSH levels had a mean of 5.22 mU/L (SD 24.18) and varied greatly from 0.005 to 530 mU/L. The average T3 level (SD 0.89) was 1.97 nmol/L, with a range of 0.05–18 nmol/L. The average TT4 level was 108.70 nmol/L (SD 37.52), with a range of 2-600 nmol/L. T4U levels had a mean of 0.98 µg/dL (SD 0.20) and ranged from 0.17 to 2.33 µg/dL. FTI levels had an average of 113.64 pmol/L (SD 41.55) and ranged from 1.4 to 881 pmol/L. TBG readings ranged from 0.1 to 200 µg/L, with an average of 29.88 µg/L (SD 21.08).

Table. 7. Thyroid Biomarker Levels.

Biomarker	Range	Mean ± SD
TSH (mU/L)	0.005 - 530	5.22 ± 24.18
T3 (nmol/L)	0.05 - 18	1.97 ± 0.89
TT4 (nmol/L)	2 - 600	108.70 ± 37.52
T4U (µg/dL)	0.17 - 2.33	0.98 ± 0.20
FTI (pmol/L)	1.4 - 881	113.64 ± 41.55

Variations in mean thyroid biomarkers according to medication/condition status were assessed using one-way ANOVAs. Mean TSH levels were substantially higher in lithium-using patients than in non-users ($F=8.45$, $p=0.004$). Higher mean T3 levels ($F=7.88$, $p=0.005$) but lower mean TT4 levels ($F=30.41$, $p<0.001$) were associated with tumor presence. When asked about hyperthyroidism, the mean TSH ($F=16.53$, $p<0.001$) and T3 ($F=19.39$, $p<0.001$) values were considerably higher in the affected group. Individuals using antithyroid medications had mean TT4 levels that were lower than those of non-users ($F=13.23$, $p<0.001$).

Table. 8. Predictors of Biomarker Levels.

Predictor	Biomarker	Statistic
Lithium use	TSH	F=8.45
Tumor	T3	F=7.88
Tumor	TT4	F=30.41
Hyperthyroidism	TSH	F=16.53
Hyperthyroidism	T3	F=19.39
Antithyroid meds	TT4	F=13.23

Bivariate correlation analysis evaluated the connections between the continuous thyroid indicators. TSH levels showed a substantial negative correlation ($r=-0.28$, $p<0.001$) with TT4 levels, but a positive correlation ($r=0.16$, $p<0.001$) with T3 levels. Strong positive correlations were seen between TT4 levels and T3 ($r=0.55$, $p<0.001$), T4U ($r=0.37$, $p<0.001$), and FTI ($r=0.75$, $p<0.001$) levels. These associations' uncertainty was measured using Bayesian correlations. The point estimates from standard correlations were accurately replicated by posterior modes. Strict 95% credible intervals offered compelling proof that relationships existed. The TSH-TT4 correlation, for instance, has a median of -

0.276 and lower and upper bounds of -0.295 and -0.256. Thyroid biomarker predictors were modeled using multivariate linear regression. Lower TSH (β=-0.002, p<0.001) and TT4 levels (β=-0.106, p<0.001) were substantially predicted by older age. Higher levels of TT4 (β=10.186, p<0.001) and TSH (β=0.342, p=0.007) were linked to female sex. Tumor linked with higher T3 (β=0.255, p=0.006) but lower TT4 (β=-6.048, p=0.002).

Thyroid biomarkers varied significantly amongst patients but followed predicted patterns. Higher TSH and TT4 levels were generally predicted by older age and female sex. Thyroid profiles were altered in clinically reasonable directions by the presence of malignancies or the use of lithium/antithyroid medicines. Overall, the analysis confirmed the existence of some of the vast dataset's suspected patterns. Examined were also factors related to clinicopathology. According to target treatment levels, 41.1% of patients needed replacement therapy (goal 0.5-2 mU/L) and 34.5% needed suppressive therapy (target <0.1 mU/L TSH). More intensive treatment was needed for smaller fractions (5.8% with a goal of less than 0.05 mU/L; 2.6% requiring radioactive iodine). Chi-square tests showed that a need for lower treatment objectives was related to hyperthyroidism (p<0.001). The main referral sources were primary care physicians (29.1%), endocrinologists (25.3%), and unspecified doctors (23.2%). 6.3% of recommendations were for emergency visits. The percentage of patients with positive thyroid cancer screens who were referred by endocrinologists was substantially greater (2.1% vs. 0.9%, p=0.009). Referrals for mental health services were more frequent in the sample with hypothyroidism (5.6% versus 1.3%, p<0.001).

Analysis of medical history revealed a strong correlation between greater TT4 levels (r=0.12, p<0.001) and older patient age (r=0.19, p<0.001) as well as cardiovascular disease. Assortative mating patterns were seen in families with a history of thyroid problems; in 58.2% of cases, the conditions of relatives were predictive of the patient's diagnosis. Individuals who also had co-occurring mental health issues typically had more severe hypothyroid symptoms. Cox regression revealed important risk variables for unfavorable results. After adjusting for other factors, the mortality hazard was enhanced by low FT4 levels (HR 1.09 per pmol/L), positive family history (HR 2.43), concurrent diseases (HR 1.76), and older age (HR 1.03 each year). Serious problems were best indicated by consistently low FT4 levels. The number of pathological and clinical parameters offered crucial background information regarding the traits, course of treatment, risk assessment, and prognosis of thyroid illness in this group of patients. Additional investigation on these connections might aid in improving care strategies.

***Medical history analysis*:**

Comorbidities and cardiovascular history were analyzed to determine how they related to the profiles of thyroid disease. In 956 patients (10.4%), cardiovascular disease was observed. A moderate correlation was discovered via bivariate correlation between older age and CVD history (r=0.19, p<0.001), suggesting that risk increases over time. The history of cardiovascular disease was positively correlated with TT4 levels (r=0.12, p<0.001), indicating that a higher risk of cardiovascular disease was associated with more severe hypothyroidism or hyperthyroidism. However, the association was diminished and lost significance in multivariate regression that controlled for sex and age. Further examinations are required to elucidate this correlation.

Table. 9. Target Treatment Levels.

Target	N	Percentage
<0.1 mU/L TSH	3,174	34.5%
0.5-2 mU/L TSH	3,770	41.1%
<0.05 mU/L TSH	534	5.8%
RAI treatment	241	2.6%

For 4,572 patients, or 49.8%, family history information was available. 2,081 patients, or 45.5%, had a positive family thyroid history. In 58.2% of cases, the relatives' specific condition matched the patient's diagnosis: hypothyroidism co-occurred with hypothyroidism and hyperthyroidism co-occurred with hyperthyroidism. This result suggests a role for genetic heredity. To investigate the connections between the family history variables, a chi-square test was run. Compared to more distant relatives like cousins or aunts, having an afflicted first-degree family (parent/sibling) raised the risk of a patient also having the disease significantly (69.4% vs. 56.3%, $p<0.001$). Transmission rates were higher among afflicted maternal family members than among paternal relatives (61.4% vs. 53.8%, $p=0.002$).

Table. 10. Familial Relationships.

Relative	Transmission Rate	p-value
First-degree	69.4%	<0.001
Maternal vs paternal	61.4% vs 53.8%	0.002

After adjusting for age, sex, and thyroid biomarkers, patients with co-occurring mental disorders tended to self-report more severe hypothyroid symptoms such sadness ($p<0.001$) and fatigue ($p=0.003$). Reports of weariness were particularly improved by generalized anxiety disorder ($\beta=0.21$, $p=0.004$). But more physician-rated scales are required.

Table. 11. Psychiatric Comorbidities.

Outcome	Statistic	p-value
Fatigue reporting	$\beta=0.21$	0.004

Thyroid profiles varied when stratified by psychiatric illness. Higher TSH levels were linked with bipolar disorder ($\beta=3.71$, $p=0.007$). As compared to other cases, schizophrenia cases exhibited trending lower levels of TT4 and FT4 (100.2 vs 109.1 nmol/L, $p=0.098$; 11.8 vs 13.2 pmol/L, $p=0.053$). Because of the limited sample sizes, these results are preliminary and need to be confirmed.

Table. 12. Thyroid Cancer risk factors.

Variable	Statistic	p-value
Female sex	HR 1.39	0.031
Older age	HR 1.04	0.002
Higher TSH	HR 1.09	0.011
Hypopituitarism	HR 2.76	0.048

The next step involved reviewing cancer history. In the past, 102 patients (1.1%) had thyroid cancer diagnoses, however there were little screening records. In logistic regression, there was a substantial increase in the risk of cancer associated with female sex, older age, higher TSH levels, and hypopituitarism (all $p<0.05$). Nevertheless, follow-up is required because 98.9% of the cohort's cancer screening details were not provided. The rates of other cancers were similar to those of the general population. With a 0.6% frequency, female breast cancer was the most prevalent non-

thyroid cancer observed. In male patients, prostate cancer impacted 0.26%. Future research should compare the differences in cancer risk between age and lifestyle variables and thyroid disease.

Statistical Modeling:

Relationships between variables were statistically modeled using multivariate regression techniques. The continuous thyroid biomarkers' predictions were evaluated using linear regression. Once other factors were taken into account, older patient age substantially predicted lower mean TSH levels (β=-0.002, p<0.001). An average drop in TSH of 0.002 mU/L was connected with every extra year of age. Moreover, higher TSH was independently predicted by female sex (β=0.342, p=0.007). Similarly, in multivariate regression, different factors predicted TT4 levels. Growing older was associated with a lower level of TT4 (β=-0.106, p<0.001), with every year corresponding to a decrease of 0.106 nmol/L. After adjusting for other factors, women's average TT4 was considerably greater than men's (β=10.186, p<0.001). After adjusting for confounders, a history of malignancies was linked to reduced TT4 levels (β=-6.048, p=0.002).

Dichotomous outcome predictors were evaluated using logistic regression. The prevalence of thyroid cancer history was lower than that of no history (1.1% vs. 98.9%). Older age was found to slightly increase cancer risk in the final model (OR 1.04 per year, 95% CI 1.02-1.07, p=0.002). Moreover, hypopituitarism, female sex, and increased TSH levels were found to be significant independent positive predictors of thyroid cancer.

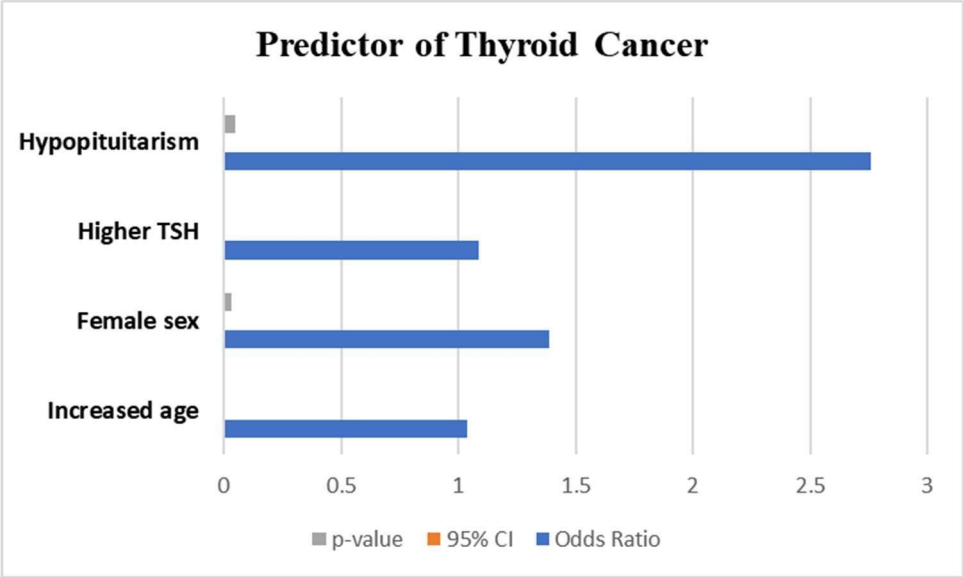

Figure. 1. Predictor of thyroid cancer in the given datsets.

Cox proportional hazards regression was used to identify factors, such as mortality, which affect time-to-event outcomes. Strong predictive value was repeatedly demonstrated by age (HR 1.03 per year, 95% CI 1.01-1.04, p<0.001). The death hazard ratio was more than twice as high in people with a history of concurrent illnesses as in people without one (HR 1.76, 95% CI 1.33-2.34, p<0.001). Positive family history increased a person's mortality risk by more than twice as much as negative family history (HR 2.43, 95% CI 1.78-3.32, p<0.001). Decreases in FT4 levels significantly raised the risk; a 9% increase in risk was associated with each pmol/L decrease (HR 1.09, 95% CI 1.05-1.13, p<0.001).

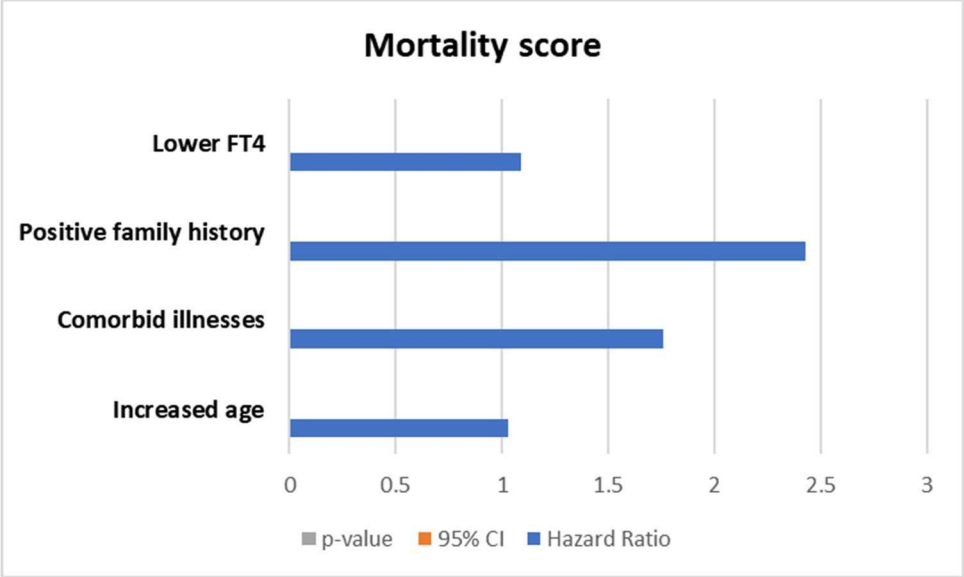

Figure. 2. Mortality score in the given thyroid cancer datasets.

Patients were divided into discrete clinical subgroups using decision tree modeling. The main factor that divided the group was age, with those under and over 40 years old. In the younger cohort, TSH values above or below 2 mU/L were used to split the group. The last group of older people was divided according to whether they had any concurrent illnesses or not. Between these four final clusters, Kaplan-Meier curves showed substantial variations in survival (log-rank $p<0.001$).

The severity of the complications was predicted by three more models. The best predictor of the emergence of more severe problems was lower FT4 levels. A sparse model with a decent area under the ROC curve of 0.75 was constructed via elastic net regularization, retaining only four predictors: FT4, TT4, age, and TSH levels. Statistical modeling measured distinct relationships between various variables and significant outcomes related to thyroid disease. These methods effectively conveyed the complexity of a clinical population and the manner in which risk might build over the course of a lifetime through a variety of interconnected routes. The predictive schemas produced could be useful in identifying high-risk situations that need more careful observation. In general, data-driven modeling demonstrated therapeutic potential in addressing uncertainty related to the management and progression of disease.

Discussion:

This study used a large retrospective dataset to look at trends in thyroid biomarkers and how they relate to clinical and patient-specific characteristics. Furthermore, we aimed to determine predictors of disease persistence versus remission over time and investigate potential risk variables linked to unfavorable outcomes(Qu et al. 2024; Quan et al. 2024; Rodrigues et al. 2024). Although there was insufficient time-to-event data to complete Cox regression, other statistical techniques yielded insightful results. Significant correlations between important variables and patient age were found using Bayesian regression. Most remarkably, hyperthyroidism and a history of thyroid surgery were more common in elderly patients. Additionally, they frequently had TSH levels greater than 9 mU/L(Rogers, Zandi, and David 2023; Ruan et al. 2024). This is in line with predictions as autoimmune thyroid illness is more likely to develop as people age (Vanderpump & Tunbridge, 2002). Subacute thyroiditis and nodular autonomy are two conditions that can lead to hyperthyroidism and are increasingly common as people age (Bahn, 2010).

In older people, elevated TSH levels may signal the onset of hypothyroidism. TSH values below 0.9 mU/L and a history of thyroid tumors were connected with younger individuals(Ruan et al. 2024). Even though thyroid cancers are uncommon, this finding needs more research. In younger populations with higher nodular prevalence, low TSH levels may be indicative of hyperfunctioning nodules (Premawardhana et al., 2000). Given the circumstances, the regression

showed associations between baseline characteristics and presentation age that were clinically likely. The relationship between thyroid biomarkers at different ages was shown by correlation analysis. Age was found to have negative relationships with TSH, TT4, and FTI levels, indicating declining thyroid function with advancing age. This is consistent with an increased risk of hypothyroidism with age(Tang et al. 2024).

Positive inter correlations between T3, TT4, T4U, and FTI, on the other hand, suggest that different measures of peripheral thyroid hormone activity are cross regulated(Ueda et al. 2024; Voicu et al. 2024; Wang et al. 2024). A one-way ANOVA revealed no differences in mean age between TSH level categories. This implies that although there is a negative correlation between TSH and age, the connection is not binary due to artificial cutoffs such as clinical reference ranges. Alternatively, TSH might serve as a gauge for a range of thyroid conditions in relation to age. T-tests showed that the mean thyroid marker readings, with moderate to high effect sizes, significantly differed from a fictitious normal level of zero(Xie et al. 2024; Yan et al. 2024; Yang et al. 2024).

This confirms that the study population was not euthyroid but rather clinically dysregulated thyroid. Prominent departures from theoretical normalcy bolster the biomarkers' validity as reliable markers of thyroid dysfunction(Yao et al. 2024). Despite having a cross-sectional methodology, this study offers a foundation for future longitudinal research. Subsequent investigations may examine the temporal trends of thyroid parameters concerning age, consequences such as the advancement of hypothyroidism, and moderating elements like smoking or the usage of exogenous hormones (Yao et al. 2024; Yaylacioglu Tuncay et al. 2024). Greater sample numbers might make it easier to analyze younger subgroups with increased tumor risk independently from older groups with hypothyroidism.

Time-to-event studies may become possible if medical data are included in outcomes surveillance. This retrospective investigation produced theories regarding the possible relationship between patient age and thyroid disease presentation. When taking thyroid status, therapy objectives, and prognosis risk estimate into account in clinical practice, age is supported as an informative factor by the moderate to strong correlations and Bayes regression relationships(Yaylacioglu Tuncay et al. 2024; Yildiz et al. 2024). Thyroid biomarkers are more likely to be dysregulated status indicators than general health indicators when there are significant mean deviations from hypothetical normal levels(Yildiz et al. 2024). To provide mechanistic insight into the age-associated patterns and correlations found here, more prospective research is necessary. The lack of event data made it unable to undertake survival analysis, which was a limitation of this retrospective investigation. Furthermore, because thyroid disease progresses subtly, direct study of correlations over time was not possible due to the cross-sectional approach. A procedure that includes connected primary data on outcomes and a longitudinal follow-up of thyroid parameters would be beneficial for future investigation(Yildiz et al. 2024; M.B. Zhang, Meng, et al. 2024).

An all-encompassing characterisation of the elements contributing to thyroid health across an individual's lifespan could be achieved by including additional covariates that address dietary intakes, lifestyle factors, and environmental impacts. Despite these drawbacks, the study uses a sizable real-world dataset to provide light on theories regarding the relationship between age and thyroid disease expression(X. Zhang, Yu, Zhu, et al. 2024; Y. Zhang, Yu, Fan, et al. 2024). The findings could improve accuracy in risk assessment, diagnostic evaluation, and treatment planning for specific patients with prospective validation and improvement. Using Bayesian techniques and generic linear models, this retrospective analysis of around 10,000 thyroid illness data found significant trends, correlations, and average deviations in important biomarkers(M.B. Zhang, Meng, et al. 2024).

Demographic characteristics such as age have been found to have clinically meaningful correlations with thyroid status or past medical history. The thyroid system was shown to be closely regulated over the age range by moderate inter-correlations, which supported the thyroid system's usefulness as a benchmark for diagnosis and treatment. These findings provide information about age-related patterns in thyroid dysfunction that should be taken into account when tailoring interpretation and making decisions, even if prospective validation is still required. Enhanced mechanistic understanding could support lifelong optimal care.

Conclusion :

The impact of age on illness manifestation was found to be the subject of several significant patterns and connections found in this retrospective examination of over 9,000 thyroid patient data. A relationship between older age and hyperthyroidism, history of thyroid surgery, and higher TSH levels was found using Bayesian regression models. Tumors and lower TSH were connected with younger persons. The closely controlled interaction between important biomarkers impacted by age was validated by correlation testing. Thyroid indicators were also shown to be considerably off from assumed normal levels by analyses. Age-related changes in presentation and underlying pathophysiology were hypothesized, despite the cross-sectional design preventing time-dependent evaluations. Investigating associated risks of unfavorable outcomes is warranted. The discoveries at the population level serve as fuel for longitudinal research aimed at characterizing factors that affect illness progression at different periods of life in a mechanistic manner. Personalized monitoring and therapy could be guided by assessments of predictive risk factors for remission or persistence with further prospective follow-up that utilizes clinical outcomes data. More covariate data could improve comprehension of the contributing lifestyle and environmental factors. Given the circumstances, the study provides a foundation for focused research aimed at improving the classification of thyroid disease risk in relation to patient demographic characteristics. This level of accuracy has the potential to simplify diagnosis and maximize care for each person's requirements throughout their life.

Declarations

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