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The Survival Rate of Leukemia Patients in Asian Regions: A Systematic Review and Meta-Analysis Study

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Abstract

Background: Leukemia is one of the most common types of cancer worldwide, especially in children. The present research aims to comprehensively estimate leukemia cancer survival in Asian countries through a systematic review and meta-analysis.

Materials and Methods: The current research is a systematic review and meta-analysis of leukemia patients' survival rates in Asian countries. Five databases ISI, PubMed, Scopus, ProQuest, and Google Scholar were used to search for relevant studies. Keywords were selected based on MeSH. The search for studies continued until February 1, 2023. The random-effects model was used to reduce the risk of bias in the studies. The Egger's regression test was also used to evaluate the risk of publication bias. A total number of 73 papers were considered for the analysis. All analyses were performed by Comprehensive Meta-Analysis Version 2 software.

Results: The overall one-year and five-year survival rates of the leukemia patients were 62.3% (95% CI: 60.9%-63.6%) and 46.7% (95% CI: 41.2%-52.3%), respectively. The results of the subgroup analysis revealed that the five-year survival rate of myeloid leukemia was 36.3% (95% CI: 35.8%-36.8%), while the five-year survival rate of lymphoid leukemia was 62.4% (95% CI: 58.2%-66.4%). The results of the overall 5-year survival rate of leukemia patients by age group showed that, in general, children have a higher survival rate than adults [63.3% (95% CI: 58.7%-67.6%) vs. 27.6% (95% CI: 23.2%-32.6%)].

Conclusion: In general, the survival rates of leukemia patients in Asian countries are very different. On the whole, however, the present study demonstrated that the five-year survival rate for leukemia patients in Asian countries has achieved a level of 46.7%, irrespective of variables such as age, cancer stage, or treatment protocol.

Keywords: Asia, Leukemia, Lymphoid, Myeloid, Survival Rate

Introduction

Cancer is a major health problem worldwide and an important cause of mortality after cardiovascular diseases. This disease is a major obstacle in increasing the average life expectancy in all continents and countries (1-3). The global burden of cancer is increasing due to aging and population growth in developing countries (4). The hematopoietic system of the human body can cause various malignant disorders in different types and forms. These malignancies can be related to bone marrow cells or the body's lymphatic system. The four leading types of blood malignancies include lymphoma, myeloma, leukemia, and plasma cell disorders (5). Leukemia is described as a cluster of malignant blood disorders in which white blood cells are abnormally increased in the blood and bone marrow. They are classified by cell type and whether they are acute or chronic, and of the lymphoid or myeloid lineages (2, 6, 7).

Leukemia is known as the most common category of malignancy in children under 15 years old (40 per 100,000 populations). About 30% of all cancers in children are related to this type (8, 9). Although leukemia is the most common type of cancer in childhood, this type of cancer is not limited to children. It also exists among adults with a higher prevalence and a more complicated treatment process (8, 10). Leukemia is categorized into four main groups with dissimilar clinical indications, namely acute myeloid leukemia (AML), acute lymphoblastic leukemia (ALL), chronic myeloid leukemia (CML), and chronic lymphoblastic leukemia (CLL). AML is common in adults and accounts for about 30% of all adult leukemia cases. ALL is the most common leukemia among children (11), and 80% of all childhood leukemia is assigned to this type. CML is mainly seen in adults, while CLL is another type of leukemia most common among adults (5, 12, 13). The etiology of leukemia is unknown and still mysterious, and epidemiological studies have evaluated the risk factors of leukemia as environmental, genetic, and infectious factors (14, 15). Other cancer risk factors include radiation, family history, specific syndromes, genetic abnormalities, and smoking (16-18). The incidence rate of leukemia varies among people depending on differences in gender, age, race, and environmental exposures, which play major roles in the death rate and prevalence of this disease (19). The survival rate is one of the most essential indexes for evaluating the quality of cancer control programs (20). So far, several studies have been conducted to estimate the survival rate of cancer patients in different countries, but each study has reported a different survival rate, based on the type of cancer and time period (21). In the study by Allemani et al., the five-year survival rate of leukemia in Korea, Japan, and Singapore was reported to be more than 80% (22). Another relevant study in Singapore reported a survival rate of 85% (23). Furthermore, another study by Nakata et al. in Japan reported that the five-year survival rate of leukemia was about 80% (24). Meanwhile, the survival rate in some studies was less than 20% (25-28). With regard to this, although various studies have been conducted in Asian countries, the results are conflicting. Considering the significance of gaining knowledge about the survival rate of this type of cancer in hospital planning and policies and with regard to different findings reported by the published studies, the present research aims to provide a comprehensive estimate of leukemia survival in Asian countries through doing a systematic review and meta-analysis.

Materials and Methods

Study design

This study is a systematic review and meta-analysis of leukemia patients' survival rates in Asia. The protocol of this research has been registered on the PROSPERO database (ID: CRD42023427378). The design of the study and its reports were based on PRISMA (29).

Search approach

Two teams, trained and proficient in searching the subject under investigation, followed the search steps in selecting relevant studies in ISI, PubMed, Scopus, ProQuest, and Google Scholar databases. The search for studies continued until February 1, 2023. Selected keywords included: ("Carcinoma" OR "Cancer" OR "Neoplasm" OR "Malignancy" OR "leukemia Cancer" OR "leukemia Neoplasms" OR "leukemia carcinoma" OR "leukemia tumor" OR "Cancer of leukemia" OR "Neoplasms of leukemia" OR "leukemia" OR "leukemia patients")

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AND ("Survival" OR "Survival Analysis" OR "Survival Rate") AND ("Asian countries", and the list of all Asian countries). OR (for synonymous keywords) and AND operators were used to combine keywords. The searched papers were subjected to EndNote X8 software to assess and manage their findings, and duplicate papers were automatically removed. In the next step, two researchers independently checked, screened, and reviewed the data required for the studies. A third investigator resolved the likely disagreements.

Quality assessment

To evaluate the quality of the studies, the Newcastle-Ottawa Quality Assessment Scale was used (20). This tool has three different parts: selection (4 questions), comparability (1 question) and outcome (3 questions), and the studies, based on the final scores/their qualities, were divided into three categories: good (3 or 4 stars in the selection domain and 1 or 2 stars in the comparability domain and 2 or 3 stars in the outcome/exposure domain), fair (2 stars in the selection domain and 1 or 2 stars in the comparability domain and 2 or 3 stars in the outcome/exposure domain) and poor (0 or 1 star in the selection domain or 0 stars in the comparability domain or 0 or 1 stars in the outcome/exposure domain). The content analysis STROBE checklist was used to do data analysis (30): Good quality: 3 or 4 stars in the selection domain AND 1 or 2 stars in the comparability domain AND 2 or 3 stars in the outcome/exposure domain; Fair quality: 2 stars in the selection domain AND 1 or 2 stars in the comparability domain AND 2 or 3 stars in the outcome/exposure domain; Poor quality: 0 or 1 star in the selection domain OR 0 stars in the comparability domain OR 0 or 1 stars in the outcome/exposure domain.

Screening of studies

Two authors performed screening of papers, extraction of data, and assessment of quality control of studies, independently. In case of possible disagreements between them, the supervisor announced the last comment on that study. Inclusion criteria included observational studies, and thus analytical cross-sectional, cohort, and case-control studies were reviewed. Although time and language limitations were not considered in this study, articles with Latin abstracts were reviewed. Exclusion criteria were as follows: 1. Studies that assessed other types of cancer. 2. Survival in individuals who reported metastasized. 3. Letters to the editor, types of review studies, research that included defined treatments (clinical trials), laboratory, cellular, and animal research. Also, summaries of conferences, seminars, and statistics, provided by organizations, were not included in the current research.

Statistical Analysis

The heterogeneity of the research was appraised by the Cochran test and I^2 statistics. The random-effect model was applied with the inverse-variance technique. Meta-regression and sub-group analysis were done to find the source of heterogeneity. In the first step, studies were analyzed based on One and Five-year survival rates. In the next step, the meta-regression analysis was done because of the high heterogeneity of the studies. Meta-regression was also performed based on the year of study and human development index. All analyses were performed by Comprehensive Meta-Analysis (CMA) Version 2 software.

Risk of Bias

A Random effects model was used to reduce the risk of bias in the studies. In addition, Egger's regression test was used to evaluate the risk of publication bias (31).

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Research selection

Initially, 948 articles were found, and after removing duplicates, 731 studies remained. Next, 236 articles were removed after checking the titles and abstracts of the studies, and 495 articles were selected for full-text review. At this stage, 422 articles were excluded due to various reasons, including the unavailability of the full text, unrelated population, lack of inclusion criteria, or lack of accurate reporting of survival rate and sample size. Finally, 73 articles were selected for carrying out meta-analysis. The research selection method is shown in Figure 1.

Study features

The included papers were published in the years 1995 to 2023. Twenty-three studies were conducted in Korea (32-53), nine in China (26, 54-61) (26, 54-61), eight in Japan (24, 25, 62-67), twelve in Iran [(68, 69, 70 (Ashrafi, 2013 #68, 71-78)], nine in Thailand (28, 79-86), five in India (27, 87-90), one in Singapore (91), one in Saudi Arabia (92), and the rest in other countries (22, 23, 93-95). In Tables I and II, the survival rates of leukemia patients in Asia are mentioned separately based on the investigated variables.

Quality assessment

In general, 63 of the selected papers had a good while 10 had a fair quality.

Finding of the meta-analysis

After sorting the articles based on their publication year, the one-year and five-year survival rates were analyzed.

The one-year survival rate

The one-year survival rate of patients with myeloid leukemia (ML) was 48.6% (95% CI: 40.6%-56.7%), I^2=97.63, P-value<0.001 (Figure 2, I). In comparison, the one-year survival rate of patients with Lymphoid Leukemia (LL) was 71.4% (95% CI, 67.6-74.9), I^2=98.17, P-value<0.001 (Figure 2, II). The overall one-year survival rate of leukemia patients

Results

was revealed as 62.3% (95% CI: 60.9%-63.6%), I^2=98.10, P-value<0.001 (Figure 2, III).

The five-year survival rate

The five-year survival rate of ML patients was 36.3% (95% CI: 35.8%-36.8%), I^2=97.59, P-value<0.001 (Figure 3, I), while the five-year survival rate of LL patients was estimated to be 62.4% (95% CI: 58.2%-66.4%), I^2=98.80, P-value<0.001 (Figure 3, II). Finally, leukemia patients' overall Five-year survival rate in Asian countries was estimated to be 46.7% (95% CI: 41.2%-52.3%), I^2=99.71, P-value<0.001 (Figure 3, III).

The five-year survival rate in males

The five-year survival rate of ML male patients was 25.1% (95% CI: 19.8%-31.4%), I^2=95.64, P-value<0.001 (Figure 4, I), but the LL type showed a higher rate of 35.9% in male patients (95% CI: 29.1%-43.3%), I^2=94.54, P-value<0.001 (Figure 4, II). Leukemia male patients' overall five-year survival rate was estimated to be 42.8% (95% CI: 38.5%-47.3%), I^2=99.19, P-value<0.001 (Figure 4, III).

The five-year survival rate in females

The results of the meta-analysis model in females showed that the survival rate of ML female patients is 25.5% (95% CI: 19.5%-32.6%), I^2=95.50, P-value<0.001 (Figure 5, I), and the survival rate of LL female patients is 37.7% (95% CI: 31.0%-45.0%), I^2=91.42, P-value<0.001 (Figure 5, II). The overall five-year survival rate of women with leukemia was also 44.5% (95% CI: 40.3%-48.7%), I^2=98.85, P-value<0.001 (Figure 5, III).

The five-year survival rate of ML patients in three different age groups

The five-year ML survival rate of patients in children, the elderly and adult groups were 38.3% (95% CI: 32.7%-44.4%), (I^2=93.01, P-value<0.001), 13.9% (95%

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CI: 11.2%-17.1%), (I^2=92.48, P-value<0.001), and 32.1% (95% CI: 28.6%-35.8%), (I^2=97.32, P-value<0.001), respectively (Figure 6, I, II and III). The age group of 0 to 18 years is considered as children, 19 to 64 years as adults, and more or equal to 65 years as the elderly group.

The five-year survival rate of LL patients in three different age groups

The five-year LL survival rates of patients in children, the elderly, and adult groups were 63.3% (95% CI: 57.6%-68.6%), (I^2=96.34, P-value<0.001), 32.3% (95% CI: 27.2%-37.8%), (I^2=80.31, P-value<0.001), and 31.9% (95% CI: 28.2%-35.8%), (I^2=91.84, P-value<0.001), respectively (Figure 7, I, II and III).

The five-year survival rate of leukemia patients in three different age groups

The findings related to the overall five-year survival rate of leukemia patients *in three different* age groups showed that, in general, children (63.3%,95% CI: 58.7%-67.6%), (I^2=97.83, P-value<0.001) have a higher survival rate than adults (27.6%,95% CI: 23.2%-32.6%), (I^2=99.77, P-value<0.001) (Figure 8). It is essential to mention that the studies did not report the overall survival rate of leukemia patients in the elderly group.

Meta-regression results

The meta-regression results revealed a significant relationship between the publication year and five-year survival rates. Therefore, the publication year of relevant studies can be the cause of variability in their findings (regression coefficient = 0.016, P<0.001). Moreover, an increased survival rate across the study period was detected. Another cause of inconsistency in the findings was the Human Development Index (HDI). HDI was a source of variability in the findings concerning the five-year survival rates (regression coefficient = 4.120, P<0.001). In other words, as the finding revealed, a higher HDI in countries was associated with an increased survival rate (Figure 9).

Risk of bias analysis

A P-value of 0.449 was obtained from the regression intercept test (0.92) by Egger, which did not present any evidence of publication bias (Figure 10).

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Table I: The one-year survival rate of leukemia patients by sample size, gender, type of cancer, time period, and country

Study name	Sample size	Event rate	Year (S)	Country	Year (P)	Cancer Type	Gender
Sriamporn, 1995 (A)	286	50.70%	1	Thailand	1985	Total	Total
Tsukuma, 2006 (A)	2935	60.78%	1	Japan	1993	Total	Total
Swaminathan, 2008 (A)	446	58.52%	1	India	1990	Total	Total
Lee, 2010 (A)	5197	54.19%	1	Korea	1993	Total	Male
Lee, 2010 (D)	10491	61.40%	1	Korea	1999	Total	Male
Lee, 2010 (G)	4031	53.19%	1	Korea	1993	Total	Female
Lee, 2010 (J)	8312	60.39%	1	Korea	1999	Total	Female
Suwanrungruang, 2011 (G)	283	44.88%	1	Thailand	1985	Total	Total
Wiangnon, 2011 (A)	1421	76.85%	1	Thailand	2003	Total	Total
Bao, 2012 (A)	209	77.99%	1	China	2002	Total	Total
Wu, 2013 (A)	1342	81.89%	1	Taiwan	1990	Total	Total
Demanelis, 2015 (A)	273	68.13%	1	Thailand	1990	Total	Total
Demanelis, 2015 (D)	152	69.08%	1	Thailand	1990	Total	Male
Demanelis, 2015 (G)	121	64.46%	1	Thailand	1990	Total	Female
Demanelis, 2015 (J)	109	66.97%	1	Thailand	1990	Total	Total
Demanelis, 2015 (M)	67	82.09%	1	Thailand	1990	Total	Total
Demanelis, 2015 (P)	47	61.70%	1	Thailand	1990	Total	Total
Demanelis, 2015 (S)	50	52.00%	1	Thailand	1990	Total	Total
Nakata, 2018 (A)	442	89.37%	1	Japan	1993	Total	Total
Nakata, 2018 (C)	355	94.65%	1	Japan	1997	Total	Total
Nakata, 2018 (E)	371	93.53%	1	Japan	2001	Total	Total
Nakata, 2018 (G)	369	94.58%	1	Japan	2005	Total	Total
Demanelis, 2015 (AX)	30	36.67%	1	Thailand	1990	ML	Female
Demanelis, 2015 (AU)	36	52.78%	1	Thailand	1990	ML	Male
Ahn, 2011 (D)	1219	54.88%	1	Korea	1993	ML	Total
Chen, 2011 (D)	216	19.44%	1	China	1992	ML	Total
Chia, 2011 (D)	390	43.08%	1	Singapore	1993	ML	Total
Jayalekshmi, 2011 (D)	30	30.00%	1	India	1991	ML	Total
Law, 2011 (D)	1389	56.37%	1	Hong Kong	1996	ML	Total
Shin, 2011 (D)	480	53.33%	1	Korea	1996	ML	Total
Sriplung, 2011 (D)	173	47.40%	1	Thailand	1990	ML	Total
Sumitsawan, 2011 (D)	122	28.69%	1	Thailand	1993	ML	Total
Suwanrungruang, 2011 (D)	129	38.76%	1	Thailand	1985	ML	Total
Swaminathan, 2011 (D)	465	36.77%	1	India	1990	ML	Total
Woo, 2011 (D)	250	63.20%	1	Korea	1997	ML	Total
Xiang, 2011 (D)	605	52.56%	1	China	1992	ML	Total
Xishan, 2011 (D)	567	76.54%	1	China	1991	ML	Total
Yeole, 2011 (D)	1261	31.80%	1	India	1992	ML	Total
Horibe, 2013 (D)	891	91.25%	1	Japan	2006	ML	Total
Demanelis, 2015 (AR)	66	45.45%	1	Thailand	1990	ML	Total
Demanelis, 2015 (BC)	19	31.58%	1	Thailand	1990	ML	Total
Demanelis, 2015 (BF)	10	70.00%	1	Thailand	1990	ML	Total
Demanelis, 2015 (BI)	15	46.67%	1	Thailand	1990	ML	Total
Demanelis, 2015 (BL)	22	45.45%	1	Thailand	1990	ML	Total
Ahn, 2011 (A)	595	67.56%	1	Korea	1993	LL	Total
Chen, 2011 (A)	81	20.99%	1	China	1992	LL	Total
Chia, 2011 (A)	205	68.78%	1	Singapore	1993	LL	Total
Jayalekshmi, 2011 (A)	38	60.53%	1	India	1991	LL	Total
Law, 2011 (A)	561	79.32%	1	Hong Kong	1996	LL	Total

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Martin, 2011 (A)	109	63.30%	1	Thailand	1990	LL	Total
Shin, 2011 (A)	222	66.22%	1	Korea	1996	LL	Total
Sriplung, 2011 (A)	99	70.71%	1	Thailand	1990	LL	Total
Sumitsawan, 2011 (A)	70	52.86%	1	Thailand	1993	LL	Total
Suwanrungruang, 2011 (A)	123	54.47%	1	Thailand	1985	LL	Total
Swaminathan, 2011 (A)	433	42.26%	1	India	1990	LL	Total
Woo, 2011 (A)	125	67.20%	1	Korea	1997	LL	Total
Xiang, 2011 (A)	338	53.25%	1	China	1992	LL	Total
Xishan, 2011 (A)	309	77.67%	1	China	1991	LL	Total
Yeole, 2011 (A)	1099	35.40%	1	India	1992	LL	Total
Horibe, 2013 (A)	2464	97.28%	1	Japan	2006	LL	Total
Demanelis, 2015 (V)	153	75.82%	1	Thailand	1990	LL	Total
Demanelis, 2015 (Y)	87	74.71%	1	Thailand	1990	LL	Male
Demanelis, 2015 (AC)	66	77.27%	1	Thailand	1990	LL	Female
Demanelis, 2015 (AF)	74	74.32%	1	Thailand	1990	LL	Total
Demanelis, 2015 (AI)	47	85.11%	1	Thailand	1990	LL	Total
Demanelis, 2015 (AL)	20	70.00%	1	Thailand	1990	LL	Total
Demanelis, 2015 (AO)	12	50.00%	1	Thailand	1990	LL	Total

ML: Myeloid leukemia, LL: Lymphoid Leukemia

Table II. The five-year survival rate of leukemia patients by sample size, gender, type of cancer, time period, and country

Study name	Sample size	Event rate	Year (S)	Country	Year (P)	Cancer Type	Gender
Ajiki,1995 (A)	734	23.43%	5	Japan	1975	Total	Total
Ajiki,1995 (B)	734	38.69%	5	Japan	1980	Total	Total
Sriamporn, 1995 (C)	286	19.23%	5	Thailand	1985	Total	Total
Ajiki, 2004 (A)	569	32.34%	5	Japan	1975	Total	Total
Ajiki, 2004 (B)	465	60.43%	5	Japan	1985	Total	Total
Tsukuma, 2006 (C)	2935	31.48%	5	Japan	1993	Total	Total
Swaminathan, 2008 (C)	446	36.32%	5	India	1990	Total	Total
Jung, 2011 (A)	2561	44.90%	5	Korea	2004	Total	Total
Matsuda, 2011 (A)	2920	32.29%	5	Japan	1993	Total	Total
Matsuda, 2011 (D)	2228	32.90%	5	Japan	1977	Total	Total
Suwanrungruang, 2011 (I)	283	20.49%	5	Thailand	1985	Total	Total
Wiangnon, 2011 (C)	1421	57.35%	5	Thailand	2003	Total	Total
Bao, 2012 (C)	209	52.15%	5	China	2002	Total	Total
Jung, 2012 (A)	2,687	46.00%	5	Korea	2005	Total	Total
Jung, 2013 (A)	2684	47.39%	5	Korea	2006	Total	Total
Wu, 2013 (C)	1342	58.49%	5	Taiwan	1990	Total	Total
Jung, 2014 (A)	2862	47.97%	5	Korea	2007	Total	Total
Moon, 2014 (A)	866	25.75%	5	Korea	1993	Total	Total
Moon, 2014 (B)	1440	35.90%	5	Korea	1996	Total	Total
Moon, 2014 (C)	1397	47.67%	5	Korea	2001	Total	Total
Moon, 2014 (D)	1435	58.82%	5	Korea	2006	Total	Total
Demanelis, 2015 (C)	273	42.86%	5	Thailand	1990	Total	Total
Jung, 2015 (A)	2826	48.90%	5	Korea	2008	Total	Total
Zheng, 2015 (A)	7764	70.49%	5	China	2000	Total	Total
Oh, 2016 (A)	3011	49.68%	5	Korea	2008	Total	Total
Park, 2016 (A)	1076	47.40%	5	Korea	1993	Total	Total
Park, 2016 (B)	1944	58.38%	5	Korea	1996	Total	Total
Park, 2016 (C)	1999	68.18%	5	Korea	2001	Total	Total
Park, 2016 (D)	1875	74.88%	5	Korea	2006	Total	Total
Park, 2016 (E)	1883	75.41%	5	Korea	2007	Total	Total
Jung, 2017 (A)	3080	51.10%	5	Korea	2010	Total	Total
Jung, 2018 (A)	3242	50.99%	5	Korea	2011	Total	Total
Nakata, 2018 (B)	442	71.27%	5	Japan	1993	Total	Total

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Nakata, 2018 (D)	355	77.75%	5	Japan	1997	Total	Total
Nakata, 2018 (F)	371	80.05%	5	Japan	2001	Total	Total
Nakata, 2018 (H)	369	82.93%	5	Japan	2005	Total	Total
Zeng, 2018 (A)	13190	19.60%	5	China	2003	Total	Total
Zeng, 2018 (B)	13190	21.00%	5	China	2006	Total	Total
Zeng, 2018 (C)	13190	19.20%	5	China	2009	Total	Total
Zeng, 2018 (D)	13190	25.40%	5	China	2012	Total	Total
Bidwell, 2019	1245	36.47%	5	Thailand	1990	Total	Total
Jung, 2019 (A)	3416	51.90%	5	Korea	2012	Total	Total
Hong, 2020 (A)	3366	53.00%	5	Korea	2013	Total	Total
Jiang, 2020	343	38.48%	5	China	2004	Total	Total
Hong, 2021 (A)	3494	53.41%	5	Korea	2014	Total	Total
Zhou, 2021	604	34.60%	5	China	2012	Total	Total
Aseafan, 2022	2395	66.97%	5	Saudi Arabia	2005	Total	Total
Kang, 2022 (A)	3738	54.49%	5	Korea	2015	Total	Total
Nemati, 2022	638	27.43%	5	Iran	2007	Total	Total
Ajiki,1995 (E)	176	3.41%	5	Japan	1975	ML	Total
Ajiki,1995 (F)	176	25.00%	5	Japan	1980	ML	Total
Ajiki,1995 (G)	25	1.92%	5	Japan	1975	ML	Total
Ajiki,1995 (H)	25	16.00%	5	Japan	1980	ML	Total
Nandakumar, 1996 (B)	13	23.08%	5	India	1982	ML	Total
Nandakumar, 1996 (C)	53	9.43%	5	India	1982	ML	Total
Ajiki, 2004 (E)	138	15.94%	5	Japan	1975	ML	Total
Ajiki, 2004 (F)	89	42.70%	5	Japan	1985	ML	Total
Akramipour, 2007	40	35.00%	5	Iran	1996	ML	ML
Ahn, 2011 (F)	1219	26.58%	5	Korea	1993	ML	Total
Chen, 2011 (F)	216	5.56%	5	China	1992	ML	Total
Chia, 2011 (F)	390	16.67%	5	Singapore	1993	ML	Total
Jayalekshmi, 2011 (F)	30	6.67%	5	India	1991	ML	Total
Law, 2011 (F)	1389	33.84%	5	Hong Kong	1996	ML	Total
Martin, 2011 (D)	137	47.45%	5	Thailand	1990	ML	Total
Martin, 2011 (E)	137	35.77%	5	Thailand	1990	ML	Total
Martin, 2011 (F)	137	33.58%	5	Thailand	1990	ML	Total
Shin, 2011 (F)	480	27.50%	5	Korea	1996	ML	Total
Sriplung, 2011 (F)	173	14.45%	5	Thailand	1990	ML	Total
Sumitsawan, 2011 (F)	122	10.66%	5	Thailand	1993	ML	Total
Suwanrungruang, 2011 (F)	129	16.28%	5	Thailand	1985	ML	Total
Swaminathan, 2011 (F)	465	15.70%	5	India	1990	ML	Total
Woo, 2011 (F)	250	40.00%	5	Korea	1997	ML	Total
Xiang, 2011 (F)	605	27.11%	5	China	1992	ML	Total
Xishan, 2011 (F)	567	67.55%	5	China	1991	ML	Total
Yeole, 2011 (F)	1261	14.59%	5	India	1992	ML	Total
Sanaat, 2011	142	25.04%	5	Iran	2001	ML	Total
Mashhadi, 2012	66	45.50%	5	Iran	2003	ML	Total
Horibe, 2013 (F)	891	75.20%	5	Japan	2006	ML	Total
Ashrafi, 2013	94	18.10%	5	Iran	2002	ML	Total
Moon, 2014 (Y)	375	25.87%	5	Korea	1993	ML	Total
Moon, 2014 (Z)	602	37.54%	5	Korea	1996	ML	Total
Moon, 2014 (AB)	624	47.12%	5	Korea	2001	ML	Total
Moon, 2014 (AC)	588	52.72%	5	Korea	2006	ML	Total
Demanelis, 2015 (AT)	66	16.67%	5	Thailand	1990	ML	Total
Park, 2015 (A)	3816	26.28%	5	Korea	1996	ML	Total
Park, 2015 (B)	4897	30.69%	5	Korea	2001	ML	Total
Park, 2015 (C)	5577	34.28%	5	Korea	2006	ML	Total
Park, 2015 (D)	5802	34.80%	5	Korea	2008	ML	Total
Park, 2016 (K)	250	26.40%	5	Korea	1993	ML	Total
Park, 2016 (L)	504	41.67%	5	Korea	1996	ML	Total

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Park, 2016 (M)	494	50.81%	5	Korea	2001	ML	Total
Park, 2016 (N)	424	58.73%	5	Korea	2006	ML	Total
Park, 2016 (O)	435	59.54%	5	Korea	2007	ML	Total
Wongmeerit, 2016 (D)	156	13.46%	5	Thailand	1993	ML	Total
Wongmeerit, 2016 (E)	156	28.85%	5	Thailand	2000	ML	Total
Wongmeerit, 2016 (F)	156	26.92%	5	Thailand	2006	ML	Total
Allahyari, 2016	96	26.00%	5	Iran	2009	ML	Total
Ssenyonga, 2022 (D)	139	27.30%	5	China	2000	ML	Total
Ssenyonga, 2022 (E)	139	29.50%	5	China	2005	ML	Total
Ssenyonga, 2022 (F)	139	43.20%	5	China	2010	ML	Total
Ssenyonga, 2022 (P)	196	52.90%	5	Japan	2000	ML	Total
Ssenyonga, 2022 (Q)	196	67.30%	5	Japan	2005	ML	Total
Ssenyonga, 2022 (R)	196	70.40%	5	Japan	2010	ML	Total
Ssenyonga, 2022 (V)	632	47.50%	5	Korea	2000	ML	Total
Ssenyonga, 2022 (W)	632	54.60%	5	Korea	2005	ML	Total
Ssenyonga, 2022 (X)	632	62.00%	5	Korea	2010	ML	Total
Ssenyonga, 2022 (AC)	33	42.40%	5	Singapore	2000	ML	Total
Ssenyonga, 2022 (AD)	33	66.70%	5	Singapore	2005	ML	Total
Ssenyonga, 2022 (AE)	33	75.80%	5	Singapore	2010	ML	Total
Ssenyonga, 2022 (AI)	270	46.70%	5	Taiwan	2000	ML	Total
Ssenyonga, 2022 (AJ)	270	54.80%	5	Taiwan	2005	ML	Total
Ssenyonga, 2022 (AK)	270	57.80%	5	Taiwan	2010	ML	Total
Ssenyonga, 2022 (AO)	84	29.80%	5	Thailand	2000	ML	Total
Ssenyonga, 2022 (AP)	84	38.10%	5	Thailand	2005	ML	Total
Ssenyonga, 2022 (AQ)	84	41.70%	5	Thailand	2010	ML	Total
Ajiki,1995 (C)	459	33.12%	5	Japan	1975	LL	Total
Ajiki,1995 (D)	459	43.79%	5	Japan	1980	LL	Total
Nandakumar, 1996 (A)	102	34.31%	5	India	1982	LL	Total
Karimi, 2002	76	72.40%	5	Iran	1995	LL	Total
Ajiki, 2004 (C)	351	39.89%	5	Japan	1975	LL	Total
Ajiki, 2004 (D)	314	67.52%	5	Japan	1985	LL	Total
Sayehmiri, 2008	206	51.90%	5	Iran	1993	LL	Total
Ahn, 2011 (C)	595	42.35%	5	Korea	1993	LL	Total
Chen, 2011 (C)	81	4.94%	5	China	1992	LL	Total
Chia, 2011 (C)	205	45.85%	5	Singapore	1993	LL	Total
Jayalekshmi, 2011 (C)	38	34.21%	5	India	1991	LL	Total
Law, 2011 (C)	561	59.89%	5	Hong Kong	1996	LL	Total
Martin, 2011 (C)	109	40.37%	5	Thailand	1990	LL	Total
Shin, 2011 (C)	222	42.34%	5	Korea	1996	LL	Total
Sriplung, 2011 (C)	99	48.48%	5	Thailand	1990	LL	Total
Sumitsawan, 2011 (C)	70	20.00%	5	Thailand	1993	LL	Total
Suwanrungruang, 2011 (C)	123	27.64%	5	Thailand	1985	LL	Total
Swaminathan, 2011 (C)	433	24.48%	5	India	1990	LL	Total
Woo, 2011 (C)	125	50.40%	5	Korea	1997	LL	Total
Xiang, 2011 (C)	338	30.18%	5	China	1992	LL	Total
Xishan, 2011 (C)	309	66.02%	5	China	1991	LL	Total
Yeole, 2011 (C)	1099	16.29%	5	India	1992	LL	Total
Horibe, 2013 (C)	2464	88.68%	5	Japan	2006	LL	Total
Almasi-Hashiani, 2013	243	53.10%	5	Iran	2004	LL	Total
Moon, 2014 (M)	237	19.83%	5	Korea	1993	LL	Total
Moon, 2014 (N)	433	28.87%	5	Korea	1996	LL	Total
Moon, 2014 (O)	379	33.77%	5	Korea	2001	LL	Total
Moon, 2014 (P)	425	48.47%	5	Korea	2006	LL	Total
Demanelis, 2015 (X)	153	54.90%	5	Thailand	1990	LL	Total
Parvareh, 2015 (A)	189	50.80%	5	Iran	1998	LL	Total
Parvareh, 2015 (B)	109	64.20%	5	Iran	2006	LL	Total
Park, 2016 (F)	665	57.29%	5	Korea	1993	LL	Total
Park, 2016 (G)	1192	67.70%	5	Korea	1996	LL	Total

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Park, 2016 (H)	1999	68.18%	5	Korea	2001	LL	Total
Park, 2016 (I)	1875	74.88%	5	Korea	2006	LL	Total
Park, 2016 (J)	1883	75.41%	5	Korea	2007	LL	Total
Wongmeerit, 2016 (A)	708	37.01%	5	Thailand	1993	LL	Total
Wongmeerit, 2016 (B)	708	58.33%	5	Thailand	2000	LL	Total
Wongmeerit, 2016 (C)	708	63.84%	5	Thailand	2006	LL	Total
Allemani, 2018 (A)	498	61.60%	5	China	2000	LL	Total
Allemani, 2018 (B)	498	53.40%	5	China	2005	LL	Total
Allemani, 2018 (C)	498	57.60%	5	China	2010	LL	Total
Allemani, 2018 (G)	1438	86.40%	5	Japan	2000	LL	Total
Allemani, 2018 (H)	1438	86.70%	5	Japan	2005	LL	Total
Allemani, 2018 (I)	1438	87.90%	5	Japan	2010	LL	Total
Allemani, 2018 (J)	3389	73.10%	5	Korea	2000	LL	Total
Allemani, 2018 (K)	3389	78.60%	5	Korea	2005	LL	Total
Allemani, 2018 (L)	3389	84.4%	5	Korea	2010	LL	Total
Allemani, 2018 (M)	1811	72.10%	5	Taiwan	2000	LL	Total
Allemani, 2018 (N)	1811	78.80%	5	Taiwan	2005	LL	Total
Allemani, 2018 (O)	1811	76.50%	5	Taiwan	2010	LL	Total
Allemani, 2018 (P)	388	79.60%	5	Singapore	2000	LL	Total
Allemani, 2018 (Q)	388	89.90%	5	Singapore	2005	LL	Total
Allemani, 2018 (R)	388	88.90%	5	Singapore	2010	LL	Total
Ssenyonga, 2022 (A)	275	42.90%	5	China	2000	LL	Total
Ssenyonga, 2022 (B)	275	49.10%	5	China	2005	LL	Total
Ssenyonga, 2022 (C)	275	49.50%	5	China	2010	LL	Total
Ssenyonga, 2022 (G)	215	77.20%	5	Israel	2000	LL	Total
Ssenyonga, 2022 (H)	215	80.50%	5	Israel	2005	LL	Total
Ssenyonga, 2022 (I)	215	83.30%	5	Israel	2010	LL	Total
Ssenyonga, 2022 (M)	438	71.50%	5	Japan	2000	LL	Total
Ssenyonga, 2022 (N)	438	77.20%	5	Japan	2005	LL	Total
Ssenyonga, 2022 (O)	438	82.60%	5	Japan	2010	LL	Total
Ssenyonga, 2022 (S)	1099	64.40%	5	Korea	2000	LL	Total
Ssenyonga, 2022 (T)	1099	70.80%	5	Korea	2005	LL	Total
Ssenyonga, 2022 (U)	1099	76.70%	5	Korea	2010	LL	Total
Ssenyonga, 2022 (Y)	112	68.70%	5	Singapore	2000	LL	Total
Ssenyonga, 2022 (Z)	112	83.00%	5	Singapore	2005	LL	Total
Ssenyonga, 2022 (AB)	112	85.70%	5	Singapore	2010	LL	Total
Ssenyonga, 2022 (AF)	646	63.60%	5	Taiwan	2000	LL	Total
Ssenyonga, 2022 (AG)	646	72.00%	5	Taiwan	2005	LL	Total
Ssenyonga, 2022 (AH)	646	72.90%	5	Taiwan	2010	LL	Total
Ssenyonga, 2022 (AL)	182	46.20%	5	Thailand	2000	LL	Total
Ssenyonga, 2022 (AM)	182	51.60%	5	Thailand	2005	LL	Total
Ssenyonga, 2022 (AN)	182	57.10%	5	Thailand	2010	LL	Total
Noroozi, 2022	176	68.20%	5	Iran	2011	LL	Total

ML: Myeloid leukemia, LL: Lymphoid Leukemia

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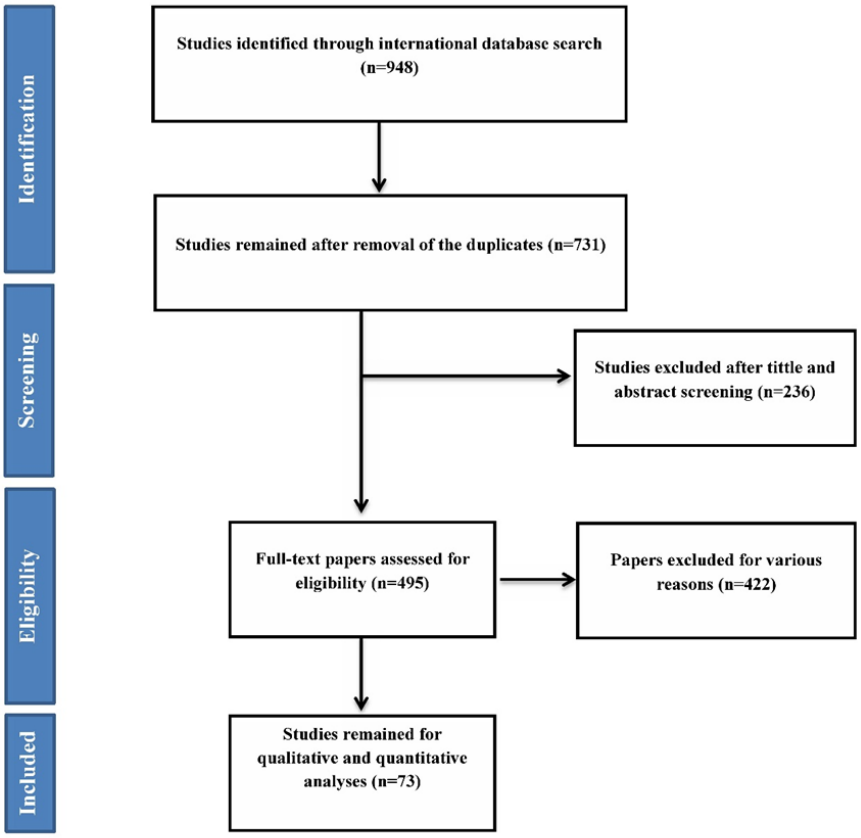

Figure 1. Study protocol

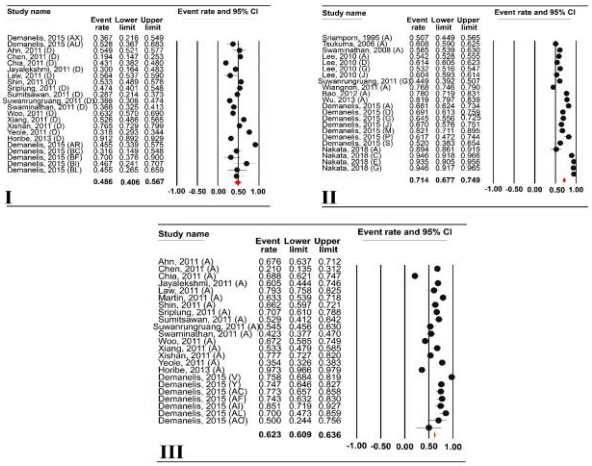

Figure 2. 1-year survival rate of leukemia patients

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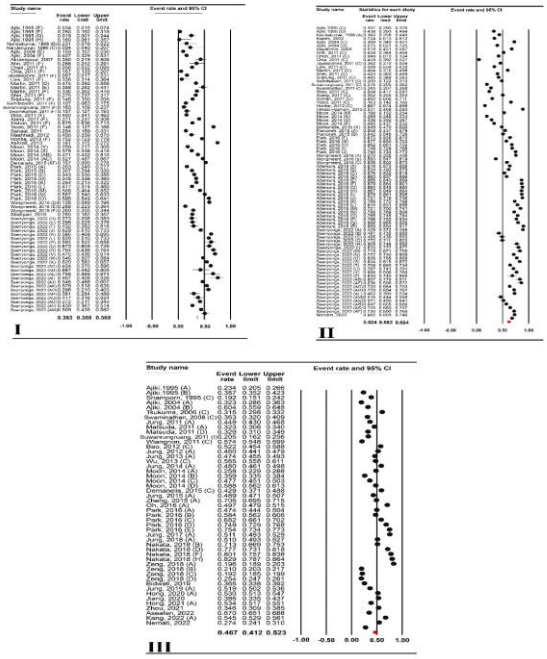

Figure 3. 5-year survival rate of leukemia patients

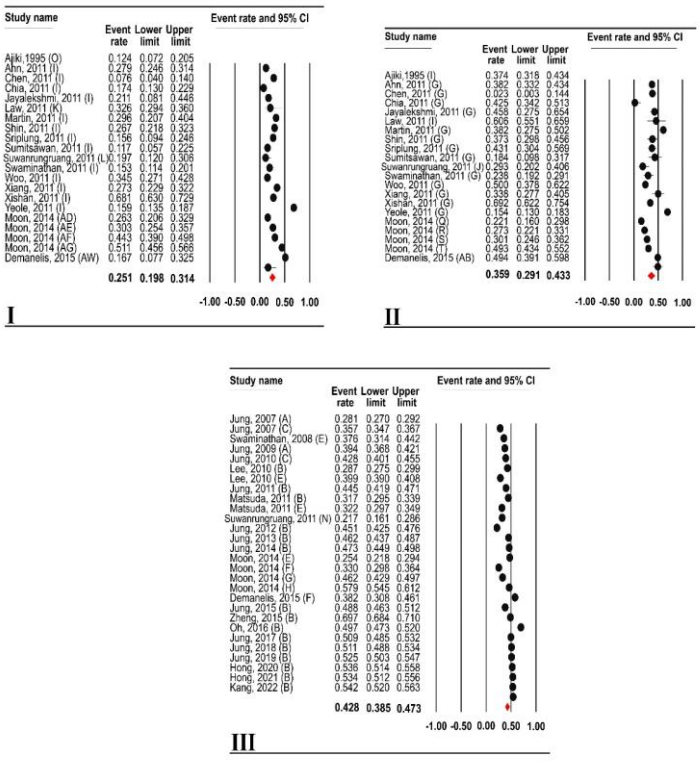

Figure 4. 5-year survival rate of male leukemia patients

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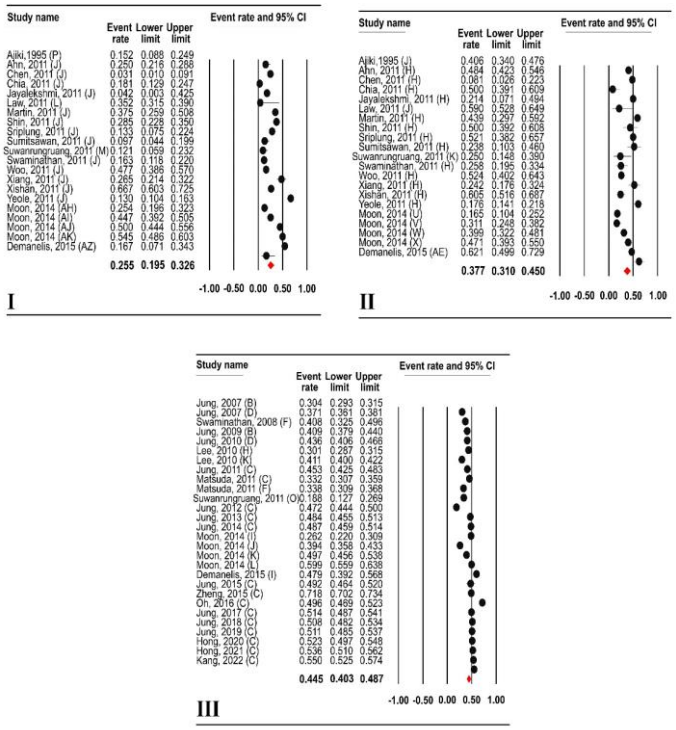

Figure 5. 5-year survival rate of female leukemia patients

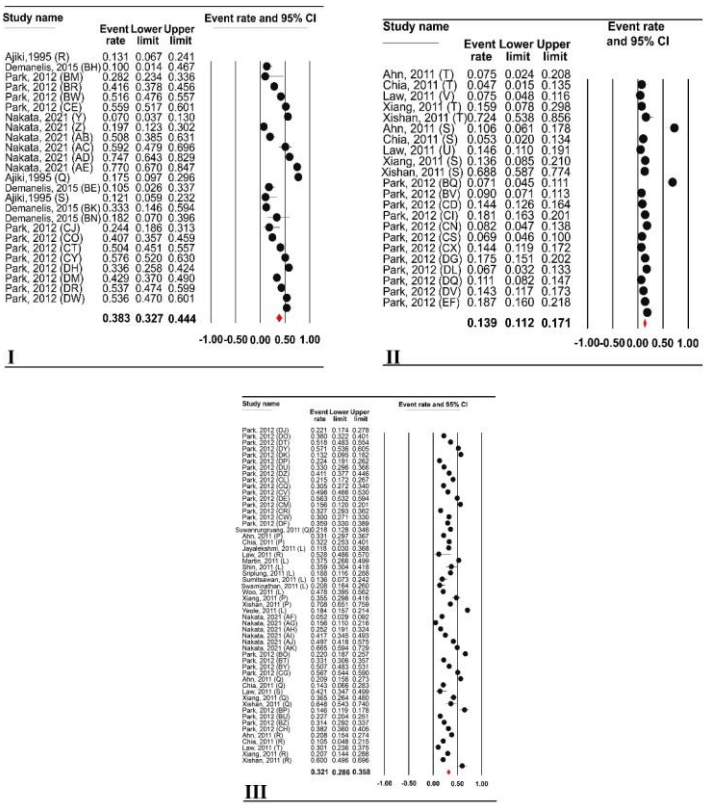

Figure 6. 5-year survival rate of ML patients by age groups

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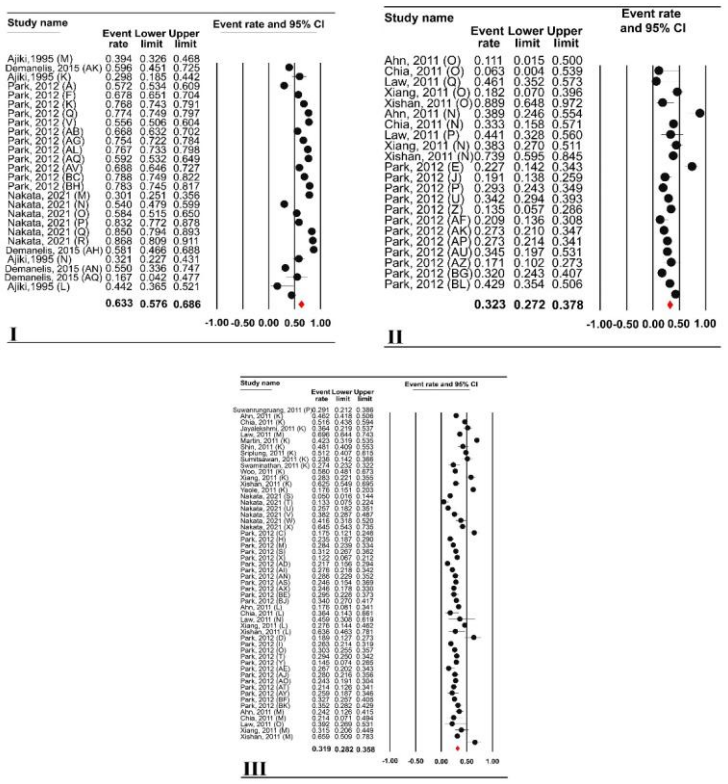

Figure 7. 5-year survival rate of LL patients by age groups

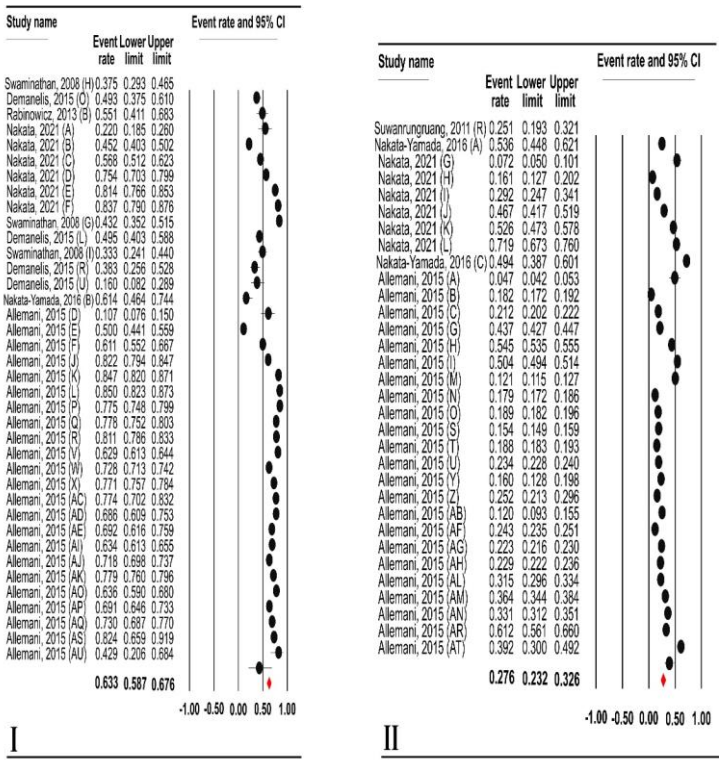

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Figure 8. 5-year survival rate of leukemia patients by age group

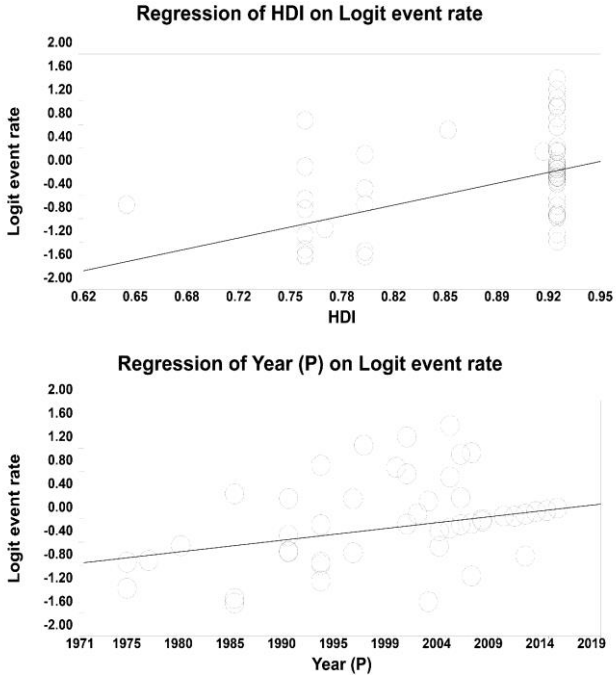

Figure 9. Meta-regression results by year of study and HDI

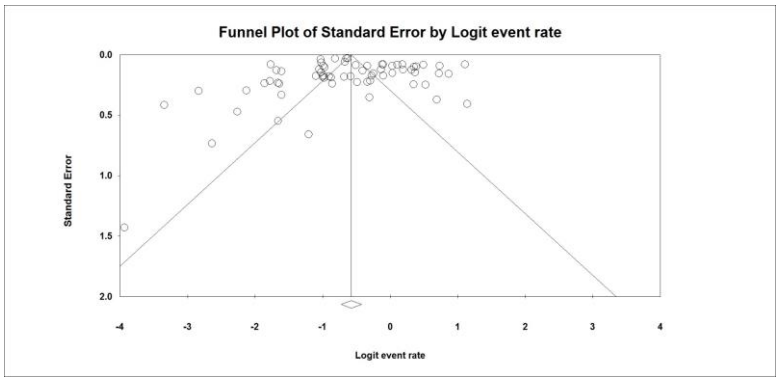

Figure 10. Funnel plot

Discussion

This study benefitted from meta-analysis to examine the survival rates of patients with ML and LL in Asia over one and five-year periods. The overall one-year survival rate for leukemia patients in Asian countries was found to be 62.3% (95% CI, 60.9-63.6). Subgroup analysis revealed a one-year survival rate of 48.6% (95% CI, 40.6-56.7) for patients with ML and a one-year survival rate of 71.4% (95% CI, 67.6-74.9) for patients with LL. Youlden et al. (96) conducted a study in Australia to determine the survival rates of LL and ML patients at various time intervals after diagnosis. The study found that the survival rate for LL patients at diagnosis, and one, three, and five years after diagnosis were 89.6%, 91.3%, 94.5%, and 97.5%, respectively. Regarding ML patients, the respective survival rates were 72.8%, 87.3%, 97.1%, and 98.7%. Based on Howlader et al.'s Cancer Statistics Review (97) report in the United States, the five-year relative survival rate of

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leukemia patients of all ages was 89%. Subgroup analysis showed that the five-year relative survival rate for patients under 50 years of age was 90.3%, while for patients over 50 years of age, it was 88.6%. The five-year relative survival rate based on race was reported to be 89.6% for white, and 82.3% for black, showing survival was poorer for black patients. In addition, the five-year relative survival rate based on ethnicity was 88.6% for Hispanics, 89.2% for American Indian/Alaska Native, 91.8% for all Asians, and 87.9% for Pacific Islanders (97). Ward et al. (98) conducted a comprehensive review of 200 countries and territories worldwide to assess the global survival rates of childhood leukemia patients. The study found that in 2015, the global five-year survival rate for patients with ML was 42.9%, while it was 56.1% for patients with LL. Notably, there were significant variations in survival rates across different regions. Our results concerning the five-year survival rates for leukemia patients in Asian countries are consistent with the results of the study conducted by Ward et al. (98). The high level of agreement between the two studies can indicate that the results of this study are reliable and accurately reflect the survival rates of leukemia patients in the region. Based on the overall results of this study, the five-year survival rate of leukemia patients in Asian countries was 46.7% (95% CI, 41.2-52.3). Additionally, the National Cancer Institute (NCI) reported an overall five-year survival rate of 65.7%, which is higher than the survival rate found in the present study (99). Specifically, the five-year survival rate for patients with ML, as reported by the NCI, was 36.3% (95% CI: 35.8%-36.8%), while the survival rate for patients with LL was 62.4% (95% CI: 58.2%-66.4%). It is noteworthy that the NCI's reported survival rate was based on a larger sample size and could include a wider range of patient demographics and disease subtypes. Furthermore, the present study's findings should be interpreted with caution as they are based on a smaller sample size and may not be representative of the broader population of patients with cancer. Globally, the survival rate of patients with LL is still significantly higher than the survival rate of patients with AML (98, 100) in Europe (101), the US (102), and Australia (96). The five-year survival rates of childhood LL exceed 90% in some European and North American countries (22, 100). This study aimed to investigate the five-year survival rate of leukemia patients based on their gender and age group. The results of the study showed that the overall five-year survival rate for male leukemia patients was 42.8%, while it was 44.5% for female patients. In both gender groups, patients with LL had a higher survival rate than patients with ML. Interestingly, the leukemia disease burden in Asia appears to be higher among females, as compared to males, which is contrary to the global statistics. Further research is needed to shed light on the underlying factors contributing to this disparity. This could include investigating differences in disease subtypes, treatment protocols, and patient demographics in Asia, in comparison to the other regions. As reported by the NCI, the sex-standardized incidence rate was 18 per 100,000 for males and it was 11 per 100,000 for females in 2022 (103). In the present research, the five-year survival rate of ML and LL patients in different age groups, namely children, adults, and the elderly showed that the survival rate of children with either type of leukemia was higher than that of adults and the elderly. In addition, the overall five-year survival rate of leukemia patients in different age groups showed that children, in general, had a higher survival rate than adults

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(63.3% vs. 27.6%). The five-year survival rates of patients with ML were 38.3% (95% CI, 32.7-44.4), 13.9% (95% CI, 11.2-17.1), and 32.1% (95% CI, 28.6-35.8) in children, the elderly, and adults, respectively. The five-year survival rates of LL patients were 63.3% (95% CI, 57.6-68.6), 32.3% (95% CI, 27.2-37.8), and 31.9% (95% CI, 28.2-35.8) in children, the elderly, and adults, respectively. In recent studies, due to the increase in new cases of leukemia and cancer survivors, especially in children reaching adulthood, there are many concerns related to treatment complications, social, psychological, and economic consequences, and a decline in quality of life (104, 105). The results of some studies show that certain groups of childhood cancer survivors achieve lower educational attainment than expected and are also at significant risk of unemployment in adulthood (106, 107). Ward et al. (98) claimed that the country where patients receive medical services is more crucial to survival than the type of cancer. This can highlight the important roles of healthcare infrastructure and access to medical resources in determining patient outcomes. It is worth noting that the implications of this research may vary depending on the specific context and healthcare system. Nonetheless, these findings emphasize the need for constant efforts to improve healthcare access and infrastructure, particularly in underprivileged areas, to enhance cancer patient outcomes. The most recent report from the American Cancer Society revealed that the five-year survival rates for individuals with LL, aged birth to 14 years and 15 to 19 years, were 92% and 76%, respectively, while they were 68% and 67%, respectively, for patients with ML (102). Furthermore, leukemia was found to be the most prevalent childhood cancer in the United States, accounting for 28% of cases. It is worth noting that there is a considerable discrepancy in the five-year survival rate of patients with leukemia between Asian and American countries, with the latter exhibiting a rate that is more than double that of the former. Dramatic reduction in mortality reflects recent progress and advances in the relevant field. Therefore, the remission rate in cases such as childhood acute LL has reached 90-100% (102). These cases indicate the uneven distribution of new treatments and protocols in low-HDI Asian countries. Among the benefits of this population-based investigation are the inclusions of all the patients diagnosed with leukemia and the analysis of the relevant data based on patients' gender and age. Moreover, the present study was not restricted to an investigation of the survival rate of patients, but rather the HDI correlation between leukemia and the survival rate was also examined. The survival rate has not increased at the same gradient all over the world, due to various reasons such as uneven allocation of resources for prevention and treatment of the disease, and differences in the level of income, age composition, life expectancy, the type of malignancy, and race or ethnicity in different countries (108, 109). Concerning the meta-regression analysis in the present study, a significant correlation was observed between the five-year survival rate of patients with leukemia and the publication year as well as HDI. The results indicated an increase in the survival rate over the study period, associated with countries having a higher HDI. However, it is noteworthy that the comparison and estimation of survival rates across different countries depend on multiple factors. For instance, Bray et al. (108) found that the incidence of leukemia and the mortality rates of patients afflicted with the disease were significantly higher in the high-HDI than in the low-HDI countries. These findings highlight the complexity of the relationship between the HDI and leukemia outcomes and underscore the

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need for further research to precisely determine the underlying factors contributing to those disparities. Such studies may include investigating differences in disease subtypes, treatment protocols, and patient demographics in various regions. Ultimately, the studies can lead to more effective treatment strategies and improve overall survival rates for patients with leukemia worldwide. The present study has such limitations as incomplete information and limited article access. Some Asian regions have not published enough studies on the survival rates of patients with leukemia, indicating a need for further research in these areas. Moreover, the study did not consider various cancer risk factors such as specific genes, racial/ethnic patterns, smoking, alcohol intake, and leukemia stage for the subgroup analysis. Additionally, the study's small sample size and potential patient selection biases may impact its results. Thus, further research with larger sample sizes is necessary to confirm the present study's findings. Nevertheless, the study can offer valuable insights into the survival rates of leukemia patients based on gender, age, and leukemia type, highlighting the need for tailored treatment strategies for different subgroups of patients. Future studies are also recommended to examine the effect of quality of life and the impact of different cancer treatment protocols on survival rates.

Conclusion

As the present study demonstrated, the five-year survival of leukemia patients in Asian countries has achieved a rate of 46.7%, irrespective of variables such as age, cancer stage, or treatment protocol. The present study further revealed a significant increase in the survival rate of Asian patients with leukemia, as compared to the survival rate of similar patients in the previous decade. The success in reducing mortality rates and increasing survival rates among leukemia patients in Asian countries has been attributed to advancements in early detection, combination therapies, targeted therapies, adjuvant chemotherapies, and new drugs, and techniques. With a more comprehensive understanding of leukemia and the development of new treatments, there is hope for continued improvements in survival rates and reduced mortality. An investment in the management and control of leukemia through basic and clinical research can further increase knowledge and lead to the development of more advanced treatments. It is important to note that while survival rates do not necessarily indicate a cure, they do provide assurance to leukemia patients and their families and can aid in future planning based on reliable data.

Data Availability

All information gathered or analyzed during this research is included in this article.

Ethical Considerations

Not applicable.

Acknowledgments

We appreciate all the researchers who collaborated with us in the preparation of the manuscript.

Authors' Contributions

HD: Study design, Methodology, Supervision, and Writing Original draft preparation. SM and HKJ: critical revision of the manuscript for important intellectual content. HH: Writing Original draft preparation and critical revision of the manuscript. EA-S: Writing Original draft preparation, interpretation of data. RA: Conceptualization. RZ: Data collection,

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Data analysis, Drafting of manuscript. All authors have contributed to the manuscript in significant ways, and have reviewed and agreed upon the manuscript content.

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Conflict of Interest
There is no conflict of interest.

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