Evaluation of effects of climatic factors on acute myeloid leukemia at Hiwa Hospital Sulaymaniyah-Iraq

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Abstract:

Recent studies have suggested seasonal variation in the diagnosis of acute myeloid leukemias (AML). Some studies have proposed that seasonal factors may play a role in etiology of this group of hematological neoplasms, but the exact association to atmospheric elements is still not clearly understood. Here, we prospectively evaluated potential seasonality of AML diagnosis among adults and children whose place of settlement was Sulaymaniyah city. Cases included in this study, were diagnosed over five years from 2019-2023 and admitted to Hiwa Hospital which is a tertiary hematology-oncology care unit in that city. Climatic elements for all the respective seasons were obtained for the years of the study from Sulaymaniyah Metrological and Earthquake Center. Pearson correlation and multiple regression analysis were used to detect possible seasonal variation. Seasons of peak diagnoses were Spring followed by Autmn. Our data showed some variation between males and females, males were more affected than females. Among the various age groups, age between 18-63 are more affected. According to the statistical analysis, climatic variables had 26.3% effects on the disease, especially sun shine, temperature and wind speed which have a positive correlation. Conversely, negative effects were found between humidity and precipitation with the disease.

Key words:

Seasons, climatic variables, acute myeloid leukemia, immunity.

Introduction

Leukemia is a neoplastic process of blood cells that is characterized by the production of abnormal leukocytes, which can be either a primary or secondary process. The process is derived from cells with failure of differentiation, and immortal proliferation. This neoplastic process can be acute or chronic based on the rapidity of cell proliferation and as myeloid or lymphoid based on the cell of origin. The predominant subtypes include acute myeloid leukemia (AML) and chronic myeloid leukemia (CML), involving the myeloid lineage, and acute lymphoblastic leukemia (ALL) and chronic lymphocytic leukemia (CLL), involving the lymphoid lineage. Acute Myelogenous Leukemia (AML) is characterized by more than 20% myeloid blasts. Here, we selected this sort of disease because it is relatively common as it accounts for 17% of all leukemias in adults in Sulaymaniyah province (Karim, Z.A.,2016, pp. 244-245) and it is the most aggressive type of leukemia, with a variable prognosis (Karunarathna, I., 2024,no page).

To reach the results, we followed the subsequent scientific steps:

1. Research problems

A. Do climatic elements have effects on occurrence of acute myeloid leukemia? If yes, to which extent does it influence the rate of occurrence of this blood disorder?
B. Is there any association between temporal changes in climatic variables and incidence of this disease?
C. What direction of relationship exists between variable climatic elements and the occurrence of the neoplasm?

2. Research hypothesis:

The research hypotheses are:

A. In general, all-weather elements together have effects on the rate of diagnosis of this type of leukemia, and the extent of this impact reaches up to 25%.
B. Temporal changes of weather affect the number of spotted patients. Differences of climatic factors from season to season shapes the prevalence of the disease.
C. All elements of weather have positive correlation with the number of identified patients except for rate of humidity and precipitation.

3. Aims and objects:

In this study, we relied on various measures of weather conditions to examine their relations to the number of cases who have the disease. Aiming at comprehensive analysis for the link and degree of the effectiveness of each weather element, taking the high incidence of the disease in to accounts in an important city of Sulaymaniyah.

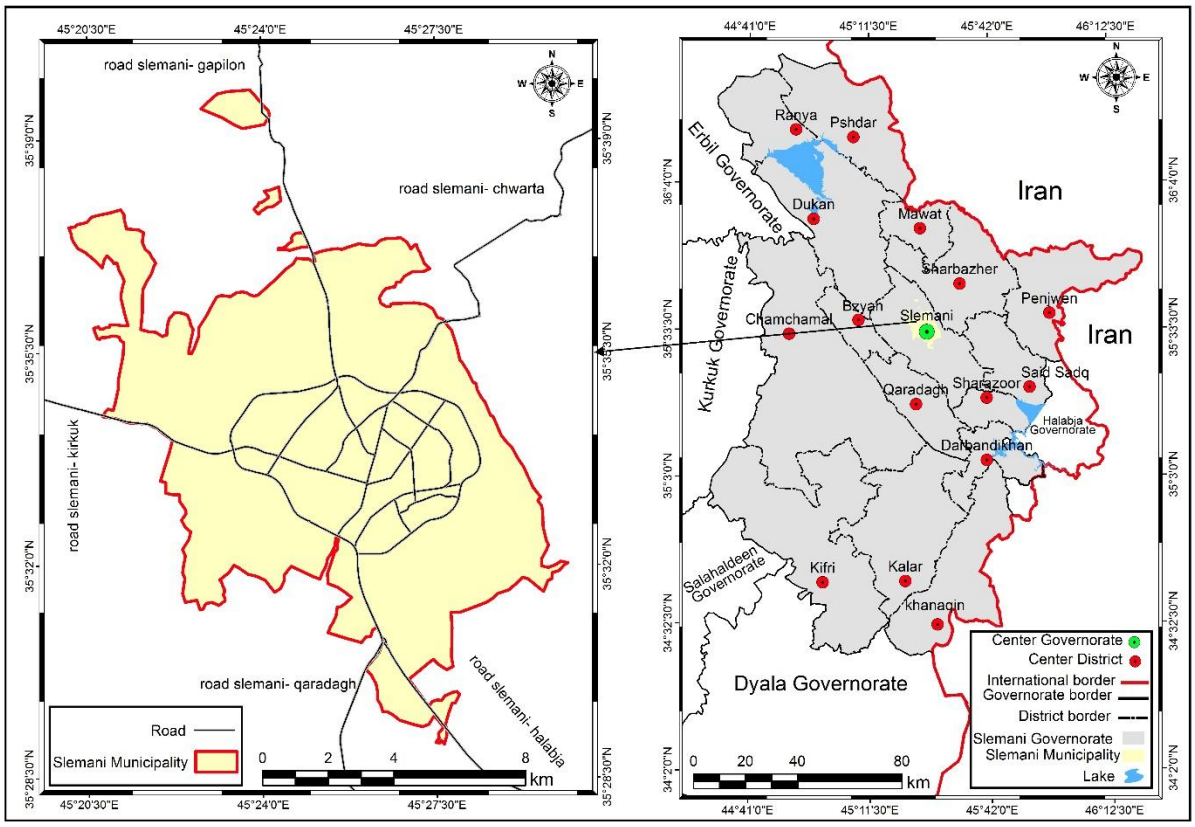
4. Methodology:

In this paper, descriptive analysis was used to explain the association between climatic condition and the disease. For such purpose, prospectively collected patients' data from Hiwa Hospital, over a span of five calendar years between 2019 -2023 inclusive and retrospective data of sunshine hours, maximum, minimum and average temperature as well as wind speed, relative humidity and precipitation, obtained from Sulaymaniyah Climate and Earthquake Center were used.

Quantitative analytic method based on Pearson correlation co-efficient was used to clarify the association between climatic factors and the number of cases. Moreover, the degree of effectiveness of the weather elements was found using statical program SPSS-26.

5. Study area:

Sulaymaniyah city is the administrative center of Sulaymaniyah province located in the north east of Iraq. It is located between latitude 35°29'3"N-35°39'49"N and longitude 45°20'7"E - 45°30'9"E (map1). The total area of the city is 113.95 km^2. The time period data was from 2019-2023.



Map 1. Sulaimani Statistical Directorate., 2024. Geographical Position of Sulaimani City. GIS Unit.

6. Results and discussion:

6-1: Elements of weather in the research area:

Here we summarized the weather of the research area as follows:

Actual sun shine: As in table 1, average sun shine duration changes with seasons, in spring average sun shine period from 2019-2023 equals to 7.2 hr per day while in summer it reaches the highest levels averaging 10.7 hr/day (June being the highest 11.2 hr in length). Then in Autumn it reduces

to average of 7.4 hr and the lowest levels of appearance is 5hr/day in winter (January is the shortest 4.7hr/day; due to abundance of clouds in the area of our research).

Sunshine Duration (h/d)	Mar	Apr	May	Spring	Jun	Jul	Oug	Summer	Sep	Oct	Nov	Autumn	Dec	Jan	Feb	Winter	Avg
2019	4.6	6.3	9.3	**6.7**	11.0	11.0	10.0	**10.7**	7.3	7.2	6.1	**6.9**	4.7	4.6	5.3	4.8	**7.3**
2020	5.8	7.3	9.3	**7.5**	11.0	10.5	10.3	**10.6**	9.2	8.1	4.4	**7.2**	5.6	3.9	4.0	4.5	**7.5**
2021	5.8	8.0	9.8	**7.9**	11.2	11.0	10.4	**10.9**	10.1	8.0	5.9	**8.0**	4.4	5.6	6.1	5.4	**8.0**
2022	5.9	6.5	8.0	**6.8**	11.8	10.3	10.1	**10.7**	9.8	7.8	6.4	**8.0**	5.6	4.1	4.9	4.9	**7.6**
2023	5.9	7.4	8.7	**7.3**	10.8	11.2	9.8	**10.6**	10.0	6.7	4.5	**7.1**	5.3	5.2	6.3	5.6	**7.7**
Avg(2019-2023	**5.6**	**7.1**	**9.0**	**7.2**	**11.2**	**10.8**	**10.1**	**10.7**	**9.3**	**7.6**	**5.5**	**7.4**	**5.1**	**4.7**	**5.3**	**5.0**	**7.6**

Table 1. Average of sunshine duration (hr/day) in Sulaymaniyah station (Sulaymaniyah Metrological and Earthquake Center 2024).

Temperature:

As has been shown in table 2, average annual temperature from 2019-2023 is 17.2 C°, average maximum temperature 19.5 C° and the average minimum temperature is 14.9 C°. In Spring average temperature from 2019-2024 is 15 C°, the highest is 17.2 C° and the minimum temperature 12.9 C°. On Summer the temperature increases to an average of 28.7 C° due to longer appearance of sun shine and dry and continental tropical airmass (CT). This average goes down for each autumn and winter seasons to 19 and 6.1, respectively. This is due to cold air mass from the poles and reduced sunshine hours.

	Temp(c)	Mar	Apr	May	Spring	Jun	Jul	Oug	Summer	Sep	Oct	Nov	Autumn	Dec	Jan	Feb	Winter	Avg
2019	Max	14.2	19.3	30.3	**21.3**	37.8	39.2	40.8	**39.3**	35.5	28.8	19.8	**28.1**	14.0	11.5	13.0	**12.8**	25.4
	Min	6.2	10.2	18.4	**11.6**	25.6	25.7	27.4	**26.3**	22.0	17.2	9.7	**16.3**	6.4	2.7	4.3	**4.5**	14.7
	Avg	10.2	14.8	24.4	**16.4**	31.7	32.5	34.1	**32.8**	28.8	23.0	14.7	**22.2**	10.2	7.1	8.6	**8.6**	**20.0**
2020	Max	18.7	22.6	30.8	**24.0**	36.6	41.0	38.6	**38.8**	37.9	32.5	20.9	**30.4**	16.3	10.5	11.7	**12.9**	26.5
	Min	8.6	12.6	18.5	**13.2**	23.1	28.5	25.7	**25.8**	24.2	16.6	10.4	**17.1**	3.8	3.2	3.6	**3.5**	14.9
	Avg	13.6	17.6	24.6	**18.6**	29.8	34.7	32.2	**32.3**	31.1	24.5	15.7	**23.8**	10.1	6.9	7.7	**8.2**	**20.7**
2021	Max	20.2	29.4	35.4	**28.3**	40.0	43.2	43.0	**42.1**	36.1	28.5	20.2	**28.3**	14.9	15.3	17.5	**15.9**	28.6
	Min	7.7	13.9	20.3	**14.0**	22.6	27.4	26.6	**25.5**	21.0	16.6	9.8	**15.8**	5.7	2.7	4.6	**4.3**	14.9
	Avg	14.0	21.7	27.9	**21.2**	31.3	35.3	34.8	**33.8**	28.6	22.5	15.0	**22.0**	10.3	9.0	11.0	**10.1**	**21.8**
2022	Max	15.3	26.2	28.2	**23.2**	37.4	40.7	42.1	**40.1**	36.9	30.5	20.0	**29.1**	14.7	9.0	15.2	**13.0**	26.4
	Min	6.4	14.6	17.3	**12.8**	24.6	26.6	28.0	**26.4**	23.3	18.0	9.8	**17.0**	6.6	1.0	5.4	**4.3**	15.1
	Avg	10.9	20.4	22.8	**18.0**	31.0	33.7	35.1	**33.2**	30.1	24.3	14.9	**23.1**	10.7	5	10.3	**8.7**	**20.7**
2023	Max	19.0	22.7	29.5	**23.7**	35.9	40.5	40.9	**39.1**	36.5	27.7	20.1	**28.1**	16.4	11.6	12.5	**13.5**	26.1
	Min	9.8	11.6	17.4	**12.9**	22.9	27.3	27.8	**26.0**	23.2	16.2	10.7	**16.7**	6.9	3.7	2.8	**4.5**	15.0
	Avg	14.4	17.1	23.4	**18.3**	29.4	33.9	34.4	**32.6**	29.9	21.9	15.4	**22.4**	11.7	7.7	7.7	**9.0**	**20.6**
Avg(2019-2023)	Max	17.5	24.0	30.9	**24.1**	37.5	40.9	41.1	**39.9**	36.6	29.6	20.2	**28.8**	15.3	11.6	14.0	**13.6**	26.6
	Min	7.7	12.6	18.4	**12.9**	23.8	27.1	27.1	**26.0**	22.8	16.9	10.1	**16.6**	5.9	2.6	4.1	**4.2**	14.9
	Avg	12.6	18.3	24.6	**18.5**	30.7	34.0	34.1	**32.9**	29.7	23.3	15.1	**22.7**	10.6	7.1	9.1	**8.9**	**20.8**

Table 2. Temperature profile in Sulaymaniyah Station (Sulaymaniyah Metroogical and Earthquake Center 2024).

Wind speed:

As in table 3, average annual wind speed from 2019-2023 was 1.4 m/sec, in spring this average reaches 1.5m/sec and in summer with increase in temperature, it records the highest average of 1.8 m/sec. Then, the average speed reduces in both autumn and winter seasons, that record 1.2 m/sec and 1.1 m/sec, respectively.

Wind(m/s)	Mar	Apr	May	Spring	Jun	Jul	Oug	Summer	Sep	Oct	Nov	Autumn	Dec	Jan	Feb	Winter	Avg
2019	1.6	1.3	1.5	**1.5**	1.7	1.5	1.9	**1.7**	1.5	1.1	1.1	**1.2**	1.0	0.8	1.2	1.0	**1.3**
2020	1.7	1.4	1.7	**1.6**	1.5	2.0	2.4	**2.0**	1.5	1.4	0.9	**1.3**	0.6	1.5	1.0	1.0	**1.5**
2021	1.4	1.3	1.7	**1.5**	1.6	1.9	1.8	**1.8**	1.2	1.1	1.3	**1.2**	0.9	1.5	1.4	1.3	**1.4**
2022	1.5	1.6	1.9	**1.7**	1.8	2.2	1.6	**1.9**	1.4	1.2	0.8	**1.1**	1.1	0.9	1.2	1.1	**1.4**
2023	1.3	1.3	1.6	**1.4**	1.7	2.0	2.0	**1.9**	1.2	0.9	0.9	**1.0**	0.7	1.5	1.3	1.2	**1.4**
Avg(2019-2023	**1.5**	**1.4**	**1.7**	**1.5**	**1.7**	**1.9**	**1.9**	**1.8**	**1.4**	**1.1**	**1.0**	**1.2**	**0.9**	**1.2**	**1.2**	**1.1**	**1.4**

Table 3. Average of wind speed in Sulaymaniyah station (Sulaymaniyah Metroogical and Earthquake Center 2024).

Humidity rate:

During 2019-2023 average ratio of humidity in the research area was 48.4%. Generally, ratio of humidity increases with the start of autumn, and the highest average humidity recodes in winter reached 68.4%, especially in January (levels of humidity 71%) and in spring average of 53.1% and in summer the lowest level of 27.3% were recorded, table 4.

Humidity(%)	Mar	Apr	May	Spring	Jun	Jul	Oug	Summer	Sep	Oct	Nov	Autumn	Dec	Jan	Feb	Winter	Avg
2019	72.3	66.4	45.4	**61.4**	27.8	26.0	28.4	**27.4**	31.8	48.1	49.2	**43.1**	71.2	80.9	69.9	**74.0**	**51.5**
2020	63.6	59.5	39.7	**54.3**	28.1	24.5	27.1	**26.6**	27.9	33.6	67.1	**42.9**	70.4	73.8	70.1	**71.4**	**48.8**
2021	57.3	42.6	33.2	**44.3**	27.5	28.6	27.9	**28.0**	32.8	40.3	55.7	**42.9**	65.9	58.6	63.0	**62.5**	**44.4**
2022	59.4	43.5	41.8	**48.2**	28.3	24.7	23.9	**25.6**	29.8	42.8	62.1	**44.9**	65.5	78.9	64	**69.5**	**47.1**
2023	67.5	60.3	44.2	**57.3**	30.5	27.4	28.7	**28.9**	34.1	48.6	68.5	**50.4**	70.5	62.7	61.3	**64.8**	**50.4**
Avg(2019-2023	**64.0**	**54.5**	**40.9**	**53.1**	**28.4**	**26.2**	**27.2**	**27.3**	**31.3**	**42.7**	**60.5**	**44.8**	**68.7**	**71.0**	**65.6**	**68.4**	**48.4**

Table 4. Average of relative humidity in Sulaymaniyah station (Sulaymaniyah Metroogical and Earthquake Center 2024).

Precipitation:

Average annual precipitation in that period (2019-2023) was 653.8 mm. With reduction in temperature and increase of humidity ratio in autumn, precipitation started, in winter months due to higher effects of Mediterranean atmosphere and reduction in temperature, promotion of rain dropping and prevention of evaporation had occurred. This led to the maximum rain fall in winter that reached an average of 282.5 mm. (January 120.2 mm). In spring, the average rain fall was 261.6 mm, table 5.

Preception(mm)	Mar	Apr	May	Spring	Jun	Jul	Oug	Summer	Sep	Oct	Nov	Autumn	Dec	Jan	Feb	Winter	Total
2019	265.7	177.3	44.1	487.1	0	0	0	0	12.1	71.8	16.4	100.3	144.5	151.2	156.9	452.6	1040
2020	188	71.2	13.4	272.6	0	0	0	0	0	0	204.2	204.2	21.7	104.1	136.5	262.3	739.1
2021	10.7	4.2	0	14.9	0	0	0	0	0	18.5	17.2	35.7	72.1	71.4	30.4	173.9	224.5
2022	58.9	42.7	0	101.6	0	0	0	0	1.2	20.9	99.1	121.2	31.9	153.3	57.5	242.7	465.5
2023	250.5	145.1	50.5	446.1	0	0	0	0	0	9.3	78.9	88.2	59.1	127.3	59	245.4	779.7
Avg(2019-2023	154.8	88.1	21.6	264.5	0.0	0.0	0.0	0.0	0.0	24.1	83.2	109.9	65.9	121.5	88.1	275.4	649.8

Table 5. Sum of rainfall in Sulaymaniyah station (Sulaymaniyah Metroogical and Earthquake Center 2024).

Assessment of climatic factors on acute myeloid leukemia diagnosis:

Various studies have proposed seasonal and geographical clustering of acute myeloid leukemia and have suggested that environmental factors such as climatic conditions play role in causation of the disease appearance. In a study performed at Saudia Arabia, the peak month for the diagnosis of a subtype of this leukemia (acute promyelocytic leukemia) was January and November (Elghazaly, A., 2022, p.087).

In another study in the south of Iraq, acute promyelocytic leukemia occurred mostly in the winter (January, February) to the end of fall (especially in March) and decline of the disease occurred in summer and autumn (Mohammed, A.S., Ali, T.H. and Alwan, A.F., 2020. p.115).

In the present study, as illustrated in table 6 and 7, the total number of patients was 193 cases over the span of 5 years of the study. Variability in the number of presented patients from one year to another can be noted. 11.3% of the patients were registered in 2019; whilst, the highest recording rate was in 2022 that accounted for 30% of the total registries. Males were more affected than females, 58.5 % and 41.4%, respectively.

Seasons	Months	2019			2020			2021			2022			2023			Sum(2019-2023)		Sum of patients
		Male	Female	Sum	Male	Female	Sum	Male	Femal	Sum	Male	Female	Sum	Male	Female	Sum	Male	Female	(2019-2023)
Winter	Dec	1	1	2	3	0	3	1	0	1	1	1	2	1	0	1	7	2	9
	Jan	0	0	0	1	1	2	3	1	4	2	3	5	1	1	2	7	6	13
	Feb	1	1	2	0	4	4	2	1	3	1	2	3	2	2	4	6	10	16
	Sum	2	2	4	4	5	9	6	2	8	4	6	10	4	3	7	20	18	38
Spring	Mar	0	2	2	6	3	9	2	2	4	0	4	4	3	0	3	11	11	22
	Apr	3	1	4	1	2	3	0	1	1	3	0	3	2	0	2	9	4	13
	May	1	2	3	3	0	3	0	2	2	4	6	10	2	3	5	10	13	23
	Sum	4	5	9	10	5	15	2	5	7	7	10	17	7	3	10	30	28	58
Summer	Jun	4	0	4	0	1	1	0	0	0	5	0	5	2	4	6	11	5	16
	Jul	0	0	0	2	0	2	3	1	4	3	2	5	0	1	1	8	4	12
	Oug	0	0	0	0	0	0	1	1	2	2	4	6	4	2	6	7	7	14
	Sum	4	0	4	2	1	3	4	2	6	10	6	16	6	7	13	26	16	42
Autumn	Sep	1	0	1	0	0	0	5	3	8	3	3	6	2	1	3	11	7	18
	Oct	2	1	3	1	0	1	0	0	0	5	3	8	7	2	9	15	6	21
	Nov	1	0	1	1	0	0	0	3	3	1	0	1	8	2	10	11	5	16
	Sum	4	1	5	2	0	1	5	6	11	9	6	15	17	5	2	37	18	55

1. Table 6: Number of the patients according to the seasons(Kurdistan Regional Government- Council of Ministers/Ministry of Health – Sulaymaniyah General Directorate of Health/ Hiwa Hospital, unpublished data).

Years	Age			
	>18	18-63	<63	Sum
2019	1	18	3	22
2020	3	21	5	29
2021	5	19	8	32
2022	11	28	19	58
2023	10	30	12	52
Sum	30	116	47	193

Table 7: Number of patients according to the age groups(Kurdistan Regional Government- Council of Ministers/Ministry of Health – Sulaymaniyah General Directorate of Health/ Hiwa Hospital, unpublished data).

Differences in the age groups involvement were also observed, 60.1% of the patients were aged between 18-63 years. 24.3% were above age 63 and 15.5% were below 18. According to the seasons, this inconsistency can also be underscored, the peak incidence was in the two transitional seasons, 58

(30.05%) and 55(28.4%) of the patients were registered in spring and autumn, respectively. While in summer, it reached 21.7% and the least number of patients being registered was in winter which was equivalent to 19.6%. This may be linked to seasonality in human immunity, for example, in a study done in the Uk, it has been shown that immune cells such as neutrophil count showed significant negative associations with day length, (Wyse, C., O'Malley., 2021 p7). In the transition seasons, because of the intermediate weather conditions, social contacts may increase, particularly in spring periods where holidays are prominent, this led to more social contact and transmission of infectious agents and disturbance of immune function.

(Willem, L., 2012, p2). Neutrophils are myeloid cells that constitute 50–70 % of all white blood cells in the human circulation. Traditionally, neutrophils are viewed as the first line of defense against infections and as a major component of the inflammatory process. In addition, accumulating evidence suggest that neutrophils may also play a key role in multiple aspects of cancer biology (Sionov, R.V., 2015, p.125).

Moreover, in a study performed in the USA, it has been found that the risk of AML was increased in male and female smokers. The risk of AML due to cigarette even appeared slightly higher in men than women, especially in the ever smoker category (Fircanis, S., 2014.p.E125-E132).

Similarly, in our study we showed that males were more affected than females, and the maximum difference between the number of affected males and females occurred in autumn followed by summer season. This may be due to some behavioral habits of males such as smoking. As in nice weather conditions, there would be less indoor restrictions, which promote males to smoke more cigarettes outdoors, and this may contribute to the seasonal changes in cigarette-smoking behavior (Momperousse, D., 2007. p.69). It is well known that a number of toxic agents found in cigarette smoke, these include benzene, formaldehyde, polonium 210, arsenic, lead, and ammonia. Of which, benzene is probably the strongest carcinogen associated with leukemogenesis (Fircanis, S., 2014.p.E125-E132).

In the present study, statistical evaluation of the cumulative effects of all the climate elements including (sunshine hours, maximum temperature, minimum temperature, average temperature, wind speed, humidity, and precipitation) on this disease using multiple regression analysis showed effects equivalent to 26.3%, according to the following formula:

$$Y=4.942+0.035(x1)-0.030(x2)-0.021(x3)+0.005(x4)+0.017(x5)-0.047(x6)+0.013(x7)$$

X1=sunshine, x2=Max Temperature, x3= Min Temperature, x4= Average Temperature, X5= Wind speed, x6= Humidity, x7= Precipitation.

Pearson correlation co-efficient revealed positive associations between (sun shine, maximum temperature, minimum temperature, average temperature and wind speed) and the number of patients. But there was negative correlation between humidity, and precipitation and the number of the affected cases (as in table 8)

Climate factors	Pearson correlation
Sunshine	0.097
Max Temperature	0.144
Min Temperature	0.162
Average Temperature	0.153
Wind speed	0.099
Humidity	-0.107
Precipitation	-0.089

Table 8: correlation between climatic elements and the disease (based on the all the tables shown earlier and SPSS-26

Conclusions:

In this study, we found that climate variables have effects on the disease, these effects differ from season to season and with changing climate elements from season to season. Over the 5 years of the study, 193 patients were studied. Variability in the number of presented patients from one year to another was found, with 2022 being the year when highest rate of patients was recorded. At the seasonal level, the peak incidence was in spring that accounted for 30.05% and lowest incidence was in winter 19.6%. Similarly, we found gender difference, males were more affected than females. Besides, adults were more affected than other age groups.

According to the statistical analysis, climatic variables had 26.3% effects on the disease, especially sun shine, temperature and wind speed which have a positive correlation. Conversely, negative effects were found between humidity and precipitation with the disease.

References:

1.Elghazaly, A., 2022. Geographical variation of acute Promyelocytic leukemia: a single center study from Saudi Arabia. *Int J Blood Res Disord*, *9*.

2.Fircanis, S., Merriam, P., Khan, N. and Castillo, J.J., 2014. The relation between cigarette smoking and risk of acute myeloid leukemia: An updated meta-analysis of epidemiological studies. *American journal of hematology*, *89*(8).

3.Karim, Z.A., Khidhir, K.G., Ahmed, R.A., Hassan, H.A. and Karim, D.O., 2016. Leukemia study in sulaymaniyah province, Kurdistan, Iraq. *Chinese medical journal*, *129*(02).

4.Karunarathna, I., De Alvis, K., Gunasena, P. and Jayawardana, A., 2024. Leukemia: Classification, risk factors, and diagnostic challenges.

5. Mohammed, A.S., Ali, T.H. and Alwan, A.F., 2020. Seasonality in acute promyelocytic leukemia: Fact or myth?. *Iraqi Journal of Hematology*, *9*(2).

6.Momperousse, D., Delnevo, C.D. and Lewis, M.J., 2007. Exploring the seasonality of cigarette-smoking behaviour. *Tobacco Control*, *16*(1).

7.Sionov, R.V., Fridlender, Z.G. and Granot, Z., 2015. The multifaceted roles neutrophils play in the tumor microenvironment. *Cancer microenvironment*, *8*.

8.Willem, L., Van Kerckhove, K., Chao, D.L., Hens, N. and Beutels, P., 2012. A nice day for an infection? Weather conditions and social contact patterns relevant to influenza transmission. *PloS one*, *7*(11).

9.Wyse, C., O'Malley, G., Coogan, A.N., McConkey, S. and Smith, D.J., 2021. Seasonal and daytime variation in multiple immune parameters in humans: Evidence from 329,261 participants of the UK Biobank cohort. *Iscience*, *24*(4).

Kurdistan Regional Government Institutions:

2. Kurdistan Regional Government- Council of Ministers/Ministry of Planning/ Kurdistan Region Statistics,2023(unpublished data).
3. Kurdistan Regional Government- Council of Ministers/Ministry of transportation and communication, Sulaimany Directorate of Meterology and Seismology,2023(unpublished data).

4. Kurdistan Regional Government- Council of Ministers/Ministry of Health – Sulaymaniyah General Directorate of Health/ Hiwa Hospital, unpublished data.

-Usage of statistical program SPSS-26, and Geographic Information System.

ملخص البحث

أظهرت الدراسات الحديثة أن هناك تباينًا موسميًا في تشخيص اللوكيميا النقوية الحادة (AML) . اقترحت بعض الدراسات أن العوامل الموسمية قد تلعب دورًا في أسباب هذه المجموعة من الأورام الدموية، لكن العلاقة الدقيقة مع العناصر المناخية لا تزال غير مفهومة بشكل واضح. قمنا في هذه الدراسة بتقييم موسمية محتملة لتشخيص اللوكيميا النقوية الحادة بين البالغين والأطفال الذين كانوا يقيمون في مدينة السليمانية. تم تشخيص الحالات المشمولة في هذه الدراسة خلال خمس سنوات من 2019-2023 مما تم تسجيلها في مستشفى هيوا للأمراض السرطانية، وهو وحدة رعاية متخصصة في أمراض الدم والأورام في تلك المدينة. وقد تم الحصول على البيانات المناخية لجميع المواسم المعنية خلال سنوات الدراسة من مركز السليمانية للأرصاد الجوية والزلازل. تم استخدام تحليل ارتباط بيرسون والتحليل الانحداري المتعدد للكشف عن التباين الموسمي المحتمل. كانت مواسم ذروة التشخيصات هي الربيع، يليه الخريف. وقد أظهرت البيانات بعض التباين بين الذكور والإناث، حيث كان تأثر الذكور أكثر من تأثر الإناث. وبين الفئات العمرية المختلفة، كانت الفئة العمرية بين 18-63 سنة أكثر تأثرًا. وفقًا للتحليل الإحصائي، كانت المتغيرات المناخية لها تأثير بنسبة 26.3% على المرض، وبخاصة أشعة الشمس ودرجة الحرارة وسرعة الرياح التي كانت لها علاقة إيجابية. وعلى الند، تم العثور على تأثيرات سلبية بين المرض وكل من الرطوبة وتساقط المطر.

كلمات المفاتح:

الفصول، المغيرات المناخية، سرطان الدم، المناعة