Magna Scientia Advanced Research and Reviews

eISSN: 2582-9394

Cross Ref DOI: 10.30574/msarr

Journal homepage: https://magnascientiapub.com/journals/msarr/

(RESEARCH ARTICLE)

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The radiologic perspective of pulmonary tuberculosis seasonality in south-south Nigeria

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Magna Scientia Advanced Research and Reviews, 2024, 12(02), 261–271

Publication history: Received on 23 October 2024; revised on 10 December 2024; accepted on 12 December 2024

Article DOI: https://doi.org/10.30574/msarr.2024.12.2.0201

Abstract

Background: The periodic variation in the occurrence of disease within a calendar period is relatively common among many diseases, especially infectious diseases like tuberculosis (TB).

Objective: The study is to radiologically evaluate the seasonality of pulmonary tuberculosis in our environment.

Materials and Method: The study was a descriptive cross-sectional study over a period of 6 years (2017-2022) with one thousand, three hundred and fifty (1350) chest radiographs diagnosed of pulmonary tuberculosis. The chest radiographs were reviewed by three Radiologists with certification from the Faculty of Radiology of the West African College of Surgeons or the National Postgraduate Medical College of Nigeria. The data was analyzed descriptively using the statistical package for social science, SPSS version 23.0.

Result: The monthly time series distribution of the radiologic diagnosis of pulmonary tuberculosis showed the lowest occurrences in the year 2020. The monthly average Seasonal Index of the radiologic occurrence of pulmonary TB shows that the months of June (1.29), July (1.95), and August (2.09) demonstrated the highest average seasonal index. The monthly averages from January to December over the 6 years of the study showed the highest occurrences in the month of August, and the lowest occurrences in the month of October.

Conclusion: Although there were inconsistencies in the monthly pattern over the six year period, the highest incidence was in the month of August, followed by the month of July. Thus the study concludes that there exist seasonal variations in the radiologic diagnosis of pulmonary tuberculosis.

Keywords: Pulmonary tuberculosis; Seasonality of pulmonary tuberculosis; Monthly Average Seasonal Index; Infectious Disease; Rivers State University Teaching Hospital

1. Introduction

Seasonal variation is the periodic variation in the occurrence of disease or the disease outcome within a calendar period. The occurrence of seasonal variation is relatively common among many diseases, especially diseases of infectious origin (1, 2).

Tuberculosis (TB) is an infectious disease that primarily affects the lungs and is caused by the bacteria *Mycobacterium Tuberculosis* (MTB). The disease has the propensity of affecting other parts of the body, thereby presenting with a wide range of symptoms (3, 4). It was estimated that about 10 million people developed active TB in 2020, which led to the death of about 1.5 million people. This makes the death from tuberculosis the second leading cause of death, following

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infectious diseases. Nigeria is the third country behind India and China concerning tuberculosis infection. Epidemiologic data shows that every year, about 245,000 Nigerians die from tuberculosis (TB) infection, and about 590,000 new cases are diagnosed, and the disease accounts for over 10% of all deaths in Nigeria. Approximately 30 people die from the disease in Nigeria despite the availability of effective treatment (1).

The infection may not show symptoms during the latent phase of the infection, but during its active stage, it presents with a chronic cough with or without blood sputum, fever, night sweats, and weight loss. The risk for contracting PTB is highest among those in close contact with patients with active TB like family or friends, people in correctional facilities, group homes, nursing homes, and shelters (6). The risk of contracting the disease is also higher with older adults, children, cigarette smokers, immunocompromised persons, as well as persons with autoimmune disorders (6).

PTB can be diagnosed by various ways, which include chest radiography, microbiological evaluation such as acid-fast bacilli (AFB) smear and culture using the conventional Ziehl-Neelsen (ZN) method. sputum culture, GenXpert assay, Nucleic Acid Amplification Test (NAAT). Other methods include the tuberculin skin test/mantoux test, interferon gamma release assay (IGRA) and bronchoscopy/lung biopsy.

Notwithstanding the enlisted diagnostic methods, radiology continues to play a vital role in the diagnosis, treatment, and follow-up of patients with pulmonary tuberculosis (7). Radiologic imaging, such as radiography (X-ray), lung ultrasonography, computed tomography (CT), positron emission tomography (PET), fluoroscopy, and magnetic resonance imaging (MRI) can be used in the management of PTB.

On chest radiography the infection could show as homogeneous, inhomogeneous, or patchy opacities, nodular and cystic lung changes (figures 1 and 2). It could also show as lung collapse (8) with associated mediastinal shift (figure 3), as well as pleural fluid collection due to pleural effusion (7) as also shown on figure 4.

PTB incidence is seasonal, which peaks during every spring and summer period. The reason for this variation is not clear and may be associated with vitamin D deficiency during the winter period. Studies have also shown that PTB could be linked to climate and weather conditions like low temperature, humidity, and rainfall. The incidence of tuberculosis varies with age, wherein in Africa, it affects adolescents and young adults primarily, whereas it affects the elderly and immunocompromised in developed countries.

In different parts of the globe, the seasonal variation of TB incidence has been greatly reported; however, conflicting incidence peaks of infection have been reported (5). Knowledge of disease seasonality will provide more information on diseases, thereby contributing to healthcare planning, and will also provide more insight towards the aetiology of the disease. Seasonality will also provide more information on disease patterns, their occurrences between extremes of weather. The previous studies have provided some information on season-specific risk factors associated with PTB and this has helped in the development of national policies on TB,(5) although there is a paucity of documentation in our environment. The study is aimed at evaluating the seasonality of pulmonary tuberculosis in our environment using radiologic evaluation.

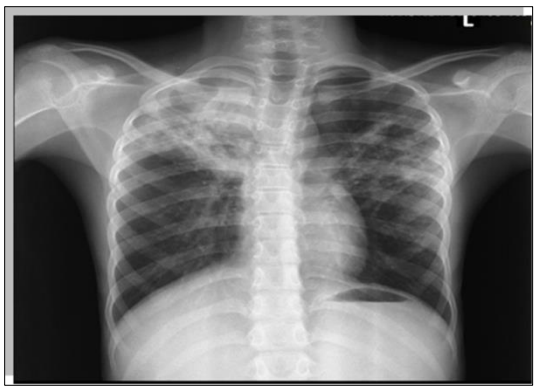

Figure 1 A frontal chest x-ray showing a fairly homogeneous opacity on the right upper lung zone with associated air bronchogramm and background cystic changes. Similar background nodular and cystic opacities are seen on the left mid lung zone all due pulmonary tuberculosis

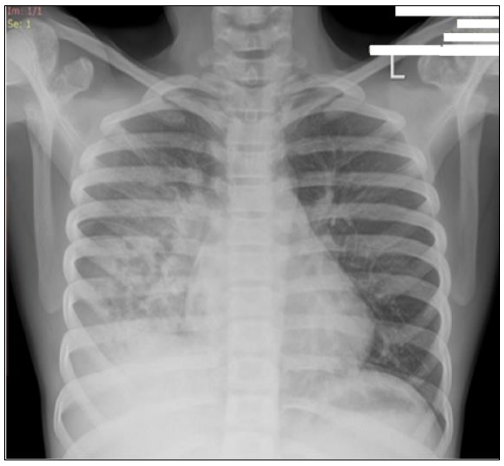

Figure 2 Chest x-ray showing patchy opacities on the right mid and lower lung zones as well as left sided pleural fluid collection

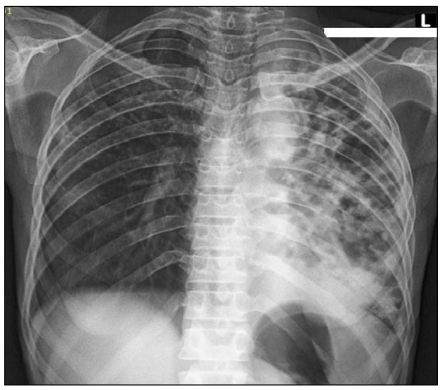

Figure 3 A frontal chest x-ray showing inhomogeneous opacities on the left hemithorax with background nodular and cystic changes with associated complete mediasternal shift to the right due to loss in lung volume (left lung collapse) in the left hemithorax. Heart size is indeterminate due to mediatersnal shift.

Figure 4 A frontal chest x-ray showing a homogeneous opacity on the left lower lung zone with obliteration of the costophrenic angle, ipsilateral hemidiaphrame and left heart border due to pleural effusion

2. Materials and Method

2.1. Research Design

The study was a descriptive cross-sectional study over a period 6 years (2017-2022).

2.2. Population for the Study

One thousand and three hundred and fifty (1350) chest radiographs with a provisional clinical diagnosis of pulmonary tuberculosis within the period under review were analyzed.

2.3. Sampling and Sampling Technique

Informed and written consent was duly obtained from the Institutional Ethical Committee. Samples were collated prospectively in the Radiology Department of Rivers State University Teaching Hospital. The chest radiographs were evaluated by three Radiologists with certification from the Faculty of Radiology of the West African College of Surgeons or the Faculty of Radiology of the National Postgraduate Medical College of Nigeria.

2.4. Methods for Data Collection

Follow-up cases with a previous radiologic diagnosis of PTB of were excluded from the study. A confirmatory test was dome with a GenXpert.

2.5. Method of Data Analysis

Data was analyzed descriptively using statistical package for social science SPSS version 23.0.

3. Result

The monthly time series distribution of the radiologic diagnosis of pulmonary tuberculosis from 2017-2022 shows the highest and lowest occurrences in the years 2022 (n=256) and 2020 (n=184), respectively, as shown in Table 1. In 2017 the highest occurrences were in the months of April (n=32) and August (n=32), while the lowest occurrence was observed in the month of December 2017 (n=5). In 2021 the highest and lowest occurrences were seen in the months of August (n=47) and January (n=3), respectively (Table 1).

On table 2, pulmonary tuberculosis was radiologically diagnosed across various age groups. Age group 31-40 years accounted for 28.74% (n=388), which was the most frequent age group, followed by age group 41-50 years (n=326; 24.15%), while the least diagnosed age group was above 80 years (n=12; 0.96%).

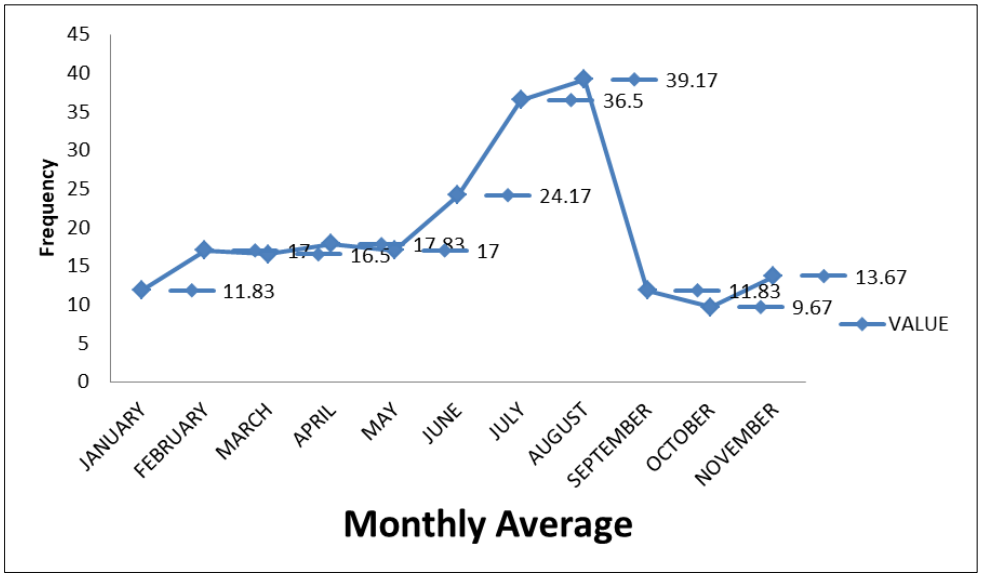

Figure 5 Monthly averages from January to December for the 6 years

The monthly averages from the months of January to December over the 6 years of the study showed the highest occurrences of the radiodiagnosis of pulmonary tuberculosis in the month of August, followed by the months of July and June, respectively, whereas the lowest occurrences were noted in the month of October (figure 5).

Table 1 Monthly time series distribution of Pulmonary Tuberculosis from 2017-2022

Month	2017	2018	2019	2020	2021	2022	Total (%)
JANUARY	11	20	21	9	3	7	71(5.26%)
FEBRUARY	18	21	10	8	18	27	102(7.56%)
MARCH	20	11	10	8	28	22	99(7.33%)
APRIL	32	21	10	15	11	18	107(7.93%)
MAY	19	17	18	14	13	21	102(7.56%)
JUNE	22	32	28	20	19	24	145(10.74%)
JULY	22	42	32	38	38	47	219(16.22%)
AUGUST	32	39	40	35	47	42	235(17.41%)
SEPTEMBER	18	8	15	10	13	7	71(5.26%)
OCTOBER	10	7	12	5	15	9	58(4.29%)
NOVEMBER	19	12	11	10	11	19	82(6.07%)
DECEMBER	5	10	7	12	12	13	59(4.37%)
Total	228 (16.89%)	240 (17.78%)	214 (15.85%)	184 (13.63%)	228 (16.89%)	256 (18.96%)	1350 (100)

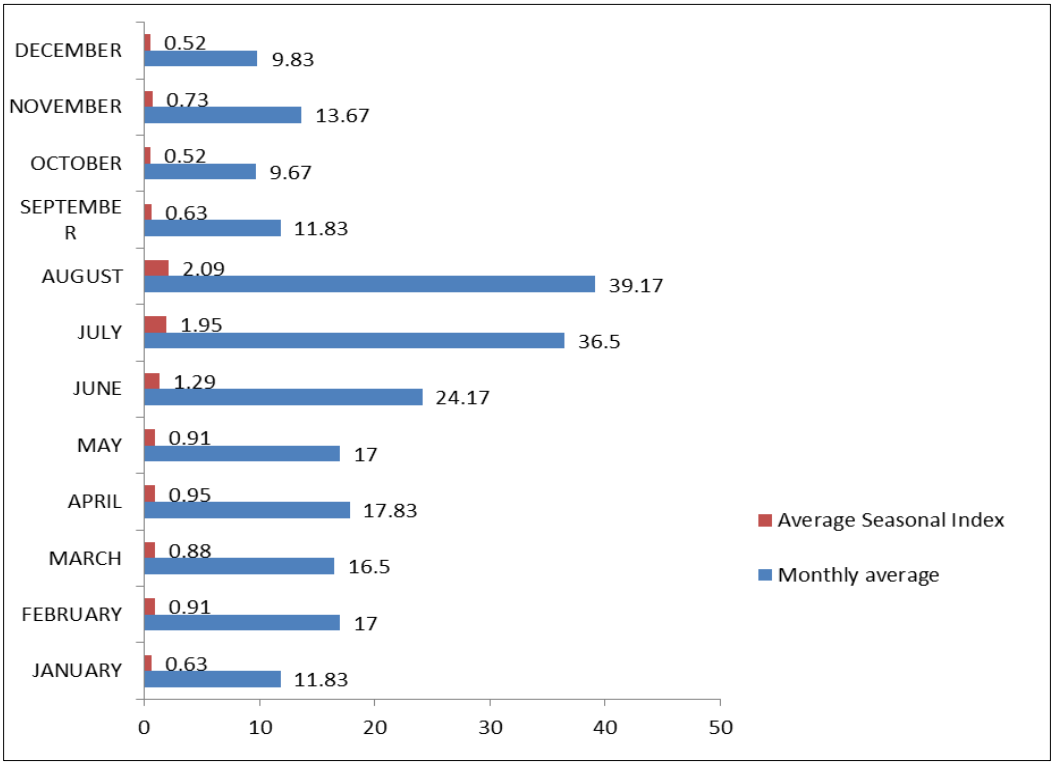

Figure 6 Monthly average and the Average Seasonal Index

Figure 6 shows the monthly average and the Average Seasonal Index of the radiologic occurrence of pulmonary TB. The figure illustrates that the months of June (1.29), July (1.95), and August (2.09) demonstrated the highest average seasonal index, while the months of October (0.52) and December (0.52) were the lowest (figure 6).

According to table 3, there was male dominance in all the years from 2017, 2020, 2021, and 2022. The cumulative analysis also showed a marginal male prevalence, showing 685 (50.75%) and 665 (49.25%) for males and females, respectively.

Tables 4-9 illustrate the type of presenting complaints of participants according to age distribution. In 2017, table 5 illustrates that nonproductive cough (71) and fever (50) were the most common presenting complaints, while in 2018 the nonproductive cough (n=86), fever (n=35), and productive cough (n=35) were the most common presenting complaints. In 2019 the nonproductive cough (n=78) and productive cough (n=41) were the most common presenting complaints, whereas in 2020 and 2021 the fever and nonproductive cough were the most common presenting complaints. In 2022 the nonproductive cough (n=90) and productive cough (n=40) were the most common presenting complaints.

Table 2 Age Distribution of Participant's

Age (years)	2017	2018	2019	2020	2021	2022	Total (%)
<10	13	21	11	8	19	17	89(6.59%)
11-20	20	27	31	19	24	58	179(13.26%)
21-30	38	33	55	31	35	29	221(16.37%)
31-40	76	71	37	68	69	67	388(28.74%)
41-50	62	63	51	44	50	56	326(24.15%)
51-60	15	18	20	9	19	22	103(7.63%)
61-70	3	3	4	2	5	2	19(1.41%)
71-80	1	2	3	1	3	3	13(0.96%)
>80	-	2	2	2	4	2	12(30.89%)
Total	228 (16.89%)	240 (17.78%)	214 (15.85%)	184 (13.63%)	228 (16.89%)	256 (18.96%)	1350 (100)

Table 3 Gender Distribution of Participant's

Gender	2017(%)	2018(%)	2019(%)	2020 (%)	2021(%)	2022(%)	Total (%)
Male	116 (16.93%)	118 (17.23%)	95 (13.87%)	93 (13.58%)	127 (18.54%)	136 (19.85%)	685 (50.75%)
Female	112 (16.84%)	122 (18.35%)	119 (17.89%)	91 (13.68%)	101 (15.19%)	120 (18.05%)	665 (49.25%)
Total	228 (16.89%)	240 (17.78%)	214 (15.85%)	184 (13.63%)	228 (16.89%)	256 (18.96%)	1350 (100%)

Table 4 Presenting complaints of participants in 2017 with age

Age (year)	Year	Presenting complaints							
	2017	Productive Cough	Non-productive cough	Fever	Weight loss	Night sweating	Headache	Chest pain	Haemoptysis
<10	13		1	1					
11-20	20	1	3	4			1	4	
21-30	38	8	4	6	4		3	7	1
31-40	76	8	10	18	2	3	1	6	17
41-50	62	8	48	8	4	2	1	3	2
51-60	15	1	2	8	1	0	1	1	4
61-70	3	1	2	1	1	0	0	1	2
71-80	1	1		1	0	0	0		1
>80	-	1	1	3		0	1	0	2
Total	228	29	71	50	12	5	8	22	29

Table 5 Presenting complaints of participants in 2018 with age

Age (years)	Year	Presenting complaints							
	2018	Productive Cough	Non-productive cough	Fever	Weight loss	Night sweating	Headache	Chest pain	Haemoptysis
<10	21		1	1					
11-20	27		3	4			1	4	
21-30	33	6	14	4	1		4	5	1
31-40	71	15	11	13	2	3	2	5	11
41-50	63	8	48	8	4	2	1	3	2
51-60	18	3	5	3	1	0	1	4	1
61-70	3	1	2	1	1	0	0	1	2
71-80	2	1	1	1	0	0	0	1	
>80	2	1	1			0	1	1	
Total	240	35	86	35	9	5	10	24	17

Table 6 Presenting complaints of participants in 2019 with age

Age (years)	Year	Presenting complaints							
	2019	Productive Cough	Non-productive cough	Fever	Weight loss	Night sweating	Headache	Chest pain	Haemoptysis
<10	11		1	1					
11-20	31		3	4			1	4	
21-30	55	3	14	4	2		3	2	1
31-40	37	11	13	7	2	3	2	5	5
41-50	51	21	41	6	4	2	1	3	1
51-60	20	3	5	3	1	0	1	5	1
61-70	4	1		1	1	0	0	1	2
71-80	3	1		1	0	0	0	1	
>80	2	1	1			0			
Total	214	41	78	27	10	5	8	21	10

Table 7 Presenting complaints of participants in 2020 with age

Age (years)	Year	Presenting complaints							
	2020	Productive Cough	Non-productive cough	Fever	Weight loss	Night sweating	Headache	Chest pain	Haemoptysis
<10	8		1	3					
11-20	19		11	13	1	3	1	1	
21-30	31	3	13	13	1	1	1	6	3
31-40	68	6	11	10	2	2	1	9	5
41-50	44	4	1	11	1		1	6	3
51-60	9	2	3	5		1		3	2
61-70	2	1	3	7		1		1	2
71-80	1	1	2	5		1		2	2
>80	2		1	1					
Total	184	17	46	68	5	10	4	28	17

Table 8 Presenting complaints of participants in 2021 with age

Age (years)	Year	Presenting complaints							
	2021	Productive Cough	Non-productive cough	Fever	Weight loss	Night sweating	Headache	Chest pain	Hemoptysis
<10	19		1	1					
11-20	24	1	1	2				1	
21-30	35	5	5	8	4	2	1	3	7
31-40	69	8	13	14	2	2	1	10	6
41-50	50	5	11	18	2	2	1	7	4
51-60	19	3	8	3		1	1	2	2
61-70	5	2	3	5		1		2	2
71-80	3	2	1	3			1	1	2
>80	4	1		1					1
Total	228	27	43	55	8	8	5	26	24

Table 9 Presenting complaints of participants in 2022 with age

Age (years)	Year	Presenting complaints							
	2022	Productive Cough	Non-productive cough	Fever	Weight loss	Night sweating	Headache	Chest pain	Hemoptysis
<10	17		1	1					
11-20	58		3	4			1	4	
21-30	29	11	14	4	1		4	5	1
31-40	67	15	15	13	2	3	2	5	9
41-50	56	8	48	8	4	2	1	3	9
51-60	22	3	5	3	1	1	1	4	1
61-70	2	1	2	3	1	0	0	1	2
71-80	3	1	1	1	0	0	0	5	
>80	2	1	1			0		1	
Total	256	40	90	37	9	6	9	28	22

4. Discussion

The monthly time series distribution of the radiologic diagnosis of pulmonary tuberculosis over a six-year period from 2017-2022 shows that the highest and lowest occurrences were in the years 2022 and 2020, respectively. The approximate percentage reduction between the highest and lowest years of occurrences was 28.13%. The reason for the highest incidences cannot be ascertained; however, the restrictions due to the Covid-19 lockdowns may have contributed to the low incidence documented in 2020. The effect of the COVID-19 restrictions on disease incidence was documented in a study by Onana *et al*. in 2022 (9) to evaluate the "Impact of the COVID-19 Pandemic on Patient Attendance and Trends in the Use of Medical Imaging Modalities in a Referral Hospital in the City of Douala." The study

revealed that there was a 25.73% reduction in the number of ultrasound scans and an 18.26% drop in the number of conventional radiographies in 2020 when compared to the preceding year (9). A similar reduction was observed in the study by Gitau *et al.* (10) and Njuguna *et al.* (11).

Concerning pulmonary tuberculosis incidence, the highest occurrences in 2017 were in the months of April and August, while the lowest occurrence was in the month of December 2017, whereas in 2021 the highest and lowest occurrences were in the months of August and January 2021, respectively. There were inconsistencies in the demonstrated monthly pattern over the six-year period; however, the cumulative evaluation showed the highest incidence in the month of August, followed by the month of July. According to the climate knowledge portal, Nigeria has two major rainfall seasons, the dry season (from November to March) and the rainy season (April to October) (12), thus the study shows that the highest incidence of radiology diagnosis of pulmonary tuberculosis was observed in the rainy season when compared to the summer or dry season. The reason may be attributed to increased severity of the diseases during the rainy season. According to a review article from 1971 to 2006 involving 11 countries/regions around the world, PTB has a seasonal pattern with a predominant peak during the spring and summer in all of the countries apart from South-Western Cameroon and Russia (13).

The monthly Average Seasonal Index of the radiologic occurrence of pulmonary TB showed that the months of June (1.29), July (1.95), and August (2.09) demonstrated the highest average seasonal index, being 29%, 95%, and 109% higher than the month's average, respectively. On the other hand, the months of October (0.52) and December (0.52) were 48% below the monthly average. It was observed that some of the request forms were not properly filled out and clinical presentation not well spelled out. Poor health-seeking behavior was a limitation, which may have affected hospital presentation and delayed undertaking the radiologic investigation. Economic reasons where existing health insurance does not cover everyone thus requested radiologic investigation may be delayed for a week or more before presenting for the investigation. This may cause overlap between months.

Pulmonary tuberculosis reveals a variety of patterns radiologically and was radiologically diagnosed across various age groups. The age group 31-40 years was the most frequent age group, followed by the age group 41-50 years, and the least group was those above 80 years.

There was a cumulative marginal male prevalence of the disease. This finding is similar in part to the review from Fares., 2011 (13). In the review, the seasonality showed slight marked male predominance over females (13). This finding is contrary to the finding from another study where there was female predominance concerning hospital attendance (14).

In 2017, 2018, and 2022, non-productive cough and fever were the most common presenting complaints, whereas in 2019, the non-productive cough and productive cough were the most common presenting complaints. In 2020 and 2021, the fever and nonproductive cough were the most common presenting complaints.

This is in accordance with the studies by Davies *et al.* (2014) and Heemskerk *et al.* (2015) (15), where persistent non-remitting cough is the most frequently reported symptom in about 95% of cases. However, the triad of fever (75%), weight loss (55%), and night sweats (45%) are the frequent presentations of patients.

5. Conclusion

There were inconsistencies in the monthly pattern over the six-year period, with the highest incidence in the month of August, followed by the month of July. Thus, the study concludes that there exist seasonal variations in the radiologic diagnosis of pulmonary tuberculosis.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest or Competing Interests concerning this manuscript.

Statement of informed consent

Informed consent was obtained from each participant before the commencement of the study.

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