Received: 15 June 2020 | Accepted: 7 December 2020

DOI: 10.1016/j.wjorl.2020.12.001

RESEARCH PAPER

World Journal of Otorhinolaryngology-Head and Neck Surgery

Association of allergic rhinitis with hypothyroidism, asthma, and chronic sinusitis: clinical and radiological features

Aljuaid Eidha Fawzan[1] | **Sara Ahmad Assiri**[2] | **Raad M. M. Althaqafi**[2] | **Atheer Alsufyani**[2] | **Ahmad Saeed A. Alghamdi**[2]

[1]Otorhinolaryngology-Head and Neck Surgery Department, Al-Hada Armed Forces Military Hospital, Taif, Saudi Arabia

[2]Taif University School of Medicine, Taif, Saudi Arabia

Correspondence
Sara Ahmad Assiri, 7811-Al Qutbiyyah, AT TAIF 26524-3301, Kingdom of Saudi Arbia.
Email: saraassiriiii@gmail.com

Funding information
None

Abstract

Background: Allergic rhinitis (AR) is characterized by mucosal inflammation that leads to a variety of symptoms, such as nasal congestion, rhinorrhea, and sneezing. This rhinitis is triggered by inhalation of allergens, such as pollen, and this condition has a negative impact on the quality of life. AR was shown to be associated with a number of co-morbidities, including hypothyroidism, asthma, and chronic sinusitis.

Objective: This study aimed to assess AR-associated comorbidities in patients presenting symptoms and paranasal sinus computed tomography (CT) scan findings in Taif City, Saudi Arabia.

Methods: This cross-sectional study evaluated medical and radiological records of AR patients retrospectively from the period of December 2018 to September 2019 in Al-Hada Armed Forces Military Hospital, Taif City, Saudi Arabia.

Results: A total of 103 AR patients with a mean age of 39.0 ± 15.6 years with 55.3% males and 44.7% females. The three most common associated comorbidities in allergic rhinitis patients were chronic sinusitis (28.2%), hypothyroidism (21.4%), and asthma (8.7%). Nasal obstruction (30.1%) was the symptom most frequently presented by all patients. Mucosal thickening occurred most frequently in patients with associated chronic sinusitis, while bilateral osteomeatal complex obliteration was observed mostly in asthmatic patients, and bony boundary thinning was more prevalent among patients with associated hypothyroidism.

Conclusion: The gender distribution of AR was 10% more common among males; however, the most common three comorbidites in allergic rhinitis patients were chronic sinusitis, hypothyroidism, and asthma, and most of those patients were females. Hypothyroidism can be a hidden predisposing factor for AR, while chronic sinusitis can be caused by AR due to secretion stasis or immune system activation.

KEYWORDS
Allergic Rhinitis, Asthma, Chronic Sinusitis, CT scan, Hypothyroidism, Nasal obstruction, Paranasal sinuses

INTRODUCTION

Allergic rhinitis (AR) is characterized by nasal congestion that is associated with rhinorrhea, sneezing, nasal and ocular itching, redness, and tearing due to mucosal inflammation.[1] AR can be triggered by inhalation of allergens, such as pollen,[2] dust mites, insects, animal dander, or molds.[3] The level of urbanization and geographical region contribute to the patterns of dominant allergen-related effects.[3] During the first year of life, indoor allergen sensitization occurs before sensitization to pollen, and it is difficult to diagnose AR, especially during the first three years since viral respiratory infections commonly occur in those years and produce symptoms that resemble AR. AR is frequently reported among adults,[4] and it peaks during the second to fourth life decades and then gradually diminishes thereafter.[5] AR has a negative impact on the quality of life and causes missed or unproductive time at work or school along with sleep problems[6] in addition to negatively impacting cognitive function, decision-making ability, and self-perception.[7] The severity of AR symptoms depends on the degree of exposure to the causative agent.[8] The incidence of AR worldwide is estimated to be approximately 600 million people of which 200 million have been reported to suffer concomitant bronchial asthma.[9] Many reports indicate the increasing frequency of sensitization to inhaled allergens worldwide with 40% of the populations in the United States[3] and Europe.[10] Epidemiological studies in Saudi Arabia have proven an increase in the prevalence of AR.[11] A more recent study with participants from different regions in the kingdom found that 34% of Saudis reported to be positive for AR.[12] Case distribution of AR among children in different cities in Saudi Arabia showed that Al-Ahssa has the highest prevalence (48.2%) followed by Riyadh (29%) and Jeddah (24.3%). In cases of mild intermittent AR disease, second generation non-sedating antihistamines are prescribed, but if the patient complains of persistent symptoms that affect the quality of life, the initial treatment of choice consists of intranasal corticosteroids.[2,13,14] Meanwhile, patients with more severe disease who do not respond to intranasal corticosteroids with or without second-line therapies should be referred for consideration[2,15,16] due to the wide range of allergic triggers and various complications that AR patients have. We aimed to cover some of the lack of literature studies that explore AR radiological and medical profiles, including socio- demographics, associated co-morbidities, symptom presentation, and findings of paranasal sinus computed tomography (CT) scans in Taif City, Saudi Arabia.

MATERIAL AND METHODS

Patient selection

AR patients' medical records from December 2018 to September 2019 in Al-Hada Armed Forces Military Hospital, Taif City, Saudi Arabia were reviewed retrospectively. Only those who had undergone CT scans of paranasal sinuses as clinically indicated were included. AR patients of all ages who had a fully documented medical record and a CT scan of the paranasal sinuses during the study period were included. Patients were excluded if the CT scan of the paranasal sinuses was ordered for post-operative evaluation.

Data collection

Socio-demographic characteristics of patients, including age and gender, were recorded in addition to their presenting symptoms, any associated acute and chronic comorbidities, findings of clinical examinations, and CT paranasal sinus reports. Approval from the Research Ethics Committee at Al-Hada Armed Forces Hospital was obtained.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) version 25 was used for data analysis. Frequency and percentage were used to express qualitative data, while mean and standard deviation (SD) were used to evaluate quantitative data variables. Significant differences among variables were identified using an independent sample *t*-test, and a P value ≤ 0.05 was considered significant.

RESULTS

A total sample of 103 allergic rhinitis patients with a mean age of 39.0 ± 15.6 years with 55.3% males and 44.7% females were included in the study. The most common presenting symptoms were nasal obstruction (30.1%), headache (12.6%), and rhinorrhea (11.7%). Clinical examination showed that most patients had a deviated nasal septum (35.9%), hypertrophy of the nasal turbinate (30.1%), and nasal polyps (18.4%). Table 1 shows age, gender, clinical findings, associated comorbidities, and presenting symptoms of AR patients.

Maxillary mucosal thickening was the most common finding among AR patients (43.7%) followed by ethmoidal sinus mucosal thickening (31.1%). Most sinus opacification was observed in the maxillary and ethmoidal sinuses (12.6%). Only 5.8% of the patients had bony boundary thinning, while 10.7% of the patients had middle turbinate pneumatization. Table 2 shows CT paranasal sinus findings from AR patients.

The three most common associated comorbidities in allergic rhinitis patients were chronic sinusitis (28.2%), hypothyroidism (21.4%), and asthma (8.7%), all of them were more predominant in females. Figure 1 shows a Venn diagram of the most common associated comorbidities among our AR patients.

Nasal obstruction was the most frequently presenting symptom in patients with comorbid asthma (44.4%), hypothyroidism (36.4%), and chronic sinusitis (31%) followed by nasal itching in patients with hypothyroidism ($P = 0.108$), headache in asthmatics ($P = 0.369$), and

TABLE 1 Gender, clinical findings, associated comorbidities and presenting symptoms of allergic rhinitis patients

Variables	Number	Percentage (%)	Variables	Number	Percentage (%)
Gender			**Presenting symptoms**		
Male	57	55.3	Rhinorrhea	12	11.7
Female	46	44.7	Nasal itching	7	6.8
Associated comorbidities			Sneezing	11	10.7
Hypothyrodism	22	21.4	Headache	13	12.6
Cardiac diseases	5	4.9	Nasal obstruction	31	30.1
Dislipidemia	6	5.8	Facial pain	7	6.8
Hypertension	8	7.8	Hearing loss	6	5.8
Diabetes mellitus (DM)	9	8.7	Otalgia	3	2.9
Gastroesophageal reflux disease (GERD)	4	3.9	Tinnitus	4	3.9
Irritable bowel syndrome (IBS)	8	7.8	Sleep apnoea	4	3.9
Asthma	9	8.7	Ansomnia	9	8.7
Upper respiratory tract infection (URTI)	5	4.9	Snoring	4	3.9
Eustachian tube disorder (ETD)	3	2.9	**Findings on clinical examination**		
Pharyngitis	2	1.9	Pale mucosa	4	3.9
Tonsillitis	1	1.0	Acquired deformity of the nose	4	3.9
Acute sinusitis	7	6.8	Deviated nasal septum	37	35.9
Fungal sinusitis	1	1.0	Hypertrophy of nasal turbinate	31	30.1
Chronic sinusitis	29	28.2	Nasal polyp	19	18.4
Otitis media	2	1.9	Hypertrophied of adenoid	6	5.8
Otitis externa	3	2.9			

The average age of these patients was 39.0 ± 15.6 years old

chronic sinusitis ($P = 0.071$) patients. Tinnitus presented mostly in patients with an associated chronic sinusitis ($P = 0.001$). During clinical examination of patients who had comorbid hypothyroidism and chronic sinusitis, the most common finding was a deviated nasal septum ($P = 0.581$), while patients with nasal polyps more predominantly had asthma ($P < 0.001$). Table 3 shows the age, gender, clinical findings, presenting symptoms in patients with comorbid hypothyroidism, asthma, and/or chronic sinusitis.

Table 4 shows the paranasal sinus CT scans in AR patients with comorbid hypothyroidism, asthma, and/or chronic sinusitis

CT scans of the paranasal sinus showed that mucosal thickening in the maxillary($P < 0.001$), sphenoidal ($P = 0.027$), frontal ($P = 0.246$) and ethmoidal ($P = 0.003$) sinuses were the most common in patients with associated chronic sinusitis, while those who had a bilateral osteomeatal complex obliteration were mostly asthmatic patients ($P = 0.069$). Bony boundary thinning was more prevalent among patients with associated hypothyroidism ($P = 0.79$). Figure 2 shows a comparison of paranasal sinus CT findings among AR patients who had comorbid hypothyroidism, chronic sinusitis, and/or asthma and those who did not have those conditions.

DISCUSSION

AR has a negative impact on the quality of life and productivity, and it can be an economic burden.[15] Thus, studying the exact presenting symptoms, clinical profiles, and radiological findings of those patients is a necessity, especially when the literature concerning the Taif region is lacking.[17] In developed countries, AR is considered to be one of the most frequently occurring atopic diseases with a prevalence of 40% in children, and 30% in adults.[18] The severity of AR is affected by the degree of allergen exposure and the level of air pollution.[18] The sample of AR patients in the current study was obtained from a central hospital in Taif region, which is well-known for the presence of many types of fruit farming that spread many pollen grains throughout the year. This finding may shed some light on the main causative allergen of AR in the studied region. One study that was conducted in Riyadh City found a strong relationship between pollen grain spread and AR development.[19] Moreover, of the main causes of AR, air pollution comes between the important elements.[2] Dust particles and different microorganisms can be carried by sandstorms, and they can stimulate or exaggerate AR.[20] Indeed, Taif Region is well-known for the presence of many mountains and

TABLE 2 Computerized topographic of paranasal sinuses in allergic rhinitis patients

Variables	Number	Percentage (%)
Mucosal thickening		
Nasal	8	7.8
Maxillary	45	43.7
Sphenoidal	22	21.4
Frontal	17	16.5
Ethmoidal	32	31.1
All sinuses	8	7.8
Sinus opacification		
Maxillary	13	12.6
Sphenoidal	12	11.7
Frontal	12	11.7
Ethmoidal	13	12.6
Osteomeatal complex obliteration		
Unilateral	7	6.8
Bilatral	11	10.7
Maxillary retention cyst		
Unilateral	3	2.9
Bilatral	2	1.9
Bony spur	4	3.9
Sphenoidal recess opacification	1	1.0
Cribriform plate defect	1	1.0
Sinus air fluid level	2	1.9
Bony boundaries thinning	6	5.8
Middle turbinate pneumatization	11	10.7

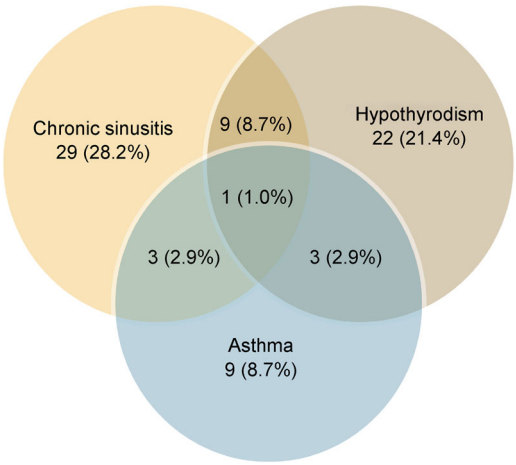

FIGURE 1 Venn diagram of associated comorbidities among allergic rhinitis patients

TABLE 3 Age, gender, clinical findings and presenting symptoms in allergic rhinitis patients with an associated hypothyroidism, asthma and chronic sinusitis

	Associated comorbidities		
Variables	Hypothyrodism	Asthma	Chronic sinusitis
Frequency (*n*)	22	9	29
Age (years, mean ± SD)	41.0 ± 11.2	44.3 ± 15.6	39.5 ± 14.0
Gender(*n*, [%])			
Females	20 (35.1)	6 (10.5)	17 (29.8)
Males	2 (4.3)	3 (6.5)	12 (26.1)
Presenting symptoms (*n*, [%])			
Rhinorrhea	2 (9.1)	0	3 (10.3)
Nasal itching	4 (18.2)	0	2 (6.9)
Sneezing	2 (9.1)	1 (11.1)	2 (6.9)
Headache	2 (9.1)	2 (22.2)	7 (24.1)
Nasal obstruction	8 (36.4)	4 (44.4)	9 (31.0)
Facial pain	1 (4.5)	1 (11.1)	3 (10.3)
Hearing loss	2 (9.1)	0	3 (10.3)
Otalgia	1 (4.5)	0	1 (3.4)
Tinnitus	1 (4.5)	0	4 (13.8)
Sleep apnoea	1 (4.5)	0	1 (3.4)
Ansomnia	2 (9.1)	1 (11.1)	4 (13.8)
Snoring	1 (4.5)	1 (11.1)	4 (13.8)
Findings on clinical examination (*n*, [%])			
Acquired deformity of the nose	0	1 (11.1)	1 (3.4)
Deviated nasal septum	8 (36.4)	1 (11.1)	10 (34.5)
Hypertrophy of nasal turbinate	3 (13.6)	2 (22.2)	6 (20.7)
Nasal polyp	4 (18.2)	8 (88.9)	7 (24.1)
Hypertrophied of adenoid	2 (9.1)	0	2 (6.9)

desert areas over which allergens and dust can spread since the country is exposed to many sandy storms all over the year.[21] Therefore, this studied region is considered to be exposed to multi-factorial inducers of AR.

In 1936 Chavanne first noticed that patients who underwent thyroidectomy had a subsequent nasal turbinates engorgement that can be cured by thyroxin injections.[22] In 1960 Weisskopf performed the first histopathological examination of the nasal mucosa in patients with hypothyroidism, he reported an increase in the ground matter of connective tissue and hypertrophy in the mucous glands.[23] More recent experimental studies to investigate the association between hypothyroidism and rhinitis have been done on rats in which

TABLE 4 Computerized topography paranasal sinuses findings in allergic rhinitis patients with an associated hypothyroidism, asthma and chronic sinusitis

	Associated comorbidities		
Variables	Hypothyrodism	Asthma	Chronic sinusitis
CT findings (*n*, [%])			
Mucosal thickening			
Nasal	1 (4.5)	1 (11.1)	1 (3.4)
Maxillary	13 (59.1)	6 (66.7)	22 (75.9)
Sphenoidal	7 (31.8)	5 (55.6)	11 (37.9)
Frontal	4 (18.2)	4 (44.4)	7 (24.1)
Ethmoidal	11 (50.0)	6 (66.7)	16 (55.2)
Sinus opacification			
Maxillary	2 (9.1)	3 (33.3)	2 (6.9)
Sphenoidal	2 (9.1)	3 (33.3)	2 (6.9)
Frontal	3 (13.6)	4 (44.4)	3 (10.3)
Ethmoidal	2 (9.1)	3 (33.3)	2 (6.9)
Osteomeatal complex obliteration			
Unilateral	3 (13.6)	1 (11.1)	3 (10.3)
Bilatral	1 (4.5)	4 (44.4)	310.3
Maxillary retention cyst			
Unilateral	1 (4.5)	0	0
Bony spur	2 (9.1)	0	2 (6.9)
Sphenoidal recess opacification	0	0	1 (3.4)
Sinus air fluid level	1 (4.5)	0	2 (6.9)
Bony boundaries thinning	3 (13.6)	2 (22.2)	1 (3.4)
Middle turbinate pneumatization	2 (9.1)	0	2 (6.9)

acid mucopolysaccharide production was increased in the nasal and paranasal sinus regions leading to rhinitis in rats with experimentally induced hypothyroidism.[24] Additionally, thyroid hormone receptors are localized in the nasal mucosa and a reported link with hypothyroidism between rats' nasal mucosal inflammation and edema was found.[25] Hormonal rhinitis caused by hypothyroidism is now accepted as one of the causes of non-allergic rhinitis.[26] The percentage of patients with hypothyroidism who experience rhinitis symptoms is estimated to be around 3%.[27] Hypothyroidism can be a hidden predisposing factor for rhinitis, and the only treatment of non-responsive rhinosinusitis in the presence of a comorbid hypothyroidism is its correction.[28] Data of hypothyroidism prevalence among the general Saudi Population is still not available, however, a single center study in Saudi Arabia estimated the prevalence of subclinical hypothyroidism to be around 10%.[29] In the current study, 21.4% of our Allergic Rhinitis patients had subclinical hypothyroidism and they were mostly females. A study shows that the incidence of subclinical hypothyroidism is 4-fold that of males.[30] This finding may suggest that hypothyroidism might be a predisposing factor for rhinitis, especially in females.

The association between AR and asthma may be attributed to the same allergen that induces AR. The coexistence of allergic diseases including, asthma, dermatitis and rhinitis are common to occur in the same patient.[31] Additionally, in genome-wide association studies, risk variants were shown to be shared between asthma, dermatitis, and rhinitis.[32,33] The proposed mechanism of the association between AR and asthma has been recently augmented by the identification of a signature of eight genes responsible for the concurrent development of asthma, rhinitis, and dermatitis.[34] The prevalence of Asthma among Allergic Rhinitis patients is estimated to be around 40%.[35] However, In the current study only 8.7% of our sample of Allergic Rhinitis patients had asthma, local studies showed that asthma prevalence in Taif Region is 6.4%.[36]

28.2% of AR patients in the current study had chronic sinusitis, making chronic sinusitis the most common associated comorbidity in our sample of patients. Allergic rhinitis may play a role in the development of more than 30% of chronic sinusitis cases.[37] One study that investigated the paranasal sinuses CT scans found that perennial AR was associated with sinusitis in 67.5% of patients compared to only 33.4% in those without perennial AR. Moreover, CT scans showing sinus involvement in allergic patients is double that of those non-allergic.[38] The inflammation of the nasal mucosa during the course of AR and the associated damage to the ciliary apparatus may cause obstruction of the drainage from the sinuses through the ostial passage with consequent secretion stasis and resultant sinusitis development.[39,40]

The association between chronic sinusitis and AR could be also attributed to the immune activation of lymphocytes and basophils in response to allergens, suggesting atopy as a risk factor for the initiation and exacerbation of both conditions. Indeed, a strong association between AR and sinusitis has been reported in natural exposure to pollen during an individual allergy season leading to both nasal and sinus inflammation.[41] The use of CT scanning to detect and identify paranasal sinuses mucosal lining abnormalities has been validated three decades ago.[42] Mucosal thickening in the maxillary, sphenoidal, frontal, and ethmoidal sinuses was mainly found in patients with chronic sinusitis, which could be attributed to predisposing AR-associated chronic sinusitis in our sample of patients. In agreement with this hypothesis, the presence of maxillary mucosal thickening is thought to increase the probability of an allergic-induced chronic sinusitis.[43]

Some of the limitations in the current study include that it was a single-center study with a retrospective data analysis. Additionally, this study excluded all Allergic Rhinitis patients who did not perform a CT scan of the paranasal sinuses.

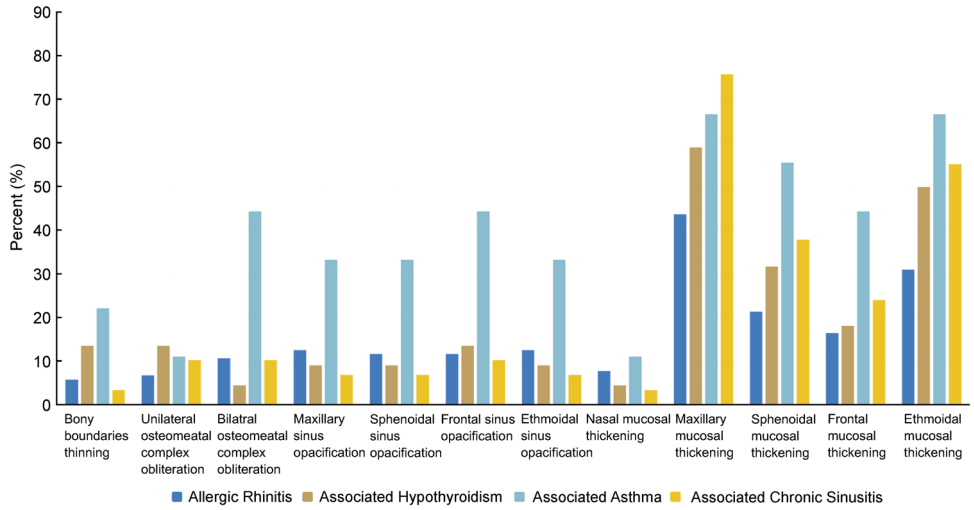

FIGURE 2 Comparison between CT paranasal sinuses findings among allergic rhinitis patients who had an associated hypothyroidism, chronic sinusitis and asthma and those who didn't have them

CONCLUSION

Taif region is considered to be exposed to multifactorial inducers of AR. The gender distribution of AR was 10% more common among males; however, the three most common comorbidites in AR patients were chronic sinusitis, hypothyroidism, and asthma, and most of those patients were females. Hypothyroidism can be a hidden predisposing factor of rhinitis, especially in females. AR and asthma may be attributed to the same allergen, while chronic sinusitis can be caused by AR due to secretion stasis or immune system activation.

AUTHOR CONTRIBUTIONS

Sara Ahmad Assiri: Conceptualization, Methodology, Software. Raad M. M. Althaqafi: Data curation, Writing- Original draft preparation. Atheer Alsufyani: Visualization, Investigation. Aljuaid Eidha Fawzan: Supervision, Validation. Ahmad Saeed A. Alghamdi: Writing-Reviewing and Editing.

ACKNOWLEDGMENTS

We are extremely grateful for the Research Ethics Committee and the staff at the radiology department at Al-Hada Armed Forces Hospital Taif city, Saudi Arabia for helping us obtain the required data and ethical approval.

CONFLICT OF INTEREST

None.

REFERENCES

1. Shedden A. Impact of nasal congestion on quality of life and work productivity in allergic rhinitis: findings from a large online survey. *Treat Respir Med*. 2005;4:439-446.
2. Seidman MD, Gurgel RK, Lin SY, et al. Clinical practice guideline: allergic rhinitis. *Otolaryngol Head Neck Surg*. 2015;152: S1-S43.
3. Salo PM, Arbes SJ Jr, Jaramillo R, et al. Prevalence of allergic sensitization in the United States: results from the National Health and Nutrition Examination Survey (NHANES) 2005–2006. *J Allergy Clin Immunol*. 2014;134:350-359.
4. Yonekura S, Okamoto Y, Horiguchi S, et al. Effects of aging on the natural history of seasonal allergic rhinitis in middle-aged subjects in South chiba, Japan. *Int Arch Allergy Immunol*. 2012;157:73-80.
5. Salo PM, Calatroni A, Gergen PJ, et al. Allergy-related outcomes in relation to serum IgE: results from the National Health and Nutrition Examination Survey 2005-2006. *J Allergy Clin Immunol*. 2011;127: 1226-1235.e7.
6. Meltzer EO, Blaiss MS, Derebery MJ, et al. Burden of allergic rhinitis: results from the pediatric allergies in America survey. *J Allergy Clin Immunol*. 2009;124:S43-S70.
7. Fineman SM. The burden of allergic rhinitis: beyond dollars and cents. *Ann Allergy Asthma Immunol*. 2002;88:S2-S7.
8. Rapiejko P, Jurkiewicz D, Pietruszewska W, Zielnik-Jurkiewicz B, Woroń J, Lipiec A. Treatment strategy of allergic rhinitis in the face of modern world threats. *Otolaryngol Pol*. 2018;72:1-12.
9. Ryan D, van Weel C, Bousquet J, et al. Primary care: the cornerstone of diagnosis of allergic rhinitis. *Allergy*. 2008;63:981-989.
10. Law M, Morris JK, Wald N, Luczynska C, Burney P. Changes in atopy over a quarter of a century, based on cross sectional data at three time periods. *BMJ*. 2005;330:1187-1188.
11. Al-Frayh A, Reilly H, Harfi HA, Hasnain SM, Thorogood R, Wilson JD. A 12-month aerobio- logical survey of pollen in Riyadh. *Ann Saudi Med*. 1989;9:443-447.
12. Alreshidi F, Alrashidi A, Alshammari F. Knowledge, attitude and practice about allergic rhinitis in Saudi Arabia. *Egypt J Hospital Med*. 2017;69:2199-2203.
13. Scadding GK, Durham SR, Mirakian R, et al. BSACI guidelines for the management of allergic and non-allergic rhinitis. *Clin Exp Allergy*. 2008;38:19-42.
14. Wheatley LM, Togias A. Clinical practice. allergic rhinitis. *N Engl J Med*. 2015;372:456-463.
15. Brozek JL, Bousquet J, Baena-Cagnani CE, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines: 2010 revision. *J Allergy Clin Immunol*. 2010;126:466-776.
16. Calderon MA, Alves B, Jacobson M, Hurwitz B, Sheikh A, Durham S. Allergen injection immunotherapy for seasonal allergic rhinitis. *Cochrane Database Syst Rev*. 2007;(1):CD001936.

17. Bousquet J, Schünemann HJ, Samolinski B, et al. Allergic Rhinitis and its Impact on Asthma (ARIA): achievements in 10 years and future needs. *J Allergy Clin Immunol*. 2012;130:1049-1062.
18. Jurkiewicz D, Ligęziński A, Zawisza E, et al. The influence of air pollution on the threshold exposure concentration allergenic pollen grains. *Otolaryngol Pol*. 1997;51:544-546.
19. Sobki SH, Zakzouk SM. Point prevalence of allergic rhinitis among Saudi children. *Rhinology*. 2004;42:137-177.
20. Meo SA, Al-Kheraiji MA, AlFaraj Z, Alwehaibi N, Aldereihim A. Respiratory and general health complaints in subjects exposed to sandstorm at Riyadh, Saudi Arabia. *Pak J Med Sci*. 2013;29: 642-646.
21. Mahboub B, Al-Hammadi S, Prakash VP, et al. Prevalence and triggers of allergic rhinitis in the United Arab Emirates. *World Allergy Organ J*. 2014;7:19.
22. Chavanne L. Secretion nasale et glande thyroide. *Otorhinolaryngol Int*. 1936;20:653-664.
23. Weisskopf A. Connective tissue: a synthesis of modern thought and its impact on the understanding of nasal disease. *Laryngoscope*. 1960;70:1029-1059.
24. Eyigor H, Basak S, Kozaci D, Culhaci N, Dost T, Ulutas P. Pathogenesis of rhinitis in rats with experimentally induced hypothyroidism. *Clin Lab*. 2012;58:1263-1268.
25. Başal Y. The effect of experimental hypothyroidism on nasal mucosa. *Turk J Ear Nose Throat*. 2018;28:21-25.
26. Hellings PW, Klimek L, Cingi C, et al. Non-allergic rhinitis: Position paper of the European Academy of Allergy and Clinical Immunology. *Allergy*. 2017;72:1657-1665.
27. Farrbaks DNF, Raphael GD. Nonallergic rhinitis and infection. In: Cummings CW, Haughey BH, Thomas JR, eds. *Cummings otolaryngoloy head and neck surgery*. 2nd ed. Philadelphia: Mosby; 2005: 775-785.
28. Jeevanan J, Gendeh BS, Satpal S. Hashimoto's thyroiditis: a rare cause for rhinosinusitis. *Med J Malaysia*. 2004;59:428-458.
29. Al Eidan E, Ur Rahman S, Al Qahtani S, Al Farhan AI, Abdulmajeed I. Prevalence of subclinical hypothyroidism in adults visiting primary health-care setting in Riyadh. *J Community Hosp Intern Med Perspect*. 2018;8:11-15.
30. Zhang J, Huang C, Meng Z, et al. Gender-specific differences on the association of hypertension with subclinical thyroid dysfunction. *Int J Endocrinol*. 2019:6053068.
31. Pinart M, Benet M, Annesi-Maesano I, et al. Comorbidity of eczema, rhinitis, and asthma in IgE-sensitised and non-IgE-sensitised children in MeDALL: a population-based cohort study. *Lancet Respir Med*. 2014;2:131-140.
32. Demenais F, Margaritte-Jeannin P, Barnes KC, et al. Multiancestry association study identifies new asthma risk loci that colocalize with immune-cell enhancer marks. *Nat Genet*. 2018;50:42-53.
33. Ferreira MA, Vonk JM, Baurecht H, et al. Shared genetic origin of asthma, hay fever and eczema elucidates allergic disease biology. *Nat Genet*. 2017;49:1752-1757.
34. Lemonnier N, Melén E, Jiang Y, et al. A novel whole blood gene expression signature for asthma, dermatitis, and rhinitis multi-morbidity in children and adolescents. *Allergy*. 2020, Apr 11. Online ahead of print
35. Bergeron C, Hamid Q. Relationship between asthma and rhinitis: epidemiologic, pathophysiologic, and therapeutic aspects. *Allergy Asthma Clin Immunol*. 2005;1:81-87.
36. Hussain SM, Farhana SA, Alnasser SM. Time trends and regional variation in prevalence of asthma and associated factors in saudi arabia: a systematic review and meta-analysis. *BioMed Res Int*. 2018:8102527.
37. Spector SL. Overview of comorbid associations of allergic rhinitis. *J Allergy Clin Immunol*. 1997;99:S773-S780.
38. Berrettini S, Carabelli A, Sellari-Franceschini S, et al. Perennial allergic rhinitis and chronic sinusitis: correlation with rhinologic risk factors. *Allergy*. 1999;54:242-248.
39. Calhoun K. Diagnosis and management of sinusitis in the allergic patient. *Otolaryngol Head Neck Surg*. 1992;107:850-854.
40. Furukawa CT, Sharpe M, Bierman CW. Allergic patients have more frequent sinus infections than non-allergic patients. *J Allergy Clin Immunol*. 1992;89:332-332.
41. Baroody FM, Mucha SM, deTineo M, Naclerio RM. Evidence of maxillary sinus inflammation in seasonal allergic rhinitis. *Otolaryngol Head Neck Surg*. 2012;146:880-886.
42. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. *Laryngoscope*. 1991;101:56-64.
43. Tezer MS, Tahamiler R, Canakçioğlu S. Computed tomography findings in chronic rhinosinusitis patients with and without allergy. *Asian Pac J Allergy Immunol*. 2006;24:123-130.

How to cite this article: Fawzan AE, Assiri SA, Althaqafi RMM, Alsufyani A, Alghamdi ASA. Association of allergic rhinitis with hypothyroidism, asthma, and chronic sinusitis: clinical and radiological features. *World J Otorhinolaryngol Head Neck Surg*. 2022;8:262-268. doi:10.1016/j.wjorl.2020.12.001