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Impact of Demographic and Occupational Factors on Respiratory Infections among Workers of Al-Baiji Oil Refinery, Iraq

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Abstract: ***Background*:** Respiratory tract may become susceptible to bacterial infection as a result of health conditions such as allergies and viral infections, as well as the effects of smoking and airborne environmental pollutants particularly inside oil refineries**.** ***Materials and Methods*:** A total number of 200 samples were taken including swabs, sputa and sera of workers in oil refinery with respiratory infections and other 200 patients who attended Tikrit Teaching hospital as control samples for comparison. Swabs and sputa were cultured. The diagnosis of bacterial isolates was done according to the microscopic examination and the results of biochemical tests. ***Results*:** The patients of refinery ranged in age between 16-65 years old, whereas those of hospital ranged between 16-95 years old who had varied jobs and some were unemployed for various reasons. G2 group forms the largest proportion of the patients from the refinery which reached 35.5 % followed by G1 group (22 %). Both who are able to perform actions that require effort, whereas G8 group formed the least proportion (3 %). This might be due to the fact that these ages include those who are at the age of retirement from work. The extent of damage is related to the pollutant's physicochemical properties, its concentration, and the duration of exposure. The most frequent cases among patients of refinery were tonsillitis (68.3 %) followed by bronchitis (13.8 %) but the same diseases formed (18.2 %) and (8.0 %), respectively in patients of hospital**.** ***Conclusions*:** it was noticed that males formed a proportion larger than that of females at all groups of age. In the current study it has been observed that the highest infection rates were among patients who did not exceed a period of 5 years of employment. Perhaps due to the fact that the group included newly recruited workers who had not yet adapt to pollutants exposure, followed by the groups (11-15) and (6-10) years of employment which were 20.5 % and 15 %, respectively. Periods of employment more than 16 years witnessed decreasing in infection rates and were so close between each other. The most frequent cases among patients of refinery were tonsillitis (68.3 %) followed by bronchitis (13.8 %) but the same diseases formed (18.2 %) and (8.0 %), respectively in patients of hospital. The other cases were higher in patients of hospital and they were pharyngitis (35.5%), chest infections (28.5 %), sore throat (8.0 %) and laryngitis (2.0%). In refinery the same cases revealed 3.7%, 6.4%, 6.4 % and 1.3%, respectively.

Keywords: Occupation, Demography, Oil Refinery, Workers, Respiratory Infections.

Research Paper

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INTRODUCTION

Most of the surfaces of the upper respiratory tract are colonized by normal flora. These organisms are usually regular inhabitants of these surfaces and rarely cause disease [1]. Some of these are opportunistic and can cause serious illness when tissue damaging occurred. Also, many naturally occurring environmental agents are opportunistic, requiring that the host have some sort of immune deficiency for infection to occur [2-6]. The respiratory tract is a frequent site of infection because it comes in direct contact with the physical environment and is exposed to airborne microorganisms. A wide range of organisms, including viruses, bacteria, fungi, and parasites, can infect the respiratory tract and cause infections [7-10]. Respiratory tract may become susceptible to bacterial infection as a result of health conditions such as allergies and viral infections, as well as the effects of smoking and airborne environmental pollutants [11-13]. Oil refineries cause smog and air pollution. Almost all refineries in every country currently pollute at unacceptable and unhealthy levels. Oil refineries are the largest sources of air pollution with large amounts of emissions those include heavy metals, very smaller size dust particles that get deep into lungs and harm ability to breathe [14-19] and many gases like sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon dioxide, carbon monoxide, methane, hydrogen fluoride, chlorine, benzene and others [20-22]. Throughout the refining process, workers can be potentially exposed to various health and safety hazards related with these pollutants [23-26]. Air pollution principally affects the respiratory, circulatory and olfactory systems with the respiratory system been the main route of entry for air pollutants, some of which may alter the function of the lungs [27-29]. Materials inhaled in the workplace can lead to all the major chronic lung diseases except those due to vascular disease [30-32]. One occupational agent may cause many diseases, just as cigarette smoke causes several distinct disorders. Conversely, one respiratory disease may have several occupational causes [33-35]. Also, Exposure to environmental pollutants may lead to selective pressures favoring certain organisms or genotypes. Many studies demonstrated positive correlations between industrial pollution and the spatial distribution of antibiotic resistance [36-40]. Antibiotic resistance in medicine generates significant health and economic impacts Heavy metal contamination is a severe environmental problem due to the increase in human and industrial activities [41-43]. Heavy metals such as lead, mercury, cadmium and nickel are emitted from oil refinery and metabolically poisonous at low concentrations. Bacterial accumulation and resistance to toxic heavy metals is a widespread phenomenon. The mechanisms of heavy metal resistance have been reported to enhance the antibiotic resistance of microorganisms [44-48]. The results from monitoring physicochemical and microbiological quality of Baiji oil refinery environmental system done by Al-Bashaar [49], and other workers [50-52] indicated a high contamination of water with pathogenic bacteria and SO_2 in the water and air systems respectively and showed that respiratory bacterial pathogens were with high resistance to heavy metal [50-53]. Also, a number of air pollutants have been consistently linked to chronic obstructive pulmonary disease including asthma which has emerged as the principal occupational lung disease [54-57]. Exacerbations have been associated with increases in ozone, particulate matter, nitrogen dioxide, carbon monoxide and sulfur dioxide [58-62].

MATERIALS AND METHODS

Description of the Refinery

This study was carried out in the Northern Refinery Company (NRC), one of the biggest factories in the country, which is located in the north of Baiji city. This factory was established in 1980, and considered as one of the major oil companies in middle-east which depends on for bridging the needs of local consumption of petroleum products and export the surplus outside. The number of workers at this refinery is about 8000 workers, distributed on six main sections, these sections are divided into major sub-sections, and the section of production is one of those where the workers exposed to the direct and indirect risks of pollution. This section composes of ten departments, only four of them are located within the limits of the refinery, and the rest of the departments are approximately 100 Km far away from the company, those departments according to their importance are: Northern Department, Salahaddin 1, and Salahaddin 2. These three departments constitute the largest cluster of activity in the refining process (Special issue, 25 years since the establishment of the North Refineries, Iraq).

Patients

From October 2008 to September 2009, samples were collected from patients with upper and lower respiratory tract infections, 200 samples were collected from patients worked in the Northern Refineries Company in Baiji town, equal number of samples was collected from patients hospitalized in Tikrit teaching hospital as control samples for comparison.

Samples

Swabs from upper respiratory tract infections: (Tonsillitis, laryngitis, sore throat and Pharyngitis) were transported to the laboratory using transport medium swabs and sputa from lower respiratory tract infections: (Bronchitis and Pneumonia) were transported using Cary-Bliar transport medium in screw capped vials (WHO, 2003). Samples were taken according to the diagnosis of specialist physicians after washing the mouth three times to eliminate much amounts of mouth normal flora [63, 64].

Isolation of Bacteria

Swabs taken from upper respiratory tract and sputum samples taken from lower respiratory tract, as soon as possible taken to the laboratory, were cultured on four plates of culture media recommended for primary isolation of pathogens. These media included two plates of blood agar, Chocolate agar and MacConkey agar. OAne plate of Blood agar and Chocolate agar were incubated in a candle jar to enhance growth, while the other two plates were incubated aerobically. All the four plates were incubated at 37 º C for 18-24 hours. Culture negative plates were re-incubated for 48 hours with daily checking before discarding. Small isolated colonies grown on blood and chocolate media were purified and cultivated by streaking on plain blood agar plates with regard of gas requirement, whereas large colonies were purified by the same method on available ordinary media such as nutrient or brain heart infusion agar to be further investigated [65, 66].

Preservation of Purified Isolates

Directly, after purification, over night culture broth at 37 º C for 18-24 hours was prepared for each stock cultures from purified isolates were made by cultivating bacteria in brain heart infusion broth and adding glycerol to obtain 20% as final concentration, then stored at - 20 º C [67, 68].

Identification methods

All the identification tests were done according to the conventional methods described by Cruickshank [69], Collee [70], Al-Jebouri and Al-Bayati [71,72].

Statistical Analyses

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics such as means, standard deviations, and frequency distributions were computed to summarize the data. A paired sample t test correlation coefficient (R) and coefficient of determination (R2) were calculated. [73-75].

RESULTS AND DISCUSSION

Distribution of Patients According to age Groups and Gender

Table 1 shows the distribution of refinery patients and the hospital ones according to age and sex. It is noted that the vast majority of patients among Baiji refinery workers were males and their number was 199 (99.5 %) in comparison with woman which was one only (0.5%). This possibly was due to the nature of dominant work and jobs that require muscular effort which is appropriate for men more than women at the refinery. In addition to the nature of the society in the country at large which is socially reserved. In contrast, in U.K. (48 %) of workers in the oil industries are women [76]. The patients of refinery ranged in age between 16-65 years old, whereas those of hospital ranged between 16-95 years old who had varied jobs and some were unemployed for various reasons. G2 group forms the largest proportion of the patients from the refinery which reached 35.5 % followed by G1 group (22 %). Both who are able to perform actions that require effort, whereas G8 group formed the least proportion (3 %). This might be due to the fact that these ages include those who are at the age of retirement from work. On the contrary, G1 group forms the largest proportion of patients from the hospital and has reached 31.5 % followed by G2 group (27.5 %). Except in G4 group, it was noticed that males formed a proportion larger than that of females at all groups of age (Figure 1). This is possible due to the fact that men in our society are with contact with the community more than women are and therefore more exposed to the infectious agents. In group G4, it was found that women constituted a proportion larger than that of men and this might be due to that this age group ranged between 46-55 years which represent the menopause in those women, are characterized by less resistance to infections [77-80].

Table 1: Distribution of patients according to age group and gender

Age groups	Range of age (years)	Refinery		Total No. (%)	Hospital		Total No. (%)
		Male No. (%)	Female No. (%)		Male No. (%)	Female No. (%)	
G1	16 - 25	44 (22%)	0 (0%)	44 (22%)	38 (19%)	25 (12.5%)	63 (31.5%)
G2	26 - 35	71 (35.5%)	0 (0%)	71 (35.5%)	34 (17%)	21 (10.5%)	55 (27.5%)
G3	36 - 45	50 (25%)	1 (0.5%)	51 (25.5%)	13 (6.5%)	9 (4.5%)	22 (11%)
G4	46 - 55	28 (14%)	0 (0%)	28 (14%)	10 (5%)	17 (8.5%)	27 (13.5%)
G5	56 - 65	6 (3%)	0 (0%)	6 (3%)	11 (5.5%)	7 (3.5%)	18 (9%)
G6	66 - 75	0 (0%)	0 (0%)	0 (0%)	6 (3%)	4 (2%)	10 (5%)
G7	76 - 85	0 (0%)	0 (0%)	0 (0%)	3 (1.5%)	1 (0.5%)	4 (2%)
G8	86 - 95	0 (0%)	0 (0%)	0 (0%)	1 (0.5%)	0 (0%)	1 (0.5%)
Total	16 - 95	199 (99.5%)	1 (0.5%)	200 (100%)	116 (58%)	84 (42%)	200 (100%)

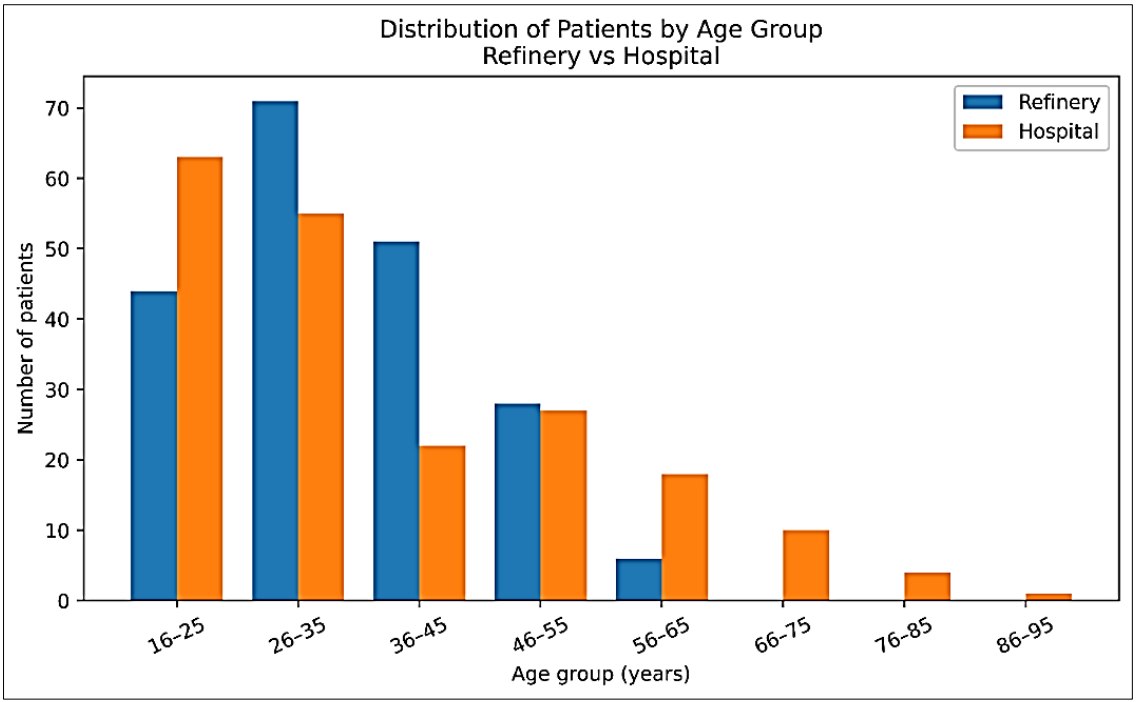


Figure 1: Distribution of patients according to age groups in the Refinery and Hospital populations

Distribution of Respiratory Infections According to the Duration of Employment

Table 2 shows the percentages of the respiratory infections distributed among patients working in Baiji oil refinery for different periods of exposure, regardless the nature of work and level of exposure, i.e where everyone works within the refinery environment. Air pollutants exert their effect by contact between the pollutant and the body, normally at the surface of exposed membranes. The extent of damage is related to the pollutant's physicochemical properties, its concentration, and the duration of exposure [16-85]. Based on the primary clinical diagnoses done at the medical centre of Baiji refinery, respiratory infections were divided into tonsillitis, bronchitis, pharyngitis, laryngitis, chest infection and sore throat. The statistical analysis showed significant differences among types of infections with periods of exposure ($P \leq 0.05$ using independent T- test, df= 41). In the current study it has been observed that the highest infection rates were among patients who did not exceed a period of 5 years of employment. Perhaps due to the fact that the group included newly recruited workers who had not yet adapt to pollutants exposure, followed by the groups (11-15) and (6-10) years of employment which were 20.5 % and 15 %, respectively. Periods of employment more than 16 years witnessed decreasing in infection rates and were so close between each other. It appears that the existence of a recovery period reduces rate of infection or this decrease might be due to that the workers have been exposed to many bacterial respiratory infections during the first years of employment, which led to acquiring immunity against reinfections later [86, 87]. Although, experimental and epidemiological data pertaining to pollutant effects in man are sparse but the effects of acute and chronic exposure to nitrogen dioxide, one of the largest air pollutants emitted by oil refinery, and for respiratory challenge with aerosols of *Klebsiella pneumoniae* in experimental animals had been tested by Ehrlich [81], who found that mortality rates increased 40% during acute exposure to the pollutant while exposure to low levels of pollutants over extended periods of time had approximately no distinct effect in animals. Also, Gray, *et al*., [88], exposed rats to 9 to 14 ppm for 4 hr per day, 5 days per week, for 6 weeks. They observed an inflammatory condition spread throughout the entire respiratory tract. According to the reports monthly issued by the unit of ecology in Baiji oil refinery for the last years, NO_2 reached extraordinary concentrations which exceed the limits permitted by World Health Organization [89]. Also, Huffman, *et al*., [90], presented the results of an investigation of the structure of PM from combustion of residual oil using a variety of analytical techniques. They revealed that the dominant molecular forms of S present were sulfate (26-84% of total S) and thiophene (13-39% of total S). Sulfate was greater in the $PM_{2.5}$ samples than in the >2.5 micron samples. This explains the spread of respiratory infections among the workers who did not exceed five years of exposure. It was noted from the table 6 that the predominant infection was tonsillitis (68.3%) in all periods of the present study followed by bronchitis (13.7%) except the period of exposure (21-25) years. Pönkä [91], found that the low levels of air pollutants like SO_2, NO_2 and the temperature were significantly correlated with increased frequency of acute tonsillitis and lower respiratory tract infection. Also, many gases like sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon dioxide, carbon monoxide, methane, dioxins, hydrogen fluoride, chlorine, benzene and others emitted by refineries can cause permanent

damage and increased respiratory diseases such as bronchitis. PM_{10} can be inhaled into the lungs where it can also cause bronchitis [92-96]. Chest infection and sore throat were also prevalent with the same frequency (14%) less than that of tonsillitis and bronchitis in all periods except the periods more than 20 which showed similar percentages in bronchitis and sore throat. Pharyngitis and laryngitis showed manifestations to a lesser extend (3.6%) and (1.3%), respectively, with periods of exposure less than 15 years (Figure 2). Oil refinery emits particulate matters with diameters of around 10 micron or less by burning of diesel fuels that remain suspended in air for extended period of time [97-100]. Particulate matter (PM) concentration directly correlates with a whole host of upper respiratory ailments to include tonsillitis, rhinitis, pharyngitis, laryngitis, as well as the common cold [101]. Refinery emissions contained several major ozone precursors. Therefore, ozone pollution became widespread as auto and industrial emissions have increased. Breathing ozone concentrations of 0.012 ppm levels is typical in many cities can irritate the respiratory tract and impair lung function, causing coughing, shortness of breath, and chest pain. Evidence also suggests ozone exposure lowers the body's defenses, increasing susceptibility to respiratory infections [102, 105]. He occurrence of acute lower respiratory infections is strongly associated with the risk of new adult-onset asthma. The link between respiratory infections and the development of asthma in adulthood has been proposed for many decades although it is still unclear how respiratory infections might induce asthma [106-110]. Age-related altered antigen presentation and decreased specific antibody responses may lead to subtle immune deficiencies that may allow respiratory infections to provoke injury to the airways [111-115].

Table 2.Distribution of Cases According to the Duration of Employment in Refinery.

Duration of employment (yr.)	No. (%) workers	No. (%) cases	Cases					
			Tonsillitis	Bronchitis	Pharyngitis	Laryngitis	Chest infection	Sore throat
≤ 5	106 (53%)	116 (53.2%)	79a (68.1%)	15a (12.9%)	3a (2.5%)	1a (0.8%)	9a (7.7%)	9a (7.7%)
6-10	30 (15%)	34 (15.5%)	25b (73.5%)	4c (11.7%)	1b (2.9%)	1a (2.9%)	1b (2.9%)	2b (5.8%)
11-15	41 (20.5%)	43 (19.7%)	27b (62.7%)	8b (18.6%)	4a (9.3%)	1a (2.3%)	2b (4.6%)	1b (2.3%)
16-20	9 (4.5%)	9 (4.1%)	6c (66.6%)	1d (11.1%)	-	-	2b (22.2%)	-
21-25	4 (2%)	4 (1.8%)	4cd (100%)	-	-	-	-	-
26-30	6 (3%)	7 (3.2%)	5cd (71.4)	1d (14.2%)	-	-	-	1b (14.2%)
31-35	4 (2%)	5 (2.2%)	3d (60%)	1d (20%)	-	-	-	1b (20%)
Total	200 (100%)	218 (100%)	149 (68.3%)	30 (13.7%)	8 (3.6%)	3 (1.3%)	14 (6.4%)	14 (6.4%)

Values in each column followed by similar letters are not significantly different.

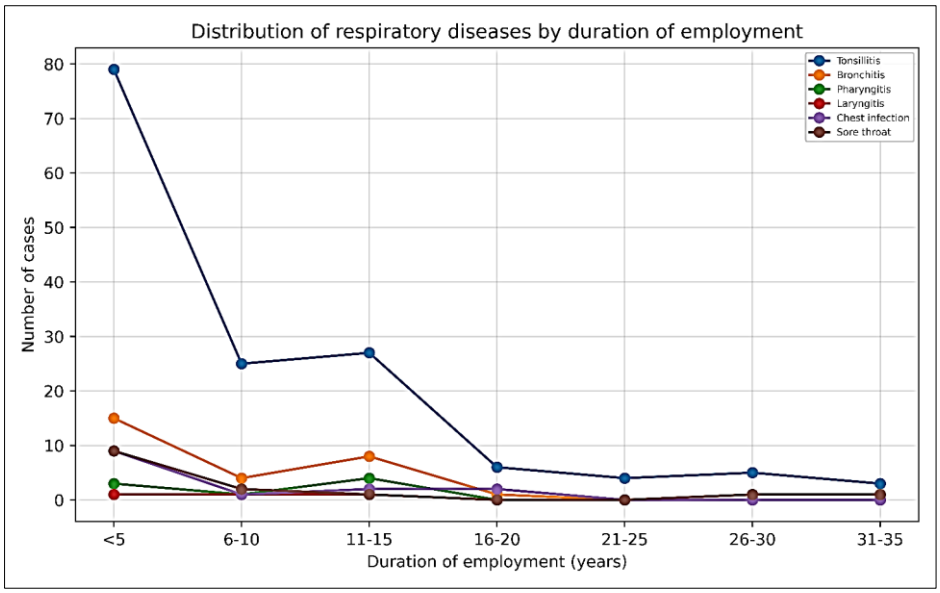


Figure 2: Distribution of Respiratory Diseases According to Duration of Employment in Refinery Workers

Comparison between Percentages of Respiratory Infections in Refinery and Hospital Cases

Table 3 shows the differences in percentages of respiratory infections between refinery and hospital. Statistical analysis showed that there was a high significant difference at $p < 0.01$ according to the degree of freedom equal to 11. The most frequent cases among patients of refinery were tonsillitis (68.3 %) followed by bronchitis (13.8 %) but the same diseases formed (18.2 %) and (8.0 %), respectively in patients of hospital. The other cases were higher in patients of hospital and they were pharyngitis (35.5%), chest infections (28.5 %), sore throat (8.0 %) and laryngitis (2.0%). In refinery the same cases revealed 3.7%, 6.4%, 6.4 % and 1.3%, respectively (Figure 3). The relationship between exposure to air pollutants and the resistance to respiratory infections had been investigated in many studies. One of those was done by Ehrlich [106]. The gaseous pollutants included in his study were ozone, NO_2, SO_2, various sulfates, nitrates, and oxides of some heavy metals. Results showed increased mortalities in experimental animals infected with *Streptococcus* with exposure to NO_2 and ozone and statistical significant increases ($p \leq 0.05$) in actual mortality were seen. Other study was carried by Klein-Petal, and his co-workers [107], proved that there was an association between poor ambient air quality and increased morbidity and mortality, including respiratory infections. They showed the effect of several air pollutants, such as particulate matters on one antimicrobial mechanism of host defense in the airway, β –defensin-2, tracheal antimicrobial peptide induction in response to lipopolysaccharide [107-110]. Also showed that low doses of residual oil fly ash, vanadium oxides and vanadium sulfates inhibit the ability of airway epithelial cells to respond to inflammatory stimuli and suggested that exposure to these agents could result in an impairment of defense against airborne pathogens [111-115].

Table 3: Comparison between percentages of respiratory infections in refinery and hospital cases.

Source of isolates	Diagnosis						Total
	Tonsillitis	Bronchitis	Pharyngitis	Laryngitis	Chest infection	Sore throat	
R	149 (68.3%)	30 (13.7 %)	8 (3.6 %)	3 (1.3 %)	14 (6.4%)	14 (6.4%)	218[a] (100%)
H	36 (18.2%)	16 (8.0%)	71 35.5%)	4 (2.0 %)	57 28.5%)	16 (8.0 %)	200[b] (100%)

a Number of refinery cases; b Number of hospital cases; R= isolates of refinery; H=isolates of hospital; $\chi 2$= 154.459; df= 11

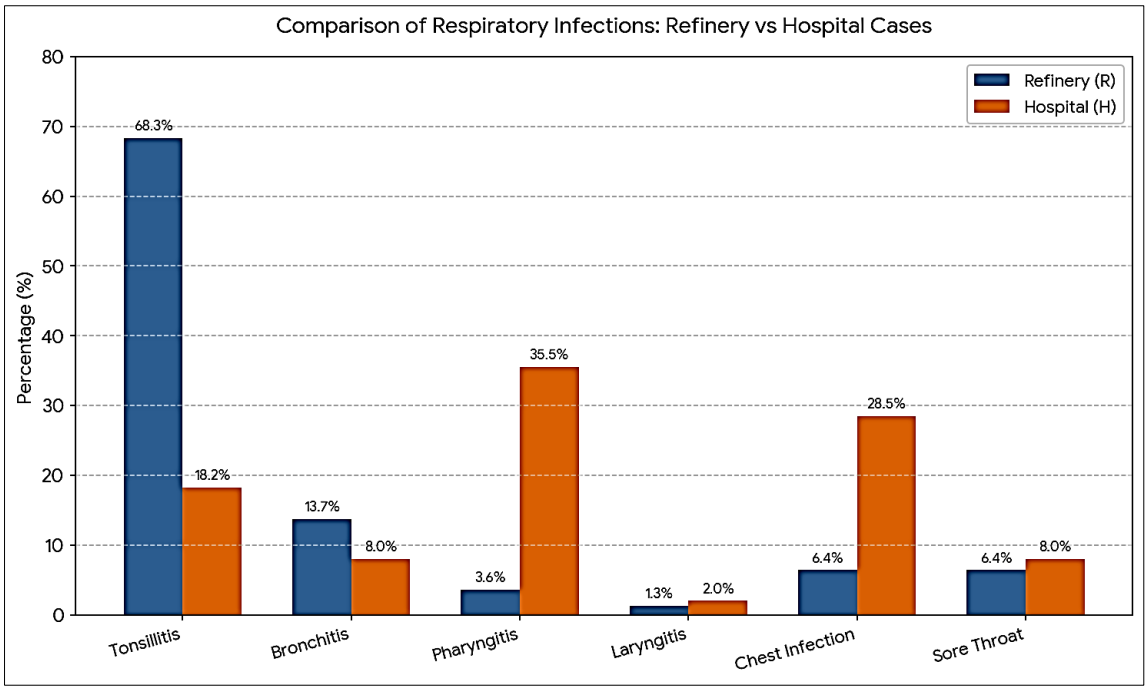


Figure 3: Comparison of respiratory infections as refinery vs hospital cases

CONCLUSIONS

It was noticed that males formed a proportion larger than that of females at all groups of age. In the current study it has been observed that the highest infection rates were among patients who did not exceed a period of 5 years of employment. Perhaps due to the fact that the group included newly recruited workers who had not yet adapt to pollutants exposure, followed by the groups (11-15) and (6-10) years of employment which were 20.5 % and 15 %, respectively. Periods of employment more than 16 years witnessed decreasing in infection rates and were so close between each other. The most frequent cases among patients of refinery were tonsillitis (68.3 %) followed by bronchitis (13.8 %) but the same diseases formed (18.2 %) and (8.0 %), respectively in patients of hospital. The other cases were higher in patients of hospital and they were pharyngitis (35.5%), chest infections (28.5 %), sore throat (8.0 %) and laryngitis (2.0%). In refinery the same cases revealed 3.7%, 6.4%, 6.4 % and 1.3%, respectively.

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Statement of Ethics

All the procedures involving human participation were conducted in strict accordance with ethical standards of Institutional Research Committee, Department of Scientific Research, Tikrit University as well as the 1964 Helsinki Declaration and its subsequent amendments or equivalent ethical norms.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest Statement: The author declares that he has no conflicts of interest, financial or otherwise.

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