



## A Statistical Analysis on the Incidence Rate of Lung Cancer in Karbala-Iraq during 2012-19

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### ABSTRACT

Cancer is one of the most deadly diseases that affect a large number of people across the globe. Iraq too has recorded a spike in cancerous patients with a high prevalence and mortality rate. Lung cancer is characterized by the uncontrolled growth of abnormal cells in one or both lungs. The current study is an epidemiological statistical approach that intends to investigate the incidence, prevalence, and growth of the lung cancer population in Iraq. The authors considered the data belonging to lung cancer patients in holy Karbala Governorate, Medical city of Imam Hussein (peace be upon him) during the period, 2012-2019. The data were classified according to age, gender, and region. The governorate is divided into several regions and the number of injuries for every region is further divided under gender and age classifications. Further, the incidence rate was determined for every region in the governorate. According to the results, the holy Karbala governorate had a total of 451 lung cancer patients during the study period at a rate of 30.68 cases per 100,000 populations. Out of the total cases, the male patients were 297 (66%) whereas the female patients were 154 (34%) and the ratio of male-to-female remained 1.9:1. The number of patients in the group aged 45 and more was higher compared to other age groups. There was an increase in the number of patients at the Center of Holy Karbala i.e., 245 patients (158 patients for male and 87 for female) while the Al-Jadawal Al Gharb reported the least number of patients (4 for male and 3 injuries for female). As per the study analysis, air pollution contributed to the increasing number of patients in the city. Though the radiation levels observed were well within the standard measurement range, one cannot conclude that radiation has no role in injury as per the studies conducted earlier.

**Keywords:** Lung cancer, Karbala Governorate, Incidence rate, Cancer in Iraq

### INTRODUCTION

Cancer has been established as a life-threatening disease and a great danger to humankind in recent decades. Though advanced technologies can be applied in the treatment of cancer, many types of cancer cannot be completely cured still. The role of specific risk factors that cause certain cancers remains unidentified, especially lung cancer. The burden of cancer across the globe has increased to 18.1 million cases and 9.6 million deaths in the year, 2018. One in 5 men and one in 6 women develop cancer worldwide during their lifetime and out of this, one in 8 men and one in 11 women die from the disease [1].

Several research works have been conducted so far to accurately measure the possible incidence of cancer (all types) in Basrah, Iraq [2-4]. These studies focused on age-specific incidence rates and intended to map the cases across different areas of the governorate. In the literature, the incidence rates of lung cancer in Lebanon were investigated from 2005 to 2015 and these rates were compared with other regions of the Middle East and North Africa (MENA) countries. In this study, Lung cancer data was collected from the National Cancer Registry of Lebanon and was stratified based on age and gender. Age-specific and age-standardized incidence rates were calculated [5]. A prospective epidemiological study was conducted through incidence, diagnosis, and treatment of lung cancer in northern Finland. The results were compared with the results obtained in a similar survey conducted two decades ago [6]. In the literature, the evidence on lung cancer epidemiology was reviewed [7]. This study included data with international scope and compared economic, social, and biologically-different patient groups. In industrialized nations, the evolving social and cultural

smoking patterns led to rising or plateauing rates of lung cancer among women. However, it lags behind the long-declining smoking and cancer incidence rates among men. In contrast, emerging economies vary widely in smoking practices and cancer incidence, but they also commonly harbor risks from environmental exposures, particularly widespread exposure to air pollution. In the study conducted earlier, risk analyses confessed that the factors such as smoking, air pollution, and occupational factors are all related to lung cancer [8]. Behavioral intervention, such as smoking cessation and screening, could effectively reduce lung cancer incidence and mortality. As per the authors, a higher incidence rate of lung cancer was recorded among young women than young men in the United States [9]. This study checked the incidence rate of lung cancer across the nation according to sex, race or ethnic group, age group (30-34, 35-39, 40-44, 45-49, and 50-54 years), year of birth (1945 to 1980), and calendar period of diagnosis (1995-1999, 2000-2004, 2005-2009, and 2010-2014). Based on the data, the authors calculated female-to-male incidence rate ratios. This study further examined the prevalence of cigarette smoking with the help of data sourced from the National Health Interview Survey conducted between 1970 and 2016.

The current study aims to analyze the incidence rates of lung cancer for a period of 8 years in Karbala city, Iraq from 2012 to 2019. Then, the number of cases reported should be compared with that of the MENA region countries and other areas. Followed by, possible risk factors behind lung cancer incidence in Karbala are discussed in detail. Karbala Governorate is divided into six regions based on its population statistics of 2019. The number of patients and their age category were determined in addition to their infection rate for every patient in the governorate. The research work is intended to find the reason behind the incidence of lung cancer.

## METHODS

Lung cancer is one of the five major incident malignancies, the injury caused by lung cancer results in deaths in Karbala and worldwide. In the treatment of lung cancer, one should ensure that the patient details are recorded properly to track the development of the disease so that its cause can be identified. The data regarding the number of patients, age, and gender were collected for the study (Table 1, and Table 2). The data regarding lung cancer patients reported from the hematology-oncology department of Imam Hussein (peace is upon him) Medical city, Holy Karbala Governorate, Iraq was collected for the period, 2012-2019. All the cases were diagnosed in the city and no cases were recorded outside the hospital. The data obtained was inclusive of all sub-regions in the governorate i.e., 111 neighborhoods. The area is managerially divided into six regions (Figure1). The population of any region in Karbala city depends on 2019 statistics.



Figure 1 Sketch map of Karbala Governorate-middle Iraq

**Table 1 Age-specific annual Incidence Rate (IR) (per 100,000) of lung cancer by gender: Karbala Governorate 2012-2019**

| Region              | Population | Cases | Age Groups | IR    |
|---------------------|------------|-------|------------|-------|
| Center of city      | 548620     | 245   | 20-90      | 44.65 |
| Al-Hur              | 247090     | 66    | 40-85      | 26.71 |
| Al-Husaniyah        | 157311     | 61    | 39-80      | 38.77 |
| Al-Hindiya          | 120626     | 51    | 42-80      | 42.27 |
| Al-Jadawal Al Gharb | 88716      | 7     | 54-73      | 7.89  |
| Al-Khurat           | 59216      | 10    | 49-75      | 16.88 |
| Ain Al-Tamur        | 29226      | 11    | 20-77      | 37.63 |
| Total               | 1250806    | 451   | 20-90      | 30.68 |

**Table 2 Cases of infection by gender and age groups for each area in the holy Karbala governorate 2012-2019**

| Region              | Female |            | Male  |            |
|---------------------|--------|------------|-------|------------|
|                     | Cases  | Age Groups | Cases | Age Groups |
| Center of city      | 87     | 20-90      | 158   | 40-86      |
| Al-Hur              | 19     | 40-75      | 47    | 40-85      |
| Al-Husaniyah        | 26     | 39-75      | 35    | 40-80      |
| Al-Hindiya          | 17     | 51-80      | 34    | 42-80      |
| Al-Jadawal Al Gharb | 0      | -          | 11    | 20-77      |
| Al-Khurat           | 2      | 60-71      | 8     | 49-75      |
| Ain Al-Tamur        | 3      | 54-73      | 4     | 58-64      |
| Total               | 154    | 20-90      | 297   | 20-86      |

## RESULTS

During the period 2012-2019, the total number of patients diagnosed with lung cancer was 451 cases who were from Karbala and they reported at the medical city of Imam Hussein (peace be upon him). Out of this population, 297 (66%) were males and 154 (34%) were females. The crude incidence rate of lung cancer was 30.68/100,000 which was directly proportional to their age in both genders. In this work, the authors found that the lung cancer incidence rate among males exceeded the female's rate and the ratio of male-to-female was 1.9:1. The center of the city reported the highest number of patients i.e., 245 while Al-Jadawal Al Gharb reported the least number of patients i.e., 7. Table 3 shows that the age group 45 and above i.e., 60-64, 65-69, and 70-74 reported the largest number of patients except Table 3 in which the cases got distributed among all age groups. Further, all the tables show that the number of male patients is higher than the female patients. The most common causes of lung cancer reported so far is exposure to ionizing radiation, air pollution, smoking, and waste of wars in Iraq. Researchers conducted different studies earlier to measure the concentration of uranium in Karbala city [10-12]. The results show that the ionizing radiation concentrations were less than the acceptable limit or the recommended range (3-10 mSv/y) (ICRP, 1993). However, this could not be inferred that there is no relationship between lung cancer and ionizing radiation. Air pollution also contributes towards the increased incidence rate of lung cancer. So, several researchers carried out research work to find out air pollution in the center of Karbala city [13,14]. The results inferred the high emission rate of hazardous gases and suspended particles such as O<sub>3</sub>, SO<sub>2</sub>, H<sub>2</sub>S, VOCS, TSP, CO, CO<sub>2</sub>, NO<sub>2</sub>, PM<sub>1</sub>, PM<sub>2.5</sub>, PM<sub>7</sub>, and PM<sub>10</sub>. Further, the study also recorded high concentrations of air pollutants in the center of Karbala. This also increased the incidence rate of lung cancer during the period, 2012-2019.

**Table 3 Number of lung cancer cases for regions in holy Karbala governorate during 2012-2019**

| Age group | City Center |      |       | Al-Hurr |      |       | Al-Husayniyah |      |       | Al-Hindiya |      |       | Ain al-Tamr |      |       | Al-Khairat |      |       | the Al-Jadawal Al gharb |      |       |
|-----------|-------------|------|-------|---------|------|-------|---------------|------|-------|------------|------|-------|-------------|------|-------|------------|------|-------|-------------------------|------|-------|
|           | Fe-male     | Male | Total | Fe-male | Male | Total | Fe-male       | Male | Total | Fe-male    | Male | Total | Fe-male     | Male | Total | Fe-male    | Male | Total | Fe-male                 | Male | Total |
| 20-24     | 1           | 0    | 1     | 0       | 0    | 0     | 0             | 0    | 0     | 0          | 0    | 0     | 0           | 0    | 0     | 0          | 0    | 0     | 0                       | 0    | 0     |

|       |    |     |     |    |    |    |    |    |    |    |    |    |    |    |    |   |   |    |   |   |
|-------|----|-----|-----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|---|---|
| 25-29 | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0  | 0 | 0 |
| 30-34 | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0  | 0 | 0 |
| 35-39 | 2  | 0   | 2   | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0  | 0 | 0 |
| 40-44 | 4  | 3   | 7   | 0  | 2  | 2  | 0  | 2  | 2  | 0  | 2  | 2  | 0  | 2  | 2  | 0 | 0 | 0  | 0 | 0 |
| 45-49 | 11 | 7   | 18  | 0  | 3  | 3  | 0  | 1  | 1  | 0  | 2  | 2  | 0  | 2  | 2  | 0 | 1 | 1  | 0 | 0 |
| 50-54 | 10 | 16  | 26  | 3  | 2  | 5  | 2  | 3  | 5  | 1  | 2  | 3  | 1  | 2  | 3  | 0 | 2 | 2  | 1 | 0 |
| 55-59 | 10 | 20  | 30  | 1  | 4  | 5  | 5  | 4  | 9  | 1  | 2  | 3  | 1  | 2  | 3  | 0 | 1 | 1  | 0 | 2 |
| 60-64 | 11 | 33  | 44  | 5  | 10 | 15 | 5  | 8  | 13 | 5  | 7  | 12 | 5  | 7  | 12 | 1 | 1 | 2  | 0 | 2 |
| 65-69 | 19 | 26  | 45  | 4  | 11 | 15 | 7  | 3  | 10 | 5  | 5  | 10 | 5  | 5  | 10 | 0 | 1 | 1  | 1 | 0 |
| 70-74 | 10 | 27  | 37  | 3  | 8  | 11 | 5  | 8  | 13 | 1  | 10 | 11 | 1  | 10 | 11 | 1 | 1 | 2  | 1 | 0 |
| 75-79 | 5  | 12  | 17  | 1  | 7  | 8  | 1  | 5  | 6  | 1  | 3  | 4  | 1  | 3  | 4  | 0 | 1 | 1  | 0 | 0 |
| 80-84 | 2  | 10  | 12  | 1  | 0  | 1  | 0  | 1  | 1  | 2  | 1  | 3  | 2  | 1  | 3  | 0 | 0 | 0  | 0 | 0 |
| 85-89 | 2  | 2   | 4   | 1  | 0  | 1  | 0  | 0  | 0  | 1  | 0  | 1  | 1  | 0  | 1  | 0 | 0 | 0  | 0 | 0 |
| 90<   | 0  | 2   | 2   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0  | 0 | 0 |
| Total | 87 | 158 | 245 | 19 | 47 | 66 | 26 | 35 | 61 | 17 | 34 | 51 | 17 | 34 | 51 | 2 | 8 | 10 | 3 | 4 |

Those persons who smoke during their earlier stages of life tend to develop lung cancer. On the contrary, those who quit smoking early reduce their risk of developing lung cancer compared to their counterparts. In Karbala city, the numbers of men who smoke are higher than the number of women due to the large number of men cafes. This explains the high prevalence of lung cancer among men than women.

Iraq experienced two devastating wars i.e., 1991 and 2003, during when Depleted Uranium (DU) was used [15]. As a consequence of radioactive contamination, human beings still suffer from different diseases like cancer, and environmental pollution is too high. For this reason, Al-Husaniyah and Al-Hur areas experienced a high incidence rate of lung cancer compared to other agricultural areas.

A study conducted earlier throughout Iraq listed the city of Karbala, a governorate in Iraq, in the first position in terms of disease prevalence (bronchial asthma, pneumonia, and bronchitis). Further, the region secured the fifth position for other diseases such as lung and pharyngeal cancer and pulmonary tuberculosis. The highest prevalence of the above-mentioned diseases was also recorded in districts and sub-districts of the Karbala governorate. The city center was first in terms of injuries, followed by Al-Hindiya district and Ain al-Tamr district respectively. The cause of pollution is the presence of pollution-causing industries inside the city of Karbala and the absence of effective control over them [16].

In Iraq, lung cancer is the second most common cancer and the most common among males. In the Basra-Iraq governorate, the number of injuries reached 746 (566 for males and 180 for females) during the period (2005-2012) and in Maysan governorate-Iraq, 119 cases (95 for males and 24 for females) were recorded during the period (2015-2016) [4,15,18,19]. The number of cases in this study was small when compared with other governorates such as Basra and Maysan, because of the waste of wars in the south of Iraq as shown in Table 4.

**Table 4 Lung cancer cases in some governorates of Iraq**

| Period  | Male | Female | Total | Governorates |
|---------|------|--------|-------|--------------|
| Basra   | 566  | 180    | 746   | 2005-2012    |
| Maysan  | 95   | 24     | 119   | 2015-2016    |
| Karbala | 297  | 154    | 451   | 2012-2019    |

**Calculations**

Incidence Rate (IR) (per 100,000)=(Cases/Population) × 100000

**Statistical Data Analysis**

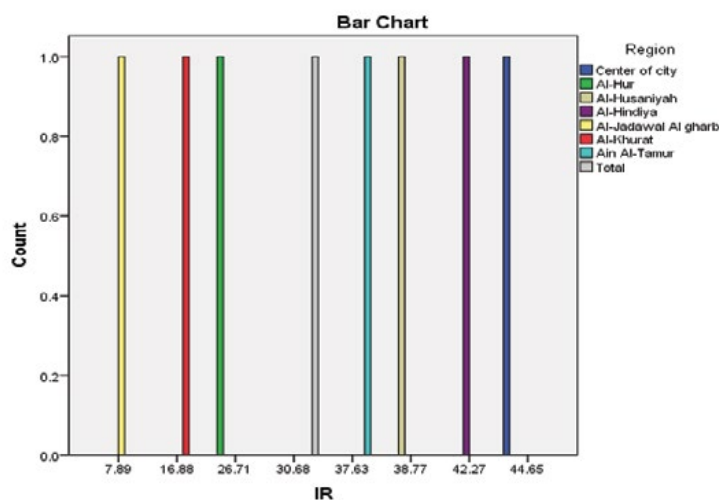
Statistical analysis was performed using Statistical Package for Social Science, version 20 (SPSS Inc., Chicago, IL, USA). A Chi-square test was used to compare qualitative categorical variables. To assess the inter-relationships between quantitative variables and the ranked ones, Spearman rank correlation was used. All the tests were two-sided whereas a p-value<0.05 was considered to be statistically significant (S). On the other end, a p-value ≥ of 0.05 was considered to be statistically non-significant (NS).

**RESULTS AND DISCUSSION**

During the period 2012-2019, the total number of confirmed lung cancer cases was 451 in Karbala which were reported at the medical city of Imam Hussein (peace be upon him). The crude Incidence Rate of lung cancer (IR) was 30.68/100,000. The center of the city had the highest number of patients (245) whereas Al-Jadawal Al Gharb has the least number of patients (7 patients). Table 5 and Figure 2 shows that there were no significant variations in IR among different regions of the Karbala governorate (p=0.229). This may be attributed to the low population in Al-Jadawal and Al Gharb compared to the center of the city.

**Table 5 Age-specific annual Incidence Rate (IR) (per 100,000) of lung cancer in Karbala Governorate between 2012 and 2019**

| Region              | Age Groups | Population | Cases | IR    | χ <sup>2</sup> | p-value    |
|---------------------|------------|------------|-------|-------|----------------|------------|
| Center of city      | 20-90      | 548620     | 245   | 44.65 | 56             | 0.229 (NS) |
| Al-Hur              | 40-85      | 247090     | 66    | 26.71 |                |            |
| Al-Husaniyah        | 39-80      | 157311     | 61    | 38.77 |                |            |
| Al-Hindiya          | 42-80      | 120626     | 51    | 42.27 |                |            |
| Al-Jadawal Al Gharb | 54-73      | 88716      | 7     | 7.89  |                |            |
| Al-Khurat           | 49-75      | 59216      | 10    | 16.88 |                |            |
| Ain Al-Tamur        | 20-77      | 29226      | 11    | 37.63 |                |            |
| Total               | 20-90      | 1250806    | 451   | 30.68 |                |            |

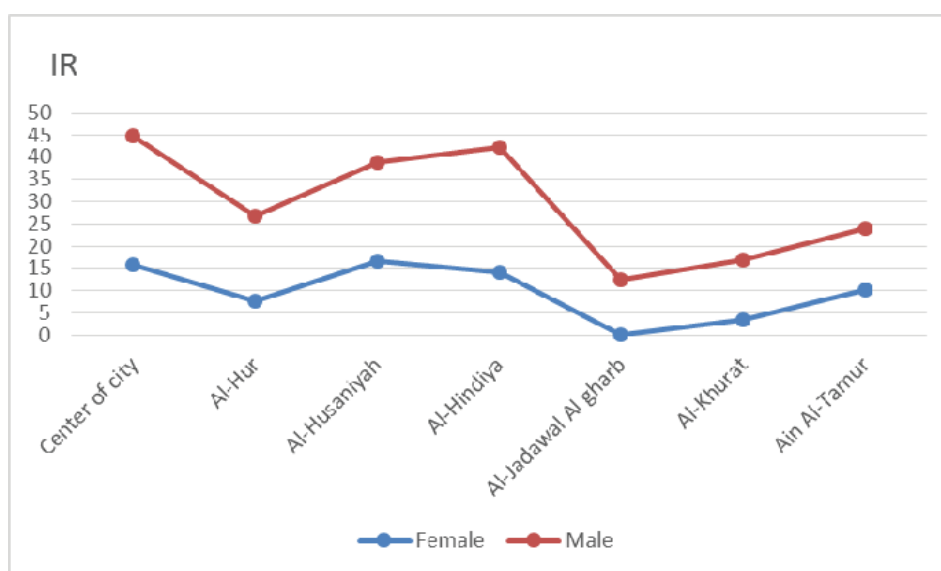


**Figure 2 Bar chart representing the annual Incidence Rate (IR) (per 100,000) of lung cancer in Karbala governorate and its regions between 2012 and 2019**

Out of the total number of lung cancer (451 cases) cases diagnosed in Karbala, 297 (66%) were males and 154 (34%) were females. IR is directly proportional to age as far as female is concerned i.e., (0.072) whereas it is inversely proportional in males (-0.405). In this work, lung cancer incidence among the males (23.74) exceeded the females (12.31) with the male-to-female ratio being (1.9:1) (Table 6, and Figure 3).

**Table 6 Gender and Age-group wise infection cases recorded in each area in Karbala governorate between 2012 and 2019**

| Region              | Female |       |            |                         | Male  |       |            |                         |
|---------------------|--------|-------|------------|-------------------------|-------|-------|------------|-------------------------|
|                     | Cases  | IR    | Age Groups | Correlation Coefficient | Cases | IR    | Age Groups | Correlation Coefficient |
| Center of city      | 87     | 15.86 | 20-90      | 0.072                   | 158   | 28.8  | 40-86      | -0.405                  |
| Al-Hur              | 19     | 7.69  | 40-75      |                         | 47    | 19.02 | 40-85      |                         |
| Al-Husaniyah        | 26     | 16.53 | 39-75      |                         | 35    | 22.25 | 40-80      |                         |
| Al-Hindiya          | 17     | 14.09 | 51-80      |                         | 34    | 28.19 | 42-80      |                         |
| Al-Jadawal Al Gharb | 0      | 0     | -          |                         | 11    | 12.4  | 20-77      |                         |
| Al-Khurat           | 2      | 3.38  | 60-71      |                         | 8     | 13.51 | 49-75      |                         |
| Ain Al-Tamur        | 3      | 10.26 | 54-73      |                         | 4     | 13.69 | 58-64      |                         |
| Total               | 154    | 12.31 | 20-90      |                         | 297   | 23.74 | 20-86      |                         |

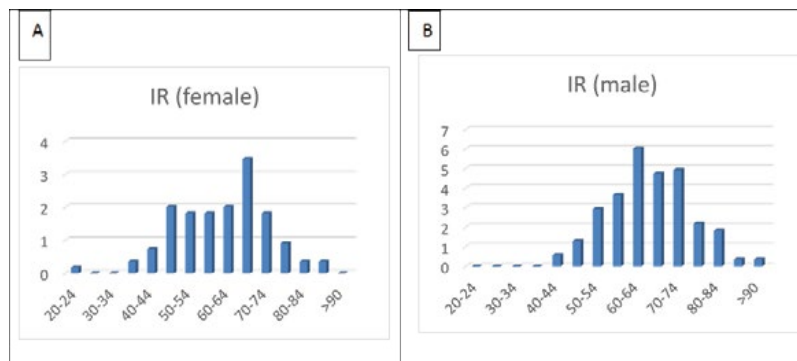


**Figure 3 IR by gender for each area in holy Karbala governorate between 2012 and 2019**

Tables 7-13 show that the age groups 60-64, 65-69, and 70-74 recorded the higher number of patients except Table 7 in which the cases were distributed across all the age groups. Further, the tables also show that the number of males was higher in all the age groups compared to females (Figures 4-10).

**Table 7** The number of lung cancer cases under each age group in the city center during the holy Karbala governorate between 2012 and 2019

| Age group | Female | Percent | IR    | Male | Percent | IR    | Total | IR    |
|-----------|--------|---------|-------|------|---------|-------|-------|-------|
| 20-24     | 1      | 100.00  | 0.18  | 0    | 0.00    | 0.00  | 1     | 0.18  |
| 25-29     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 30-34     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 35-39     | 2      | 100.00  | 0.36  | 0    | 0.00    | 0.00  | 2     | 0.36  |
| 40-44     | 4      | 57.14   | 0.73  | 3    | 42.86   | 0.55  | 7     | 1.28  |
| 45-49     | 11     | 61.11   | 2.01  | 7    | 38.89   | 1.28  | 18    | 3.28  |
| 50-54     | 10     | 38.46   | 1.82  | 16   | 61.54   | 2.92  | 26    | 4.74  |
| 55-59     | 10     | 33.33   | 1.82  | 20   | 66.67   | 3.65  | 30    | 5.47  |
| 60-64     | 11     | 25.00   | 2.01  | 33   | 75.00   | 6.02  | 44    | 8.02  |
| 65-69     | 19     | 42.22   | 3.46  | 26   | 57.78   | 4.74  | 45    | 8.20  |
| 70-74     | 10     | 27.03   | 1.82  | 27   | 72.97   | 4.92  | 37    | 6.74  |
| 75-79     | 5      | 29.41   | 0.91  | 12   | 70.59   | 2.19  | 17    | 3.10  |
| 80-84     | 2      | 16.67   | 0.36  | 10   | 83.33   | 1.82  | 12    | 2.19  |
| 85-89     | 2      | 50.00   | 0.36  | 2    | 50.00   | 0.36  | 4     | 0.73  |
| >90       | 0      | 0.00    | 0.00  | 2    | 100.00  | 0.36  | 2     | 0.36  |
| Total     | 87     | 35.51   | 15.86 | 158  | 64.49   | 28.80 | 245   | 44.66 |



**Figure 4** The number of lung cancer cases in the center of city, holy Karbala governorate during the period 2012-2019; A): in females; B): in males

**Table 8** The number of lung cancer cases for each age group in the Al-Hurr region in the holy Karbala governorate during the period 2012-2019

| Age group | Female | Percent | IR   | Male | Percent | IR    | Total | IR    |
|-----------|--------|---------|------|------|---------|-------|-------|-------|
| 20-24     | 0      | 0.00    | 0.00 | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 25-29     | 0      | 0.00    | 0.00 | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 30-34     | 0      | 0.00    | 0.00 | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 35-39     | 0      | 0.00    | 0.00 | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 40-44     | 0      | 0.00    | 0.00 | 2    | 100.00  | 0.81  | 2     | 0.81  |
| 45-49     | 0      | 0.00    | 0.00 | 3    | 100.00  | 1.21  | 3     | 1.21  |
| 50-54     | 3      | 60.00   | 1.21 | 2    | 40.00   | 0.81  | 5     | 2.02  |
| 55-59     | 1      | 20.00   | 0.40 | 4    | 80.00   | 1.62  | 5     | 2.02  |
| 60-64     | 5      | 33.33   | 2.02 | 10   | 66.67   | 4.05  | 15    | 6.07  |
| 65-69     | 4      | 26.67   | 1.62 | 11   | 73.33   | 4.45  | 15    | 6.07  |
| 70-74     | 3      | 27.27   | 1.21 | 8    | 72.73   | 3.24  | 11    | 4.45  |
| 75-79     | 1      | 12.50   | 0.40 | 7    | 87.50   | 2.83  | 8     | 3.24  |
| 80-84     | 1      | 100.00  | 0.40 | 0    | 0.00    | 0.00  | 1     | 0.40  |
| 85-89     | 1      | 100.00  | 0.40 | 0    | 0.00    | 0.00  | 1     | 0.40  |
| >90       | 0      | 0.00    | 0.00 | 0    | 0.00    | 0.00  | 0     | 0.00  |
| Total     | 19     | 28.79   | 7.69 | 47   | 71.21   | 19.02 | 66    | 26.71 |

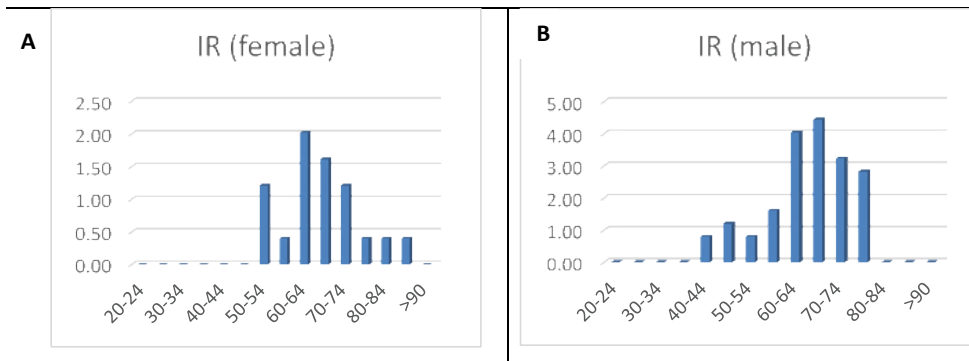


Figure 5 The number of lung cancer cases in Al-Hurr region in the holy Karbala governorate during the period 2012-2019; A): in females; B): in males

Table 9 The number of lung cancer cases for each age group in the Al-Husayniyah area in the holy Karbala governorate during the period 2012-2019

| Age group | Female | Percent | IR    | male | Percent | IR    | Total | IR    |
|-----------|--------|---------|-------|------|---------|-------|-------|-------|
| 20-24     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 25-29     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 30-34     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 35-39     | 1      | 100.00  | 0.40  | 0    | 0.00    | 0.00  | 1     | 0.40  |
| 40-44     | 0      | 0.00    | 0.00  | 2    | 100.00  | 0.81  | 2     | 0.81  |
| 45-49     | 0      | 0.00    | 0.00  | 1    | 100.00  | 0.40  | 1     | 0.40  |
| 50-54     | 2      | 40.00   | 0.81  | 3    | 60.00   | 1.21  | 5     | 2.02  |
| 55-59     | 5      | 55.56   | 2.02  | 4    | 44.44   | 1.62  | 9     | 3.64  |
| 60-64     | 5      | 38.46   | 2.02  | 8    | 61.54   | 3.24  | 13    | 5.26  |
| 65-69     | 7      | 70.00   | 2.83  | 3    | 30.00   | 1.21  | 10    | 4.05  |
| 70-74     | 5      | 38.46   | 2.02  | 8    | 61.54   | 3.24  | 13    | 5.26  |
| 75-79     | 1      | 16.67   | 0.40  | 5    | 83.33   | 2.02  | 6     | 2.43  |
| 80-84     | 0      | 0.00    | 0.00  | 1    | 100.00  | 0.40  | 1     | 0.40  |
| 85-89     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| >90       | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| Total     | 26     | 42.62   | 10.52 | 35   | 57.38   | 14.16 | 61    | 24.69 |

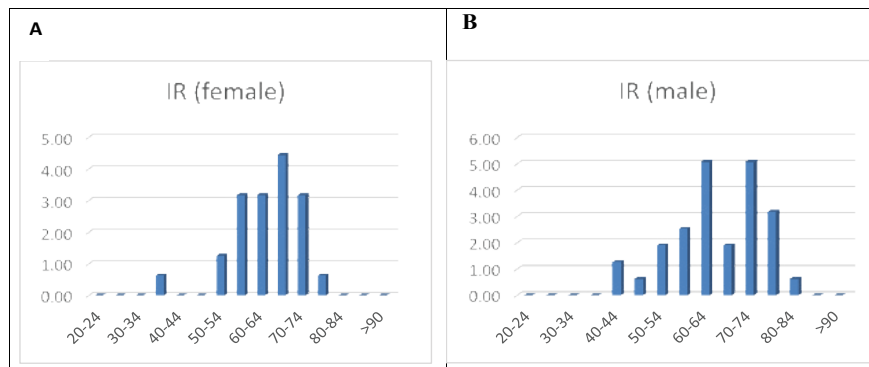
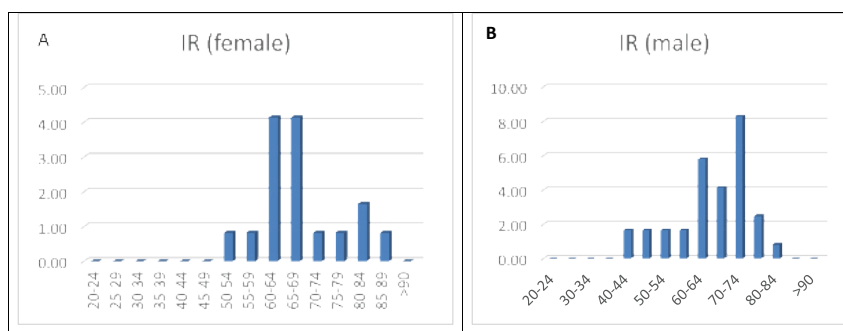


Figure 6 The number of lung cancer cases in Al-Hurr region in Al-Husayniyah governorate during the period 2012-2019; A): in females; B): in males



**Table 10** The number of lung cancer cases for each age group in Al-Hindiya area in holy Karbala governorate during the period 2012-2019

| Age group | Female | Percent | IR    | Male | Percent | IR    | Total | IR    |
|-----------|--------|---------|-------|------|---------|-------|-------|-------|
| 20-24     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 25-29     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 30-34     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 35-39     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 40-44     | 0      | 0.00    | 0.00  | 2    | 100.00  | 1.66  | 2     | 1.66  |
| 45-49     | 0      | 0.00    | 0.00  | 2    | 100.00  | 1.66  | 2     | 1.66  |
| 50-54     | 1      | 33.33   | 0.83  | 2    | 66.67   | 1.66  | 3     | 2.49  |
| 55-59     | 1      | 33.33   | 0.83  | 2    | 66.67   | 1.66  | 3     | 2.49  |
| 60-64     | 5      | 41.67   | 4.15  | 7    | 58.33   | 5.80  | 12    | 9.95  |
| 65-69     | 5      | 50.00   | 4.15  | 5    | 50.00   | 4.15  | 10    | 8.29  |
| 70-74     | 1      | 9.09    | 0.83  | 10   | 90.91   | 8.29  | 11    | 9.12  |
| 75-79     | 1      | 25.00   | 0.83  | 3    | 75.00   | 2.49  | 4     | 3.32  |
| 80-84     | 2      | 66.67   | 1.66  | 1    | 33.33   | 0.83  | 3     | 2.49  |
| 85-89     | 1      | 100.00  | 0.83  | 0    | 0.00    | 0.00  | 1     | 0.83  |
| >90       | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| Total     | 17     | 33.33   | 14.09 | 34   | 66.67   | 28.19 | 51    | 42.28 |



**Figure 7** The number of lung cancer cases in Al-Hindiya area in the holy Karbala governorate during the period 2012-2019; A): in females; B): in males

**Table 11** The number of lung cancer cases for each age group in the Ain al-Tamr area in the holy Karbala governorate for the period 2012-2019

| Age group | Female | Percent | IR    | Male | Percent | IR    | Total | IR    |
|-----------|--------|---------|-------|------|---------|-------|-------|-------|
| 20-24     | 0      | 0.00    | 0.00  | 1    | 0.00    | 0.00  | 1     | 0.00  |
| 25-29     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 30-34     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 35-39     | 0      | 100.00  | 0.64  | 0    | 0.00    | 0.00  | 0     | 0.64  |
| 40-44     | 0      | 0.00    | 0.00  | 0    | 100.00  | 1.27  | 0     | 1.27  |
| 45-49     | 0      | 0.00    | 0.00  | 2    | 100.00  | 0.64  | 2     | 0.64  |
| 50-54     | 0      | 40.00   | 1.27  | 2    | 60.00   | 1.91  | 2     | 3.18  |
| 55-59     | 0      | 55.56   | 3.18  | 0    | 44.44   | 2.54  | 3     | 5.72  |
| 60-64     | 0      | 38.46   | 3.18  | 2    | 61.54   | 5.09  | 12    | 8.26  |
| 65-69     | 0      | 70.00   | 4.45  | 0    | 30.00   | 1.91  | 10    | 6.36  |
| 70-74     | 0      | 38.46   | 3.18  | 2    | 61.54   | 5.09  | 11    | 8.26  |
| 75-79     | 0      | 16.67   | 0.64  | 1    | 83.33   | 3.18  | 4     | 3.81  |
| 80-84     | 0      | 0.00    | 0.00  | 1    | 100.00  | 0.64  | 3     | 0.64  |
| 85-89     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 1     | 0.00  |
| >90       | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| Total     | 0      | 42.62   | 16.53 | 11   | 57.38   | 22.25 | 11    | 38.78 |

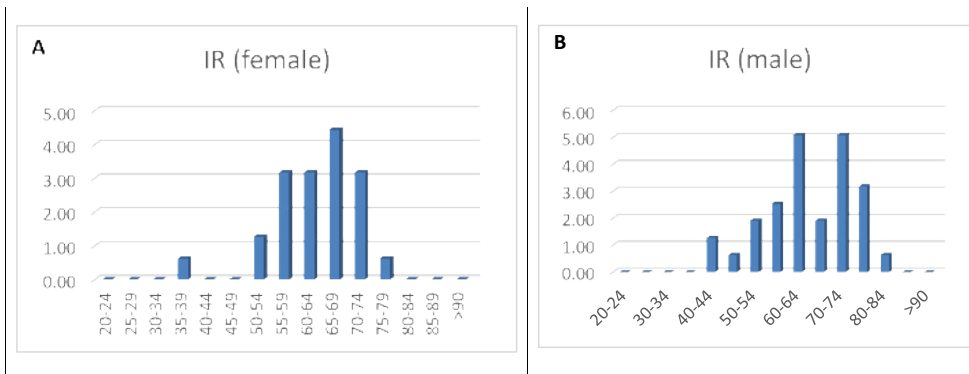


Figure 8 The number of lung cancer cases in Ain al-Tamr in the holy Karbala governorate during the period 2012-2019; A): in females; B): in males

Table 12 The number of lung cancer cases for each age group in the Al-Khurat area in the holy Karbala governorate during the period 2012-2019

| Age group | Female | Percent | IR    | Male | Percent | IR    | Total | IR     |
|-----------|--------|---------|-------|------|---------|-------|-------|--------|
| 20-24     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00   |
| 25-29     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00   |
| 30-34     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00   |
| 35-39     | 0      | 100.00  | 1.69  | 0    | 0.00    | 0.00  | 0     | 1.69   |
| 40-44     | 0      | 0.00    | 0.00  | 0    | 100.00  | 3.38  | 0     | 3.38   |
| 45-49     | 0      | 0.00    | 0.00  | 1    | 100.00  | 1.69  | 1     | 1.69   |
| 50-54     | 0      | 40.00   | 3.38  | 2    | 60.00   | 5.07  | 2     | 8.44   |
| 55-59     | 0      | 55.56   | 8.44  | 1    | 44.44   | 6.75  | 1     | 15.20  |
| 60-64     | 1      | 38.46   | 8.44  | 1    | 61.54   | 13.51 | 2     | 21.95  |
| 65-69     | 0      | 70.00   | 11.82 | 1    | 30.00   | 5.07  | 1     | 16.89  |
| 70-74     | 1      | 38.46   | 8.44  | 1    | 61.54   | 13.51 | 2     | 21.95  |
| 75-79     | 0      | 16.67   | 1.69  | 1    | 83.33   | 8.44  | 1     | 10.13  |
| 80-84     | 0      | 0.00    | 0.00  | 0    | 100.00  | 1.69  | 0     | 1.69   |
| 85-89     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00   |
| >90       | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00   |
| Total     | 2      | 42.62   | 43.91 | 8    | 57.38   | 59.11 | 10    | 103.01 |

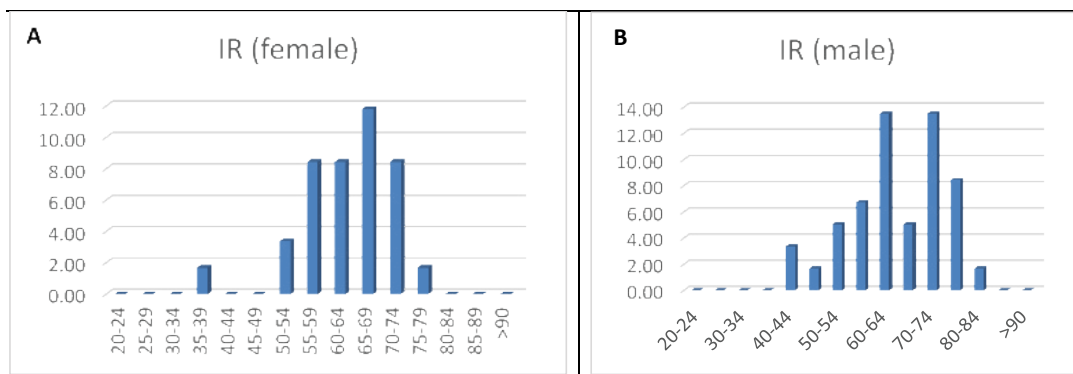
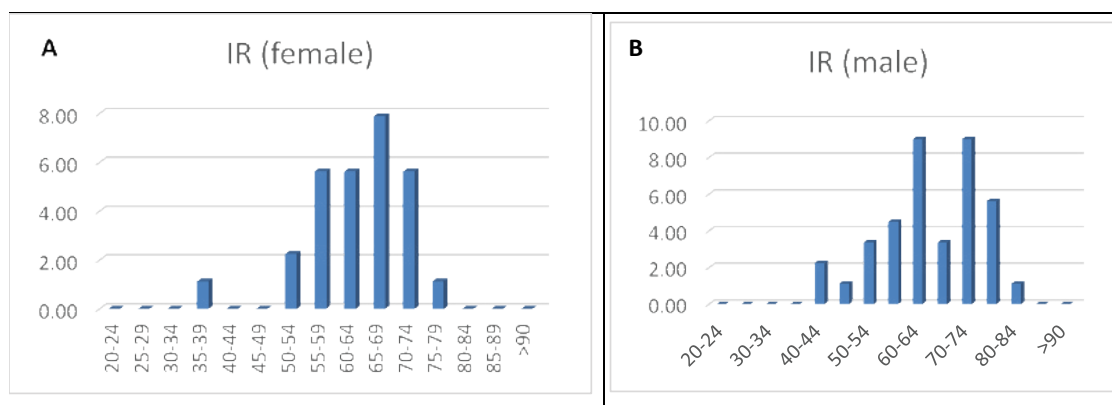


Figure 9 The number of lung cancer cases in Al-Khurat in the holy Karbala governorate during the period 2012-2019; A): in females; B): in males

**Table 13** The number of lung cancer cases for each age group in the Al-Jadawal Al Gharb area in the holy Karbala governorate during the period 2012-2019

| Age group | Female | Percent | IR    | Male | Percent | IR    | Total | IR    |
|-----------|--------|---------|-------|------|---------|-------|-------|-------|
| 20-24     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 25-29     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 30-34     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| 35-39     | 0      | 100.00  | 1.13  | 0    | 0.00    | 0.00  | 0     | 1.13  |
| 40-44     | 0      | 0.00    | 0.00  | 0    | 100.00  | 2.25  | 0     | 2.25  |
| 45-49     | 0      | 0.00    | 0.00  | 0    | 100.00  | 1.13  | 0     | 1.13  |
| 50-54     | 1      | 40.00   | 2.25  | 0    | 60.00   | 3.38  | 1     | 5.64  |
| 55-59     | 0      | 55.56   | 5.64  | 2    | 44.44   | 4.51  | 2     | 10.14 |
| 60-64     | 0      | 38.46   | 5.64  | 2    | 61.54   | 9.02  | 2     | 14.65 |
| 65-69     | 1      | 70.00   | 7.89  | 0    | 30.00   | 3.38  | 1     | 11.27 |
| 70-74     | 1      | 38.46   | 5.64  | 0    | 61.54   | 9.02  | 1     | 14.65 |
| 75-79     | 0      | 16.67   | 1.13  | 0    | 83.33   | 5.64  | 0     | 6.76  |
| 80-84     | 0      | 0.00    | 0.00  | 0    | 100.00  | 1.13  | 0     | 1.13  |
| 85-89     | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| >90       | 0      | 0.00    | 0.00  | 0    | 0.00    | 0.00  | 0     | 0.00  |
| Total     | 3      | 42.62   | 29.31 | 4    | 57.38   | 39.45 | 7     | 68.76 |

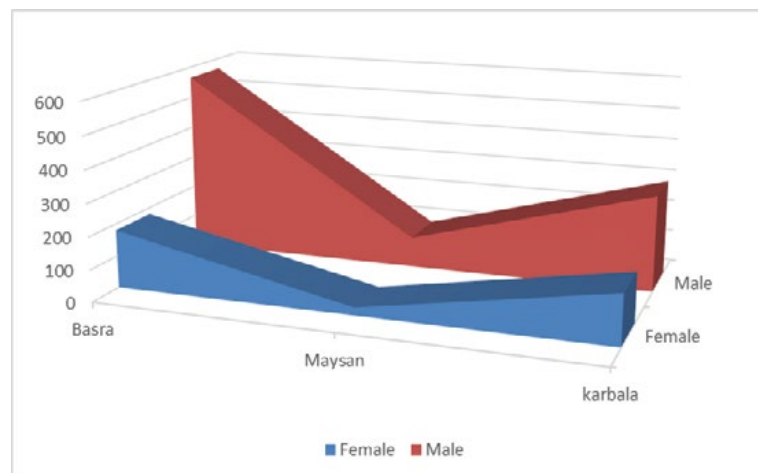


**Figure 10** The number of lung cancer cases in Al-Jadawal Al Gharb in the holy Karbala governorate during the period 2012-2019; A): in females; B): in males

In Iraq, lung cancer is the second most common cancer and the most common among males. In the Basra-Iraq governorate, the number of injuries reached 746 (566 for males and 180 for females) while the ratio was 3.17: 1 between 2005 and 2012. In Maysan governorate, Iraq, a total of 119 cases (95 for males and 24 for females) was reported at a ratio of 4:1 during the period, 2015-2016 (Table 14, and Figure 11).

**Table 14** Cases of lung cancer in some governorates of Iraq

| Governorates | Male | Percent | Female | Percent | Total | The period |
|--------------|------|---------|--------|---------|-------|------------|
| Basra        | 566  | 75.87   | 180    | 24.12   | 746   | 2005-2012  |
| Maysan       | 95   | 79.83   | 24     | 20.17   | 119   | 2015-2016  |
| karbala      | 297  | 65.85   | 154    | 34.15   | 451   | 2012-2019  |



**Figure 11 Cases of lung cancer in some governorates of Iraq**

### CONCLUSION

Cancer data with regards to its incidence and prevalence are highly important for lung cancer management. The incidence rate of lung cancer in the center of the holy Karbala governorate was recorded to be higher than in other areas. Further, the incidence of lung cancer among males was higher compared to females. Most of the cases reported with lung cancer were in the age groups of 60-64, 65-69, and 70-74. Air pollution and the waste of wars in Iraq created a heavy impact upon the citizens of Iraq. However, the number of lung cancer patients reported in Karbala city was found to be less than the other governorates such as Basra and Maysan.

According to a study conducted earlier, 88% of air pollution was recorded in Karbala. In this scenario, there is no waste recycling plant exist in Karbala. Further, the governorate has 18% garbage disposal, 16% greenery, and parks with 2.5 PM of particulate matter. So, Karbala has been cited as one of the polluted cities (85) with unhealthy living conditions.

Air pollution in Karbala governorate can be attributed to different reasons one of which is a huge number of generators in almost all the districts of Karbala, especially in the center of the city. This is because there occur frequent power outages for long periods and safety conditions are not observed. Further, the number of cars that ply in the city center and the corresponding traffic congestion to increases the air pollution, especially in the city center and Al-Hindiya district. The other reasons cited for this chaos are as follows; Presence of heavy pollution-creating industries in or around the center of the city; loss of health awareness among its citizens; indifference and lack of green spaces; bulldozing of orchards due to increasing population; and finally inhalation of strong detergents by the women. The cleaning materials are imported from multiple global sources and are not subjected to any supervision or quality control. Most of the age groups reported heavy smoking in recent years and the imported cigarettes are not subjected to health control restrictions when they enter Iraq. Most of the hospitals in Karbala lack modern technology, and there is no specialized hospital existent to treat cancer until now.

Based on the study findings, the government policymakers and the local officials are suggested to incorporate stringent policies that reduce pollution in this governorate. The arrival of pollution-causing goods from any country must undergo necessary quality check arrangements at entry and exit points of the country. The health department must create awareness about the increasing incidence of lung cancer in this region and bring necessary precautionary methods, primary, secondary, and tertiary treatment protocols, and healthcare facilities in the governorate. Further, the policies must be implemented and followed to curb the growth of this deadly cancer in this region.

### DECLARATIONS

#### Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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