

Incidence, Prevalence and Associated Risk Factors for Leukemia and Lymphoma Occurrence in Iran: A Systematic Review and Meta-analysis

Aghilallah Keykhosravi¹, Mahbobeh Neamatshahi^{2*}, Elham Navipour³, Zahra Barabadi⁴, Mohammad Neamatshahi⁵

¹ Department of Pediatrics, Faculty of Medicine, Sabzevar University of Medical Sciences, Sabzevar, Iran

² Department of Community Medicine, Faculty of Medicine, Research Center Social Determinants Health, Sabzevar University of Medical Sciences, Sabzevar, Iran

³ Department of community Medicine, Faculty of Medicine, Sabzevar University of Medical Sciences, Sabzevar, Iran

⁴ Department of Tissue Engineering, School of Medicine, Hamadan University of Medical Sciences, Hamadan, Iran

⁵ Department of Anesthesiology, Faculty of Medicine, Sabzevar University of Medical Sciences, Sabzevar, Iran

* **Corresponding Author:** Mahbobeh Neamatshahi, Department of Community Medicine, Faculty of Medicine, Research Center Social Determinants Health, Sabzevar University of Medical Sciences, Sabzevar, Iran. E-mail: mahneamatshahi@yahoo.com

Received September 2, 2020; Accepted October 18, 2020; Online Published June 5, 2021

Abstract

Background: Leukemia and lymphoma account for the leading cause of death worldwide and in Iran. Numerous studies have been conducted with various results in different regions of Iran. The largest study was conducted on 18,353 lymphoma cases in Iran during 2003-2008. The present study aimed to gather a higher level of evidence for an aggregated 1,478,583 cases of leukemia and lymphoma.

Objective: Risk factors and etiology of leukemia and lymphoma are variable in different parts of the country; therefore, identifying them is essential for prevention and better management.

Method: The present study is a systematic review and meta-analysis to indicate the risk factors and to estimate the incidence of leukemia and lymphoma in Iran. All databases, including PubMed, Scopus, Springer, Cochrane, Google Scholar, were searched between 1970 and 2016. Out of the 152 selected articles in the preliminary search, 15 articles were reviewed, and the results of 11 studies were finally combined using the random-effects meta-analysis approach. The meta-regression and I_2 statistic were used to assess the heterogeneity. Data analysis was performed using STATA 12 software.

Results: In addition to non-modifiable risk factors, modifiable risk factors are effective in the development of the disease. The incidence and overall prevalence of leukemia and lymphoma in Iran were estimated to be 3.26% (95% confidence interval: 2.7%-3.7%) and 7.15% (95% confidence intervals: 5.92%-8.37%), respectively.

Conclusion: It can be stated that there is an increasing rate of hematologic cancers in Iran. This increase may be due to enhanced reporting and the presence of modifiable risk factors.

Keywords: Epidemiology, Prevalence, Incidence, Leukemia, Lymphoma, Risk Factors

Introduction

Despite a lot of success in preventing and controlling infectious diseases in recent decades, the rate of chronic diseases is continuously growing.¹ Cancer is a leading cause of death worldwide, responsible for 9% of all deaths.^{2,3} This group of disease is known as the second cause of mortality in developed countries and the fourth in developing countries.⁴ Hematologic cancers are the most common type of all new cancer cases followed by the cancers of lymphatic glands, bone and joints, central nervous system (CNS), eyes, brain, kidneys and urinary tract, digestive system, skin, soft tissues, thyroid, endocrine glands,

respiratory system, lips, mouth and throat, breast, and male and female sex organs, respectively.⁵ Hematologic cancer affects all age groups and leads to a significant morbidity and mortality rate, so that its diagnosis and treatment impose a high financial burden on the patients, their families and the healthcare system.⁶

In Iran, cancers are the third most frequent cause of mortality after cardiovascular diseases and traffic accidents, accounting for 20% of deaths.⁷ There are many factors that influence individuals in different situations and age groups. Nowadays, we are

witnessing an increasing rate of non-communicable diseases, due to population ageing and lifestyle changing in different societies. Geographic distribution, race and lifestyle are factors which have ranked cancers as the third cause of death in Iran.^{8,9}

Although hematologic cancer in children accounts for less than 1% of deaths from cancer, it is still one of the main causes of mortality in children.^{10,11} Epidemiologic studies which investigate the prevalence and risk factors of cancer in Iran include cross-sectional, population-based and geographic-based studies. Data also come from the cancer registration statistics.^{12,13} The study of leukemia and lymphoma in various research works indicates the geographical diversity of risk factors in different provinces of the country. On the other hand, only a few studies have examined the risk factors of the disease, and the data collected from the Cancer Registry are limited to the type of cancer, incidence, sex and age, and less attention has been paid to subjects' life-style, education, job and socioeconomic status.

Objective: The aim of this research is to provide a study with a higher level of evidence and to investigate the risk factors that increase the incidence of leukemia and lymphoma.

Methods

Search strategy

The present study is a systematic review and meta-analysis on risk factors for the incidence and prevalence of leukemia and lymphoma in Iran, which was carried out through a review of literature and meta-analysis of available data. To find the studies conducted on this subject in the country, articles published in English language journals and local conferences, as well as the articles in the bibliographic databases, such as PubMed, Embase, Google Scholar, were been considered. Search was mainly done using the systematic search of Persian keywords and their English equivalents in accordance with their Medical Subject Headings (MeSH), with all the possible combinations of important, original and sensitive words. The keywords used in the search included epidemiology, prevalence, incidence, leukemia, lymphoma, and risk factors.

Definition of Reviewed Variables

In this study, original data about the incidence of leukemia and lymphoma in general, in men and women separately, and their prevalence were obtained from

studies carried out in Iran without time limitation.

Selection Criteria and Quality Assessment of Studies

First, we searched articles based on titles, followed by their abstract screening, so that non-related abstracts or repetitive titles were deleted. The full text of the related articles was extracted, and the quality assessment was done by two researchers independently based on the Critical Appraisal Skills Programme (CASP) checklist. The main inclusion criterion included articles which estimated the incidence and prevalence of leukemia and lymphoma in the Iranian population and mentioned to risk factors. In the first stage, 152 papers were selected based on the title, of which 49 were excluded as they did not meet the inclusion criteria. The full text of 15 articles was reviewed for risk factors, and then 11 articles entered the meta-analysis. Required information including corresponding author's name, publication time, type of study, sample size, demographic characteristics, risk factors and the indices and statistical tests results were extracted from the articles and sorted in a table by their publication time. Fifteen studies were evaluated for risk factors of leukemia and lymphoma. All the reviewed studies described the risk factors and none of them mentioned the odds ratio or relative risk. Five studies had been conducted on the incidence and six on prevalence.

The inclusion criteria were studies which discussed the risk factors for leukemia and lymphoma, the incidence and prevalence of leukemia (myeloid and lymphoma), lymphoma (Hodgkin and non-Hodgkin), without time limitation in general, and for men and women separately. The exclusion criteria included studies that reported a crude incidence, age-standardized studies, and works that did not include enough information, as well as poor-quality studies based on the CASP checklist. The CASP checklist has 11 parts; each part was given one point except some parts which were more important for the research team.

Data Extraction

In the next step, the full text of the articles was reviewed, and the papers were evaluated using the CASP checklist. Finally, data were extracted from the 11 selected papers and introduced into the STATA12 software.

In the preliminary search, 152 articles were found, of which 15 articles entered the final process based on the inclusion and exclusion criteria. Most studies

conducted in Iran had not directly examined the risk factors, so what the authors had reported as probable factors in different provinces was examined. Out of 15 studies, 11 studies had estimated the incidence and prevalence of leukemia and lymphoma, and all 15 were examined in terms of risk factors. Since the information about both incidence and prevalence was not available in all reviewed articles, the articles containing information about the incidence and/or prevalence were separately analyzed.

The extracted data included: corresponding author's name, province where the study was conducted, publication date, sample size under study, and study type. Some of the most important characteristics of the selected studies are listed in Table 1. In these 11 papers, there were 10 cross-sectional studies and one literature review.

Heterogeneity and Subgroup Analysis

For heterogeneity assessment, we used the accumulation graph method and Chi-square test. Because of the difference in incidence rates and the high heterogeneity index in studies (I_2), a random-effects model, and meta-regression was performed to examine the relationship between the incidence of leukemia and the year of the study.

Statistical Analysis

At first, the incidence and prevalence rates of leukemia and lymphoma in Iran were extracted from the selected studies. In case the confidence interval was not reported in a study, it was calculated. Heterogeneity

was calculated by the Cochran test and I_2 index. To calculate the incidence and prevalence rate, the inverse-variance method and the fixed model were used in the homogeneity, and DerSimonian-Laird random-effects method was carried out for those with heterogeneity. Because of the type of analyzed data (incidence and prevalence), and the evaluation of articles by quality control checklist, there was no need to determine the distribution bias and draw a funnel plot. Data analysis was done using the STATA 12 software and the "metan" command. In the heterogeneity test, P value less than 0.05 was considered statistically significant.

Results

In this systematic review and based on original results, among the 152 articles found in the initial search, the full text of 15 articles was reviewed for risk factors, and then 11 articles entered the meta-analysis. The article selection process is shown in Figure 1. Studies in Iran were carried out between 1970 and 2016. The aggregated sample size was 1,478,583 from 11 cross-sectional and literature review studies. Original results were collected from studies in different provinces (Tabriz, Ardebil, Sistan and Baluchestan, Mazandaran, Fars, Kerman, Mashhad, and Cancer Registry Center). All studies have been done on both sexes. Out of the total studies on leukemia or lymphoma in Iran, six studies reported incidence rates, and five reported prevalence (Figure 1).

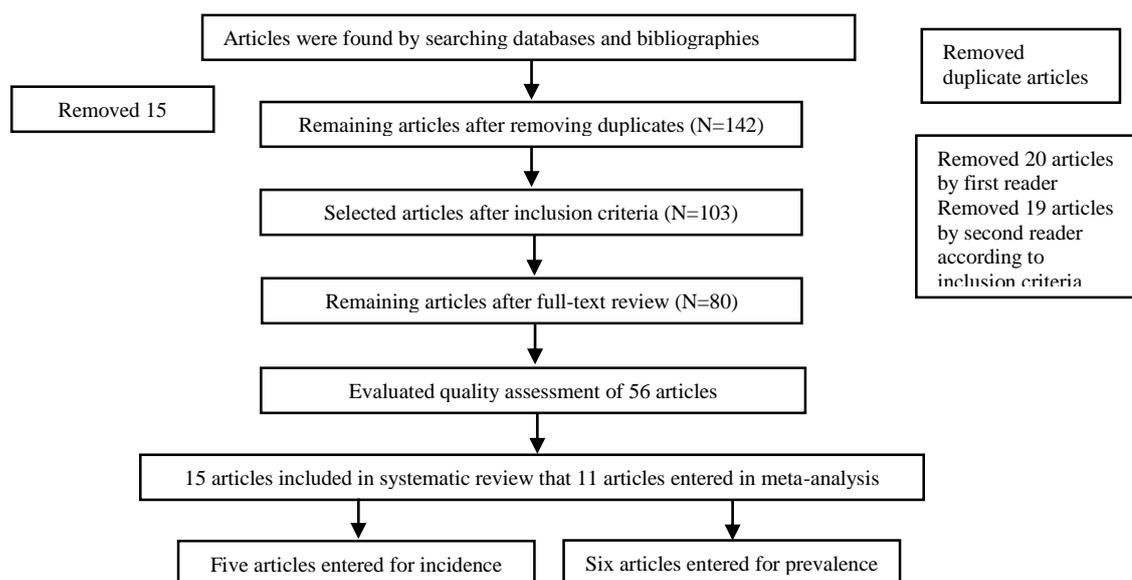


Figure 1. Flowchart of articles entry and selection process

Table 1. Characteristics of the articles entered the study

Corresponding author's name	Place	Time	Sample size	Incidence of leukemia and lymphoma	Sample size	Incidence in male population	Sample size	Incidence in women population	Prevalence of leukemia and lymphoma
Saeed Dastgiri	Tabriz	2011	334	3.7	377	4.34	292	3.50	-
Saeed Dastgiri	Ardebil	2011	335	4.9	-	-	-	-	-
Hamid Salehiniya	Sistan and Baluchestan Province	2015	3535	2.31	-	-	-	-	6.93
Hamid Salehiniya	Mazandaran Province	2007	10418	2.38	6509	1.55	3904	1.14	-
Bahram Tahmasebi	Mazandaran Province	2007	10418	3.53	6509	3.3	3904	0.8	-
Farzane Zolali	Fars Province	2005	1438030	2.26	737382	3.79	700648	2.71	-
Alireza Mosavi Jarrahi	Iran	2009	-	-	12488020	0.6	677469	0.22	-
Hamid Salehiniya	Southeast of Iran	2015	10595	-	-	-	-	-	7.05
Malekzadeh	Kerman	2007	5884	-	-	-	-	-	4.6
Malekzadeh	Kerman	2007	5884	-	-	-	-	-	5.8
Parviz Haghighi	Fars Province	1970	3295	-	-	-	-	-	5.03
Haleh Boroumand	Mashhad	2016	1764	-	-	-	-	-	10.30
National Report on Cancer Registration in 2008	Iran	2011	4393	-	-	-	-	-	10.64
Alireza khoshdel	Iran	2015	-	--	-	-	-	-	-
Azim mehrvar	iran	2015	-	-	-	-	-	-	-
Talaiezadeh abd	iran	2013	-	-	-	-	-	-	-
Salman khazaei	iran	2016	-	-	-	-	-	-	-
Hosein rafiemanesh	iran	2015	-	-	-	-	-	-	-

Risk Factors of Leukemia and Lymphoma

In the study of Fathi et al. they showed a direct relationship between the incidence of leukemia in northwest of Iran (Ardebil) with blood group, family history of cancer, taking medicine during pregnancy, father's job, history of radiation, smoking of parents, residence less than 500m from high pressure electric lines, and exposure to electromagnetic fields greater than 0.45 micro Tesla.¹⁴

In another study in the northwest of Iran (Tabriz), Dastgiri et al. also indicated that the incidence of leukemia among males was much higher than females. Age was also considered to be a factor in the incidence of leukemia, with the highest incidence occurring between the ages of 15-29 and over 60 years.¹⁵

Salehiniya et al. showed that the rate of leukemia in male cases was much higher than in females in the Sistan and Baluchestan province, like other common

cancers in that area.¹⁶ In the study by Tahmasebi et al. in Mazandaran Province in 2006, they reported that the highest incidence of leukemia and lymphoma was seen in men over the age of 70. Income, nutritional status, and environmental exposures, such as physical and chemical exposure, which are affected in some way by socioeconomic status, also contribute to the incidence of these two diseases.¹⁷

Mosavi-Jarrahi et al. indicated that the incidence of leukemia due to job-related exposures in the population of Tehran metropolitan area is very low, although males are at greater risk than females.¹⁸ In another study by Salehiniya et al. conducted in the southeast of Iran (Province of Kerman), the authors reported that leukemia among males is more widespread than among females. They discussed that smoking is one of the most important risk factors for leukemia, and one of the causes of the increased incidence of leukemia in

Kerman is the higher rate of smoking in that province. They mentioned also other reasons such as changes in lifestyle, and the increase of life expectancy.¹⁹

The incidence of leukemia and lymphoma were reported mostly for under the age of 25 and in both sexes, in the study by Sajadi et al. carried out in the province of Kerman in 2007.²⁰ In a work by Boroumand et al. in Mashhad in 2016, they concluded that the incidence of leukemia and lymphoma in Iran is increasing which may be due to the improvements of the cancer registry system, in addition to all the other risk factors.²¹

In the work by Khoshdel et al. in 2015, they summarized the main leukemia and lymphoma risk factors as follows: the exposure to chemicals such as benzene, pesticides, and insecticides, radiation, and weakened immune systems.² For a rare type of non-Hodgkin's lymphoma, they listed some specific infections including HTLV-1 that is transmitted through sexual and contaminated needles and syringes, as vertical transmission. Non-Hodgkin's lymphoma occurs in adults with an average age of 60 years.

Khazaei et al. in their assessment of geographical distribution of the incidence in Iran indicated the difference of incidence of leukemia and lymphoma in central and northwest regions (leukemia was less common in the central region than in the southwest). They argued that the difference is due to factors such as genetics, nutrition status, cultural context, and behavioral patterns.⁶

In the investigation conducted by Taleiezadeh et al. in the southwest of Iran, Khuzestan Province, in 2013, they reported a low incidence of lymphoma due to more exposure to sunlight and vitamin D sufficient. On

the other hand, occupational-related exposures were one of the risk factors for leukemia.²²

Out of 11 selected articles, the highest and lowest incidence rates were seen in Ardabil and Fars, with 4.9 and 2.26, respectively, and the highest and lowest prevalence was found in Mashhad and Kerman, 10.3 and 4.6 respectively, as presented in Table 1.

The Results of Meta-analysis on the Incidence of Leukemia and Lymphoma in Iran

Adequate information was obtained about the incidence rate with a sample size of 1,453,670 subjects from six studies. The selected studies had high heterogeneity, and this heterogeneity was confirmed by Q-Cochran test = 2140.64 and $I^2 = 99.8$. So, the random-effects model was used to combine the results extracted from the studies. According to this model, in five articles, the incidence of leukemia and lymphoma in Iran was 3.26% (95% confidence interval: 2.80%-3.73%) (Figure 2).

Meta-analysis Results of the Incidence of Leukemia and Lymphoma in Iranian Men and Women

Five articles had sufficient information on the incidence rate of these diseases in men and women separately, resulting in 13,238,757 males and 1,386,217 females entering the analysis. The high level of heterogeneity between the studies was confirmed by $I^2 = 100$. Combining the results was done using the random-effects model. According to this model, the incidence of leukemia and lymphoma in males and females in Iran was respectively 2.7% (95% CI: 1.34%-4.06%) (Figure 3-A) and 1.66% (95% CI: 0.46%-2.86%) (Figure 3-B). As shown in Figures 3-A and 3-B, the incidence of leukemia in Iranian males is higher than in females.

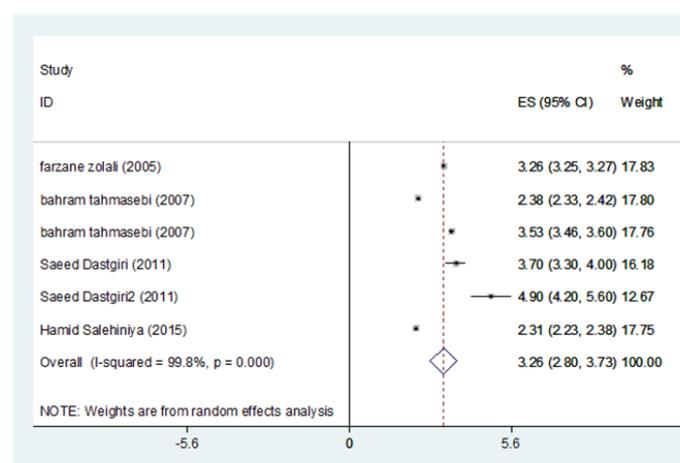


Figure 2. The incidence of leukemia in Iran and 95% confidence interval based on the random-effects model (The midpoint of each line segment shows the incidence rate of each study, and the diamond shape represents the total incidence rate of the country in all studies)



Figure 3. The incidence of leukemia in Iranian A: male and B: female population, according to studies and based on the random-effects model

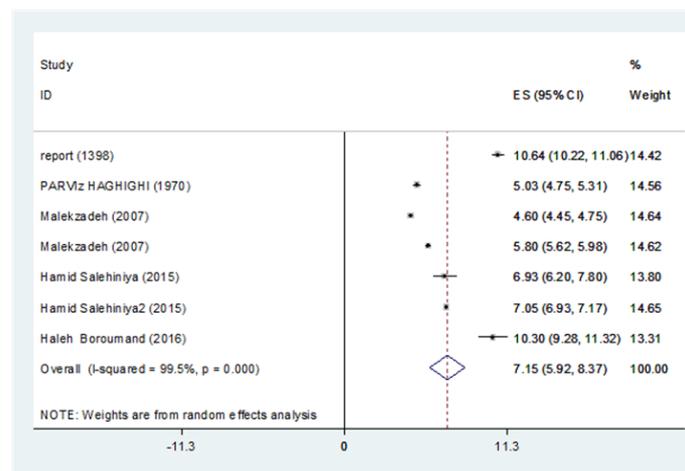


Figure 4. The prevalence of leukemia and lymphoma in Iran and 95% CI in the reviewed studies, based on the year and the area of study using a random-effects model (The midpoint of each line segment shows the prevalence rate while the segment length is 95% confidence interval, and the diamond shape represents the total prevalence rate of the country in all studies)

Meta-analysis Results of the Incidence of Leukemia and Lymphoma in Iranian Men and Women

Five articles had sufficient information on the incidence rate of these diseases in men and women separately, resulting in 13,238,757 males and 1,386,217 females entering the analysis. The high level of heterogeneity between the studies was confirmed by $I^2 = 100$. Combining the results was done using the random-effects model. According to this model, the incidence of leukemia and lymphoma in males and females in Iran was respectively 2.7% (95% CI: 1.34%- 4.06%) (Figure 3-A) and 1.66% (95% CI: 0.46%-2.86%) (Figure 3-B). As shown in Figures 3-A and 3-B, the incidence of leukemia in Iranian males is higher than in females.

The Results of Meta-analysis on the Prevalence of Leukemia and Lymphoma in Iran

Out of 11 studies, six had sufficient information on disease prevalence; therefore, 35,350 subjects entered the analysis. The selected studies had a high heterogeneity confirmed by Q-Cochran test = 1208.05 and $I^2 = 99.5$. So, the random-effects model was used to combine the results extracted from the studies. In the six reviewed articles, the leukemia and lymphoma prevalence in Iran was 7.15% (95% CI: 5.92%-8.37%) (Figure 4). As shown in Figure 4, the prevalence rate of leukemia in Iran has increased over time. The highest prevalence rate was in Mashhad, while the lowest was found in Kerman Province.

Discussion

In this systematic review and meta-analysis, the full text of articles were examined from various aspects, and 56 articles were evaluated for quality assessment.

Then, 15 papers entered the systematic review and meta-analysis.

In each of the 15 studies, several risk factors were identified, where each one affected the geographical distribution of leukemia and lymphoma. Numerous risk factors have been mentioned in studies conducted in other parts of the world. Adalberto Miranda-Filho in 2018 indicated that the geographical diversity of leukemia is due to gene-environment interactions.²³

Some studies in reported the father's occupation and smoking as factors associated with leukemia and lymphoma.

Hashemi et al in a case-control study performed on 86 children with leukemia or lymphoma and 188 healthy children showed that in comparison between two groups, the fathers' job in the case group was mostly farming (58.1%), painting and jobs exposed to hydrocarbons (16.6%). On the other hand, the use of cigarettes (43%), alcohol (5.8%) and addiction (18.6%) in the fathers of the case group was more than the control group and this relationship was statistically significant.²⁴ In a study of 1764 children, Hashemizadeh et al. reported that men were more likely to develop leukemia and lymphoma than women (33.1%, 23.2% respectively).²¹

Income, nutritional status, and environmental exposures, such as physical and chemical exposure (benzene (OR = 2.10) and vinyl chlorides (OR = 2.81), creosote and tanning solutions (ORs = 2.68-4.03) and socioeconomic status, smoking (RR = 1.40) and life style are other factors probably affecting the incidence of leukemia and lymphoma.^{25,26}

Our studied population was of both sexes. Out of 11 articles that entered the estimation analysis of incidence and overall prevalence, 10 articles were analytic-descriptive and one article was literature review. Eleven studies evaluated the incidence or prevalence of hematologic cancer. Based on population-based studies, the hematologic cancers with the highest incidence in the Iranian population were leukemia and lymphoma.

Influencing risk factors of prevalence and incidence of hematologic cancer vary in different regions and ethnicities; we therefore examined the results in various regions and in both sexes. This is the first systematic review on the risk factors of leukemia and lymphoma in the Iranian population. In this systematic review, we reported an overall incidence for leukemia

and lymphoma (equal to 3.26) because we did not have enough articles to do a meta-analysis on lymphoma and leukemia incidence rates separately.

Sant Milena et al. examined the hematologic cancer subgroup incidence rates in the European regions. They reported the overall crude incidence rate of lymphoid subgroup as 2.49, and of leukemia subgroup as 1.28.²⁷ The overall incidence was higher in males than females as in our study.

Xin-Chuan and Xin-Zu,¹ in a study in 2012, compared the mortality-to-prevalence ratio of leukemia, non-Hodgkin lymphoma, Hodgkin's lymphoma, and multiple myeloma between Europe and China. The prevalence of leukemia, non-Hodgkin lymphoma, and Hodgkin's lymphoma were respectively 6.7, 6.3, and 0.6 per 100 000 individuals in China, which were lower than Europe. In our study, this value was 11.63. The higher prevalence in Iran compared to Europe and China is due to the fact that in Iran, the overall prevalence of hematologic malignancies was assessed.

Alex Smith et al. reported that hematologic malignancies can be diagnosed at any age, the median age ranging from 15.3 years to 77.3 years in 2011. Most subtypes had an older median diagnostic age (70.6 years for all hematologic malignancies combined).⁷ In our study, patients had an age range of 15-76 years old.

In 2018 Bray et al. reported that leukemia was the 15th, in terms of the number of cases involved, and the 11th cause of mortality worldwide in 2018. They also indicated that leukemia is more widespread among males than females.²⁸ Also, Bispo Jordan A et al. in 2019 discussed the leukemia and lymphoma causing factors, including genetic abnormalities, inherited disorders, ionizing radiation, chemotherapy, and carcinogenic chemicals like benzene.²⁹

Conclusion

The aim of this study was to investigate the risk factors of leukemia and lymphoma and to estimate the prevalence and incidence of hematological malignancies. The limitations of this article included few existing studies, so more surveys are needed to find the reported risk factors, and the heterogeneity of studies in the meta-analysis. The other limitation was the lack of sufficient studies to calculate the hematologic malignancy subgroups incidence and prevalence.

Acknowledgement

This study is supported by a grant from the Sabzevar University of Medical Sciences.

References

- Chen X-C, Chen X-Z. Epidemiological differences in haematological malignancies between Europe and China. *The Lancet Oncology*. 2014;15(11):e471-e2. doi:10.1016/S1470-2045(14)70441-3
- Esmaeimzadeh N, Salahi-Moghaddam A, Khoshdel A. Geographic distribution of important cancers in Iran. *Hormozgan Medical Journal*. 2015;19(2):66-76.
- Etemadi A, Sadjadi A, Semnani S, Nouraei SM, Khademi H, Bahadori M. Cancer registry in Iran: a brief overview. *Archives of Iranian Medicine*. 2008;11(5):577-80
- Ghojogh M, Kor Y, Rafiemanesh H. Leukemia in Iran: Epidemiology and morphology trends. *Asian Pacific Journal of Cancer Prevention*. 2015;16(17):7759-63. doi:10.7314/apjcp.2015.16.17.7759
- Kamangar F, Dores GM, Anderson WF. Patterns of cancer incidence, mortality, and prevalence across five continents: defining priorities to reduce cancer disparities in different geographic regions of the world. *Journal of Clinical Oncology*. 2006;24(14):2137-50. doi:10.1200/JCO.2005.05.2308
- Khazaei S, Ayubi E, Soheylizad M, Manosri K. Incidence rate and distribution of common cancers among Iranian children. *Middle East Journal of Cancer*. 2016;8(1):39-42.
- Li J, Smith A, Crouch S, Oliver S, Roman E. Estimating the prevalence of hematological malignancies and precursor conditions using data from Haematological Malignancy Research Network (HMNRN). *Cancer Causes & Control*. 2016;27(8):1019-26. doi:10.1007/s10552-016-0780-z
- Long N, Moore M, Chen W, Gao C, Lai M-S, Mizoue T, et al. Cancer epidemiology and control in north-East Asia-past, present and future. *Asian Pacific Journal of Cancer Prevention*. 2010;11(Suppl 2):107-48.
- Mehrvar A, Faranoush M, Asl AA, Tashvighi M, Fazeli MA, Mehrvar N, Zangoie R, Sadeghian A, Jafarpour A, Sobuti B, Alebouyeh M. Epidemiological features of childhood acute leukemia at MAHAK's Pediatric Cancer Treatment and Research Center (MPCTRC), Tehran, Iran. *Basic & Clinical Cancer Research*. 2015;7(1):9-15.
- Mohagheghi MA, Mosavi-Jarrahi A. Review of cancer registration and cancer data in Iran, a historical prospect. *Asian Pacific Journal of Cancer Prevention*. 2010;11(4):1155-7.
- Mousavi SM, Gouya MM, Ramazani R, Davanlou M, Hajsadeghi N, Seddighi Z. Cancer incidence and mortality in Iran. *Annals of Oncology*. 2009;20(3):556-63. doi:10.1093/annonc/mdn642
- Mousavi SM, Mohagheghi MA, Mousavi-Jarrahi A, Nahvijou A, Seddighi Z. Burden of breast cancer in Iran: a study of the Tehran population based cancer registry. *Asian Pacific Journal of Cancer Prevention*. 2006;7(4):571.
- Radmard AR. Five common cancers in Iran. *Archives of Iranian Medicine*. 2010;13(2):143.
- Fathi A, Bahadoram M, Amani F. Epidemiology of childhood cancer in Northwest Iran. *Asian Pacific Journal of Cancer Prevention*. 2015;16(13):5459-62.
- Dastgiri S, Fozounkhah S, Shokrgozar S, Taghavinia M, Kermani AA. Incidence of Leukemia in the Northwest of Iran. *Health Promotion Perspectives*. 2011;1(1):50. doi:10.5681/hpp.2011.004
- Rafiemanesh H, Mehtarpour M, Mohammadian-Hafshejani A, Salehiniya H, Enayatrad M, Khazaei S. Cancer epidemiology and trends in Sistan and Baluchestan province, Iran. *Medical Journal of the Islamic Republic of Iran*. 2015;29:254.
- Tahmasebi B MM, Yahya Pour Y, Jamshidi M, Halakoie Naini K. Determination and comparison of incidence rate and trend of morbidity of leukemia and lymphoma in Mazandaran province (1376-1382). *Journal of Mazandaran University of Medical Sciences*. 2006;16(54):87-9.
- Mosavi-Jarrahi A, Mohagheghi MA, Kalaghchi B, Mousavi-Jarrahi Y, Kolahi AA, Noori MK. Estimating the incidence of leukemia attributable to occupational exposure in Iran. *Asian Pacific Journal of Cancer Prevention*. 2009;10(1):67-70.
- Keyghobadi N, Rafiemanesh H, Mohammadian-Hafshejani A, Enayatrad M, Salehiniya H. Epidemiology and trend of cancers in the province of Kerman: southeast of Iran. *Asian Pacific Journal of Cancer Prevention*. 2015;16(4):1409-13.
- Sajadi A, Zahedi M, DARVISH MS, Nouraei M, ALI MM, Ghorbani A, et al. The first population-based cancer survey in Kerman Province of Iran. 2007;36(4):26-34.
- Boroumand H, Moshki M, Khajavi A, Darabian M, Hashemizadeh H. Epidemiology of Childhood Cancer in Northeast of Iran. *Iranian Journal of Pediatric Hematology and Oncology*. 2017;7(1):9-15.
- Talaiezhadeh A, Tabesh H, Sattari A, Ebrahimi S. Cancer incidence in southwest of iran: first report from khuzestan population-based cancer registry, 2002-2009. *Asian Pacific Journal of Cancer Prevention*. 2013;14(12):7517-22. doi:10.7314/apjcp.2013.14.12.7517
- Miranda-Filho A, Piceros M, Ferlay J, Soerjomataram I, Monnereau A, Bray F. Epidemiological patterns of leukaemia in 184 countries: a population-based study. *The Lancet Haematology*. 2018;5(1):e14-e24. doi:10.1016/S2352-3026(17)30232-6
- Mirmohammadi SJ, Souzani A, Atefi A, Zareian Yazdi Z. Environmental Risk Factors for Acute Leukemia and Non-Hodgkin Lymphoma in Children. *Iranian Journal of Pediatric Hematology and Oncology*. 2010;1(1):1-3.
- Poynter JN, Richardson M, Roesler M, Blair CK, Hirsch B, Nguyen P, et al. Chemical exposures and risk of acute myeloid leukemia and myelodysplastic syndromes in a population-based study. *International Journal of Cancer*. 2017;140(1):23-33. doi:10.1002/ijc.30420
- Fircanis S, Merriam P, Khan N, Castillo JJ. The relation between cigarette smoking and risk of acute myeloid leukemia: An updated meta-analysis of epidemiological studies. *American Journal of Hematology*. 2014;89(8):E125-E32. doi:10.1002/ajh.23744
- Sant M, Allemani C, Tereanu C, De Angelis R, Capocaccia R, Visser O, et al. Incidence of hematological malignancies in Europe by morphological subtype: results of the HAEMACARE project. *Blood*. 2010;116(19):3224-34. doi:10.1182/blood-2010-05-282632
- Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: A Cancer Journal for Clinicians*. 2018;68(6):394-424. doi:10.3322/caac.21492
- Bispo JAB, Pinheiro PS, Kobetz EK. Epidemiology and Etiology of Leukemia and Lymphoma. *Cold Spring Harbor Perspectives in Medicine*. 2019;a034819. doi:10.1101/cshperspect.a034819